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(54) DISCHARGE LAMP LIGHTING EQUIPMENT AND ILLUMINATING SYSTEM

(57) Filaments FL1a,FL1b are preheated by converting direct current from a DC power source E to a high frequency current by means of an inverter circuit 11. As a discharge detecting circuit 12 does not form a closed circuit of direct current in that state, the voltage resulting from the direct current is not applied to a condenser C3. Therefore, the condenser C3 is not charged. Upon lighting the fluorescent lamp FL1 through an electrical discharge, the voltage resulting from the direct current is not applied to the condenser C3. When the voltage exceeds the voltage on a reference power source E1, it is judged that the fluorescent lamp FL1 has been lit by an electrical discharge. Should a discharge be detected when preheating is still necessary, the output from the inverter circuit 11 is reduced by means of a negative feedback, and the filaments FL1a,FL1b are preheated again, in the state where the glow discharge is maintained. When the filaments FL1a,FL1b are sufficiently preheated, the voltage on the reference power source E1 is increased by means of a timer or the like so that the output from the inverter circuit 11 is increased to start, in other words light, the fluorescent lamp FL1.

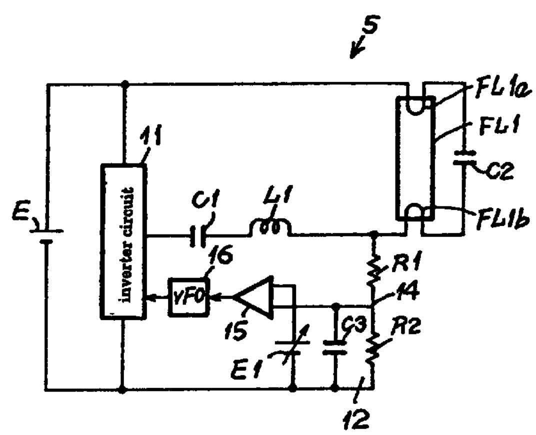

Fig. 1

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Description

TECHNICAL FIELD

[0001] The present invention relates to a discharge lamp lighting equipment and an illuminating system which are capable of appropriately preheating the discharge lamp.

BACKGROUND ART

[0002] Generally speaking, when lighting a discharge lamp having filaments which are positioned in a bulb and act as the hot cathodes, cold-starting the lamp makes it difficult for the filaments to emit thermions and therefore often results in damage of the filaments. For this reason, a discharge lamp lighting equipment for such a discharge lamp typically lights the lamp by preheating the filaments in order to facilitate the emission of thermions and then starting an arc discharge.

[0003] To be more specific, having a configuration that includes a preheating condenser connected in parallel with the filaments of the discharge lamp, and the discharge lamp lighting equipment is so designed as to preheat the filaments by applying to the discharge lamp a voltage lower than the discharge lamp starting voltage in order to pass a preheating current to the filaments prior to lighting the discharge lamp; measure thereafter a given length of time period with a timer or the like; and increase the voltage applied to the discharge lamp after the given length of time has elapsed, thereby starting up the discharge lamp. A configuration which calls for connecting an inverter transformer having a preheating winding to a discharge lamp lighting equipment and preheating filaments by use of the preheating winding is also known to those skilled in the art.

[0004] Improper preheating of the filaments of a discharge lamp, such as an instantaneous lighting or insufficient preheating caused by irregularity in the starting voltage, preheating based on inappropriate criteria, and so forth, tend to cause various problems including rapid blackening of the discharge lamp.

[0005] Therefore, it is necessary to allow a wide range of tolerance in setting the starting voltage, or add a control circuit for maintaining the preheating voltage at a constant level, a power source fluctuation compensating circuit or the like to the discharge lamp lighting equipment. This, however, complicates the configuration of the device.

[0006] Some discharge lamps are known to have white rings around the filaments in order to prevent blackening of the regions of the bulb wall near the filaments, which are heated during a preheating process.

[0007] Slender-type discharge lamps that have bulbs with a reduced outer diameter, for example not more than 21 mm, are becoming more commonplace. As these slender bulbs have virtually no clearance around the filaments and, it is therefore impossible to attach a ring.

[0008] Granting that a ring can be fitted around a filament, the heat resulting from preheating of the filament removes the emitter applied to the surface of the bulb wall. When the resistance of the filament increases as a result of the removal of the emitter, the insufficient distance between the bulb wall and the filament causes what is generally called a ring-hanging, i.e. melting of the ring itself. Therefore, a slender-type discharge lamp without a ring, too, has to undergo a normal preheating process before being put in an actual lighting mode by an arc-discharge.

[0009] However, when the filaments of such a lamp are preheated and become reddish, the absence of rings around the filaments brings about an undesirable result such that the red color is conspicuous when viewed from the outside. Such a red color is especially conspicuous in case of a slender-type discharge lamp, because the distance between the bulb wall and each filament is very short.

[0010] In order to solve the above problems, an object of the present invention is to provide a discharge lamp lighting equipment and a illuminating system that have a simple configuration and are capable of appropriately preheating a discharge lamp and also capable of making the red color of the filaments inconspicuous while sufficiently preheating the filaments.

DISCLOSURE OF INVENTION

[0011] A discharge lamp lighting equipment according to the invention includes a discharge lamp lighting means for lighting a discharge lamp having filaments; a discharge detecting means for detecting a discharge from said discharge lamp; and a control means adapted to cause the filaments to be preheated by reducing the output from the discharge lamp lighting means when the discharge detecting means has detected a discharge.

[0012] With the configuration as above, wherein the output from the discharge lamp lighting means is reduced by the control means when a discharge has been detected by the discharge detecting means, the discharge lamp is prevented from being lit before the lamp is sufficiently preheated. Thus, a proper preheating is ensured.

[0013] According to another feature of the invention, the discharge detecting means has a simple configuration and is capable of accurately detecting a discharge from the discharge lamp based on detection of a DC voltage, which is generated for the first time as a result of a discharge being initiated at the starting up of the lamp.

[0014] According to another feature of the invention, the discharge lamp lighting means is adapted to preheat the filaments in such a manner as to maintain generation of microdischarge in the discharge lamp and is capable of preheating the discharge lamp under stable preheating conditions. Furthermore, the discharge detecting means is provided with a filter for removing the lighting frequency at which the discharge lamp is lit. By removing the lighting frequency for the discharge lamp by means of the filter, the discharge detecting means eliminates the influence of pulsating currents at the lighting frequency. Thus, the discharge detecting means is accurately detects a discharge from the discharge lamp with a simple configuration.

[0015] A discharge lamp lighting equipment according to yet another feature of the invention includes an output-variable inverter circuit having a switching element for performing a switching function, said inverter circuit adapted to apply voltage to and between a pair of filaments of a discharge lamp which has a tube diameter of not more than 21 mm and is provided with said filaments and phosphor; an inverter control circuit for changing the output from said inverter circuit by controlling the switching function of said switching element; a discharge detecting means for detecting a discharge from the discharge lamp; and a start-up control circuit having a discharge detecting means for detecting a discharge from the discharge lamp, the start-up control circuit adapted to cause said inverter control circuit to function such that discharge breakdown voltage is applied between the filaments of the discharge lamp throughout a given period of preheating, thereby generating a glow discharge from the lamp; secondary lamp voltage for shifting the mode of discharge to the arc discharge mode is applied between the filaments of said discharge lamp when said preheating period has elapsed; and that the voltage between the filaments of the discharge lamp is reduced when the discharge is detected by said discharge detecting means.

[0016] With the configuration as above, throughout the preheating that is conducted for a preset period of time, the inverter control circuit controls the inverter circuit to apply a discharge breakdown voltage between the filaments of the discharge lamp, thereby initiating a weak glow discharge. As a result of the glow discharge, preheating is done by a flow of glow current that is not intense enough to damage the filaments. While the glow discharge is conducted, the voltage on the lamp increases, thereby passing a large amount of preheating current to the filaments. The preheating of the filaments involving the glow discharge causes the phosphor of the discharge lamp to emit light so that the red color of the filaments is reduced to a relatively inconspicuous level. When the period allotted for preheating has elapsed, a secondary lamp voltage for switching the mode of discharge to an arc discharge is applied between the filaments. When the discharge detecting means detects the switching to an arc discharge, in other words detects that the lamp has been lit, the inverter control circuit reduces the voltage on the inverter circuit to maintain the discharge lamp in the lit state. As the discharge lamp lighting equipment described above uses a glow discharge that is not intense enough to damage the filaments, thereby preheating the filaments and causing the phosphor to emit light prior to an arc discharge, which is the principal means for lighting the lamp, the discharge lamp lighting equipment presents no danger of the filaments incurring damage and is also capable of making reddening of the filaments inconspicuous.

[0017] According to yet another feature of the invention, the inverter circuit includes a DC interrupting line and a DC output line, the DC interrupting line connected to one of the two filaments of the discharge lamp via a DC interruption condenser for removing the DC component from the current, and the DC output line connected to the other filament and adapted to pass the current without interrupting a DC component; the discharge detecting means is provided with a DC voltage-detecting element for detecting a DC voltage on the DC interrupting line; and the output from the discharge detecting means is controlled based on the value of the voltage on the DC interrupting line detected by the DC voltage-detecting element. As a discharge between the filaments can be detected by the use of said DC voltage-detecting element which is adapted to detect a DC voltage which is generated on the DC interrupting line of the inverter circuit as a result of the starting up of the discharge between the filaments, output from the inverter circuit can be controlled by the start-up control circuit and the inverter control circuit.

[0018] According to yet another feature of the invention, the inverter circuit includes a DC interrupting line and a DC output line, the DC interrupting line connected to one of the two filaments of the discharge lamp via a DC interruption condenser for removing the DC component from the current, and the DC output line connected to the other filament and adapted to pass the current without interrupting the DC component; the discharge detecting means is provided with a first DC voltage-detecting element for detecting the DC voltage on the DC interrupting line and a second DC voltage-detecting element for detecting the DC voltage on the DC output line so that the output from the discharge detecting means is controlled based on a difference between the voltage on the first DC voltage-detecting element and the voltage on the second DC voltage-detecting element. As no DC voltage is generated on the DC output line prior to the discharge from the discharge lamp, the discharge between the filaments can be detected based on the decrease in the difference between voltages on the first DC voltage-detecting element and the second DC voltage-detecting element during the performance of these detecting elements to detect a DC component of the voltage between the filaments. Therefore, the discharge lamp lighting equipment described above is capable of controlling the output from the inverter circuit by means of the start-up control circuit and the inverter control circuit immediately after generation of a discharge.

[0019] According to yet another feature of the invention, the inverter circuit includes a DC interrupting line and a DC output line, the DC interrupting line connected to one of the two filaments of the discharge lamp via a DC interruption condenser for removing the DC component from the current, and the DC output line connected to the other filament and adapted to pass the current without interrupting the DC component; the discharge detecting means is provided with an AC voltage-detecting element for detecting the AC voltage on the DC interrupting line and is adapted to output, in order to control the secondary voltage on the lamp, the amount detected by the AC voltage-detecting element, said detected amount corresponding to the voltage on the DC interrupting line. Based on whether there is a DC component in the current when the discharge lamp is on as a result of a discharge or when the lamp is not lit, the AC voltage-detecting element detects the discharge between the filaments by detecting the AC voltage on the DC interrupting line. Therefore, the discharge lamp lighting equipment described above is capable of controlling the output from the inverter circuit by means of the start-up control circuit and the inverter control circuit immediately after generation of a discharge.

[0020] According to yet another feature of the invention, the DC voltage-detecting element of the discharge detecting means is provided with a DC voltage-detecting element adapted to function in the full-intensity illumination mode and a DC voltage-detecting element adapted to function in the dimming mode, said DC voltage-detecting elements having different disregard levels. Thus, the discharge detecting means having this feature is capable of easily coping with the full-intensity illumination mode and the dimming mode, simply by changing disregard levels.

[0021] According to yet another feature of the invention, the DC voltage-detecting element for the full-intensity illumination mode includes a disregard level switching means adapted to change disregard levels depending on whether the current mode is the preheating mode or the full-intensity illumination mode, wherein the respective disregard levels in the preheating mode, the dimming mode and the full-intensity illumination mode are smaller in the indicated order, i.e. the disregard level in the preheating mode > the disregard level in the dimming mode > the disregard level in the full-intensity illumination mode. Therefore, the discharge detecting means having this feature is capable of reliable detection of preheating, dimming and full-intensity illumination by means of changing disregard levels.

[0022] According to yet another feature of the invention, the discharge detecting means includes a current detecting element for detecting a lump current, and is adapted to output a signal from the current detecting element to the start-up control circuit upon detection of a lamp current. Therefore, the discharge lamp lighting equipment having this feature is capable of preheating the filaments to the maximum extent while maintaining a glow discharge by detecting, by means of the current detecting element, whether there is a lamp current before the discharge lamp is lit, and reducing the output from the inverter circuit by means of the start-up control circuit and the inverter control circuit when the lamp current is detected.

[0023] According to yet another feature of the invention, the inverter circuit includes a DC interrupting line and a DC output line, the DC interrupting line connected to one of the two filaments of the discharge lamp via a DC interruption condenser for removing the DC component from the current, and the DC output line connected to the other filament and adapted to pass the current without interrupting a DC component; and the discharge lamp lighting equipment further includes a life-end detecting circuit and an oscillation stopping circuit, wherein the life-end detecting circuit is provided with a first DC voltage-detecting element connected to the DC interrupting line and a second DC voltage-detecting element connected to the DC output line, the life-end detecting circuit being adapted to output a signal representing a detected amount corresponding to the difference between the voltage on the first DC voltage-detecting element and the voltage on the second DC voltage-detecting element, and the oscillation stopping circuit is adapted to stop the switching action of the switching element of the inverter circuit based on a stop signal output from the life-end detecting circuit. Normally, a discharge lamp does not produce a difference between the voltage on the first DC voltage-detecting element and the voltage on the second DC voltage-detecting element when it is lit. In cases where the discharge lamp is close to the end of its life span, however, one of the filaments becomes increasingly unable to emit electrons, which results in a half-wave discharge. In such a situation, by means of the life-end detecting circuit, the discharge lamp lighting equipment according to the invention detects the difference between the DC component detected by the DC interrupting line and the DC component detected by the DC output line, and stops the oscillation action of switching element of the inverter circuit by means of the oscillation stopping circuit.

[0024] According to yet another feature of the invention, a plurality of inverter circuits respectively corresponding to a plurality of discharge lamps are installed, said discharge lamps having an identical lighting frequency and different lamp powers; and the discharge lamp lighting equipment further includes a source power input circuit which has a full-wave rectifying circuit for performing full-wave rectification of the AC supply voltage having a low frequency and is so connected as to be shared by the inverter circuits corresponding to said different lamp voltages; and the discharge lamp lighting equipment also includes a plurality of low-distortion circuits connected so as to respectively form the sections located in front of said inverter circuits, each low-distortion circuit including a first condenser that has such a capacity as to not present a smoothing effect with respect to a low frequency voltage, a second condenser having a capacity greater than that of the first condenser and connected to a point closer to the source power input circuit than is the first condenser, a rectifying diode which is connected to a point between the first condenser and the second condenser and adapted to switch the cathode, which is located at the side connected to the first condenser, by means of a high-frequency current resulting from the reactive power to be recycled to the input side, and a series circuit consisting of a smoothing condenser and an inductor element and connected in parallel with the first condenser. Thus, the discharge lamp lighting equipment according to the invention improves the power factor by means of the structure wherein a low-distortion circuit is installed in front of each inverter circuit so that a high-frequency current resulting from a reactive power to be recycled to the input side when the switching element of the inverter circuit is turned off causes a high-frequency voltage to be superimposed over the condenser connected to a point between the DC output terminals of the full-wave rectifying circuit and that the rectifying diode functions at the same frequency as the lighting frequency of the inverter circuit over the entire range where the input current flows. As any difference in lighting frequencies of the inverter circuits would appear as a difference in switching frequencies of the rectifying diodes and generate beat noises through oscillation, the lighting frequencies of the respective inverter circuits are set at the same level so as to prevent generation of beat noises.

[0025] According to yet another feature of the invention, the discharge lamp lighting equipment includes a plurality of inverter circuits respectively corresponding to a plurality of discharge lamps that have an identical lighting frequency and different lamp powers; a source power input circuit which has a rectifying circuit for performing full-wave rectification of a low frequency AC supply voltage and is so connected as to be shared by the inverter circuits corresponding to said different lamp voltages; a plurality of low-distortion circuits connected so as to respectively form the sections located in front of said inverter circuits, each low-distortion circuit having a first condenser having such a capacity as to not present a smoothing effect with respect to a low frequency voltage, a second condenser having a capacity greater than that of the first condenser and connected to a point closer to the source power input circuit than is the first condenser, a rectifying diode which is connected to a point between the first condenser and the second condenser and adapted to switch the cathode, which is located at the side connected to the first condenser, by means of a high-frequency current that results from the reactive power to be recycled to the input side, and a series circuit consisting of a smoothing condenser and an inductor element and connected in parallel with the first condenser; a circuit base on which said inverter circuits are mounted in such a state as to be separated into blocks; and heat sinking plates which are mounted on said circuit base together with the switching elements of the inverter circuits, each heat sinking plate disposed at such a position as to bridge two of said blocks. The structure that calls for lighting a plurality of discharge lamps by means of a plurality of inverter circuits respectively associated therewith tends to cause interference between the inverter circuits. According to the above feature of the invention, however, interference between the inverter circuits is prevented, because the inverter circuits are mounted in such a state as to be separated into blocks. As heat sinks for discharging heat from heat generating elements, such as the switching elements of the inverter circuits, are mounted on the circuit base in such a manner that each heat sink bridges two blocks, interference between the switching elements is reduced, and wiring in the blocks is facilitated.

[0026] A illuminating system according to the invention is provided with a discharge lamp lighting equipment having any one of the features of the present invention described above and a main body, to which said discharge lamp lighting equipment is attached.

[0027] According to yet another feature of the invention, the illuminating system includes a discharge lamp lighting equipment having any one of the features of the present invention described above; the discharge lamps consist of a plurality of annular fluorescent lamps which have different outer ring diameters and adapted to be respectively energized by the inverter circuits, each lamp formed of a tube having a diameter of not more than 21mm; and the main body of the illuminating system is in the shape of a disk and supports the fluorescent lamps in such a state that they are concentrically arranged.

BRIEF DESCRIPTION OF DRAWINGS

[0028]

Fig. 1 is a circuit diagram of an embodiment of a discharge lamp lighting equipment according to the present invention; Fig. 2 is an exploded perspective of a illuminating system for said discharge lamp lighting equipment; Fig. 3 is an equivalent circuit diagram of same in the state where the fluorescent lamps are not in the course of discharge; Fig. 4 is an equivalent circuit diagram of same in the state where the fluorescent lamps are in the course of discharge; Fig. 5 is an equivalent circuit diagram of same in the state where the fluorescent lamps are not mounted; Fig. 6 is a circuit diagram of another embodiment of the discharge lamp lighting equipment according to the present invention; Fig. 7 is an exploded perspective of another embodiment of the illuminating system of the invention; Fig. 8 is a circuit diagram of the discharge lamp lighting equipment of said illuminating system; Fig. 9 is a schematic top view of a circuit base for illustrating an example of a manner of mounting of the discharge lamp lighting equipment; Fig. 10 is a circuit diagram principally illustrating an inverter unit.

BEST MODE FOR CARRYING OUT THE INVENTION

[0029] Next, an illuminating system according to an embodiment of the present invention is explained hereunder, referring to the drawings.

[0030] Fig. 2 is an exploded perspective of said illuminating system. As shown in Fig. 2, a main body 1 in the shape of a thin disk is attached to a ceiling socket by mean of an adapter 2. A holder 3 for mounting fluorescent lamps FL1,FL2 thereon is attached to the underside of the main body 1. The fluorescent lamps FL1,FL2, which serve as discharge lamps, are covered by a translucent shade 4 together with the holder 3 on which the lamps are mounted. A discharge lamp lighting equipment 5 is housed in the main body 1.

[0031] Fig. 1 is a circuit diagram of the discharge lamp lighting equipment, which illustrates only the circuit concerning the fluorescent lamp FL1. As shown in Fig. 1, the discharge lamp lighting equipment 5 includes a DC power source E, an inverter circuit 11 connected to the DC power source E and serving as a discharge lamp lighting means, filaments FL1a,Fl1b of the fluorescent lamp FL1, a condenser C1 for interrupting direct current, an inductor L1 and a condenser C2 for starting-up, wherein one end of the combination of the filaments FL1a,Fl1b is connected to the inverter circuit 11 via the condenser C1 and the inductor L1, while the condenser C2 is connected to a point between the other ends of the respective filaments FL1a,Fl1b. The inverter circuit 11 is designed so as to increase the output in the event where the voltage on the fluorescent lamp FL1 increases due to a failure in lighting, provided that the output does not exceed the set voltage.

[0032] A discharge detecting circuit 12 serving as a discharge detecting means is connected to a junction of an end of the filament FL1a of the fluorescent lamp FL1 and the inductor L1, which is located at the side where the condenser C1 for interrupting DC current is located. The discharge detecting circuit 12 includes a low-pass filter 14 for shutting out the AC component having a frequency in such a range as to light the fluorescent lamp FL1, a series circuit consisting of a resistor R1 and a resistor R2, and a condenser C3 connected in parallel with the resistor R2. Connected to the junction point between the two resistors R1,R2 is one of the input terminals of a comparator 15 that serves as a control means. The other input terminal of the comparator 15 is connected to a variable output voltage reference power source E1. The output terminal of the comparator 15 is connected to the inverter circuit 11 via a VFO 16 for changing oscillation frequencies of the inverter circuit 11 based on the voltage.

[0033] The fluorescent lamp FL2, too, is provided with a separate inverter circuit having a similar configuration.

[0034] Next, the function of the embodiment described above is explained hereunder.

[0035] First, the direct current from the DC power source E is converted to a high frequency current by means of the inverter circuit 11 to preheat the filaments FL1a,FL1b of the fluorescent lamp FL1. In this state, the start-up condenser C2 is connected to the inverter circuit 11 via the resistors R1a,R1b of the filaments FL1a,FL1b as shown in the equivalent circuit represented by Fig. 3. However, as the presence of the condenser C1 and the condenser C2 prevents the formation of a closed DC circuit, a voltage resulting from the direct current is not applied to the condenser C3. Therefore, the condense, C3 is not charged.

[0036] When the fluorescent lamp FL is lit as a result of the discharge, the resistor RFL is electrically connected and forms a series circuit that consists of the resistor RFL, the resistor R1 and the resistor R2 as shown in the equivalent circuit represented by Fig. 4 so that the DC component is applied to the condense, C3. When the voltage on the condenser C3 exceeds the reference voltage E1, this indicates the discharge from the fluorescent lamp FL and that the fluorescent lamp FL has been lit. The voltage on the reference power source E1 has to be maintained at a low level when the filaments FL1a,FL1b of the fluorescent lamp FL1 is in the course of preheating.

[0037] When the discharge from the fluorescent lamp FL1 is detected in the state where the filaments FL1a,FL1b need preheating, the output from the inverter circuit 11 is reduced by negative feedback, and the filaments FL1a,FL1b are preheated again by feeding a filament preheating current to the filaments via the condenser C2 while the fluorescent lamp is maintained in the non-discharge state or the microdischarge state, such as glow discharge. Thereafter, when the filaments FL1a,FL1b have sufficiently been preheated, the voltage on the reference power source E1 is increased by using a timer or other means to increase the output from the inverter circuit 11, thereby actuating and lighting the fluorescent lamp FL1. After lighting the fluorescent lamp, the circuit is put in the mode for detecting the end of the life-span of the fluorescent lamp FL1 or for other desired detection based on the increased voltage on the reference power source E1. Preheating the filaments FL1a,FL1b to a sufficient extent while maintaining the glow discharge has a number of benefits: as there is no need of taking the fluctuation of the preheating voltage into consideration, it is possible to simplify the structure of the circuit by eliminating the power source fluctuation compensating circuit or any other circuits for compensating fluctuation; and as it eliminates the irregularity in the preheating conditions, it reduces deterioration of the filaments and thereby increases the life span of the fluorescent lamp FL1. Furthermore, as the filaments FL1a,FL1b are preheated by means of glow discharge, which provides a certain degree of luminosity, the discomfort resulting from the slow starting is alleviated, even though the preheating takes a somewhat long period of time.

[0038] When the filaments are preheated, the light is tinged with red due to the red heat of the filaments. However, radiation by the glow discharge reduces the intensity of the red color and thus alleviates the discomfort that might otherwise be felt.

[0039] In cases where the fluorescent lamp FL1 is not mounted, the presence of the condensers C1,C2 prevents the formation of a closed DC circuit in the discharge detecting circuit 12. As the voltage resulting from the direct current is not applied to the condenser C3, the condenser C3 remains uncharged. When such a state continues for longer than a given length of time, the device judges that the fluorescent lamp FL1 is not connected and stops the output from the inverter circuit 11.

[0040] The end of the life span of the fluorescent lamp FL1 can be detected through the following process. In cases where, for example, there is a half-wave discharge from the filament FL1a of the fluorescent lamp FL1 to the filament FL1b, electric charge accumulates on the condenser C3 accordingly. When the voltage on the condenser C3 exceeds the voltage on the reference power source E1, the device judges that the fluorescent lamp FL1 is close to the end of its life span and therefore reduces or stops the output from the inverter circuit 11.

[0041] In cases where there is a half-wave discharge from the filament FL1b of the fluorescent lamp FL1 to the filament FL1b, the voltage on the condenser C3 never exceeds the voltage on the reference power source E1, because the voltage on the condenser C3 is in the reversed direction. Therefore, the output from the comparator 15 does not cause the reduction of the output from the inverter circuit 11. Based on the increase in the voltage on the fluorescent lamp FL1, however, the device judges that the fluorescent lamp FL1 is close to the end of its life span and reduces or stops the output from the inverter circuit 11 accordingly.

[0042] Next, another embodiment of the invention is explained hereunder, referring to Fig. 6.

[0043] Fig. 6 is a circuit diagram of another embodiment of the discharge lamp lighting equipment according to the present invention, which has a configuration similar to that of the embodiment shown in Fig. 1 except that a single inverter circuit 11 is connected to two fluorescent lamps FL1,FL2 and that a discharge detecting circuit 12 is connected to each fluorescent lamp FL1/FL2.

[0044] With regard to the manner of control of the inverter circuit 11, preheating can be done through simultaneous control of the two fluorescent lamps FL1,FL2. In cases where termination of the life span or other problems occur with either one of the fluorescent lamps FL1,FL2, it is sufficient to control the corresponding fluorescent lamp FL1/FL2 alone to stop the output. Notwithstanding the above explanation, different lengths of time may be set to conduct preheating for the respective fluorescent lamps FL1,FL2.

[0045] According to either one of the embodiments described above, discharge may be detected by canceling a filament preheating current by using a transformer or the like or detecting a portion where the filament preheating current is not flowing. In this case, as the detected value corresponds to the amount of discharge, the detection can be conducted efficiently by means of peak detection or the like.

[0046] Furthermore, the method of reducing the output from the inverter circuit 11 is not limited to those that call for changing frequencies; the output may be controlled by converting duty ratios.

[0047] The discharge lamp lighting equipment 5 according to either one of the embodiments described above detects discharge from the fluorescent lamp FL1 and/or the fluorescent lamp FL2 by means of a discharge detecting circuit 12 or discharge detecting circuits 12, and, upon detection of discharge from the fluorescent lamp FL1 and/or the fluorescent lamp FL2, reduces the output from the inverter 11 by means of the comparator 15, thereby preventing the fluorescent lamps FL1,FL2 from initiating a discharge before they are sufficiently preheated. By thus preventing a premature lighting, the discharge lamp lighting equipment 5 ensures appropriate preheating and increases the life span of the fluorescent lamps FL1,FL2.

[0048] Each discharge detecting circuit 12 is not connected to the inverter circuit by way of direct current. By thus shutting out the DC components from the current flowing into the discharge detecting circuit 12, the discharge from the fluorescent lamp FL1 and/or the fluorescent lamp FL2 can be detected accurately.

[0049] As the inverter circuit 11 preheats the filaments FL1a, FL1b, FL2a, FL2b, while maintaining the fluorescent lamps FL1,FL2 in the state where the microdischarge is being conducted, the inverter circuit 11 is capable of ensuring a certain degree of luminosity and preheating the fluorescent lamps FL1,FL2 under stable preheating conditions.

[0050] Furthermore, the discharge detecting circuit 12 has a low-pass filter 14 for shutting out the component having a frequency in such a range as to light the fluorescent lamps FL1,FL2. By removing the component having a frequency in such a range as to light the fluorescent lamps FL1,FL2 by the use of the low-pass filter 14, the discharge lamp lighting equipment is capable of eliminating the influence of the pulsating current having a frequency m such a range as to light the fluorescent lamps. Therefore, a simple configuration of the discharge lamp lighting equipment according to the invention is capable of accurately detecting a discharge from the fluorescent lamp FL1 and/or the fluorescent lamp FL2.

[0051] Next, other embodiments of the invention are explained hereunder, referring to the drawings.

[0052] Fig. 7 is an exploded perspective of a illuminating system. The illuminating system shown in Fig. 7 has a configuration similar to that of the illuminating system shown in Fig. 2 except that the discharge lamps of a hot cathode type consist of three annular fluorescent lamps that are of the slender tube type having a tube diameter of not more than 21 mm and held in the state where they are concentrically arranged. The three lamps have different outer ring diameters and output powers. For example, they may consist of a 20W fluorescent lamp FL1, a 27W fluorescent lamp FL2 and a 34W fluorescent lamp FL3. As these fluorescent lamps FL1,FL2,FL3 are of a slender tube type and have to be handled with care, they are supported by holders which are not shown in the drawing. A circular opening 21 is formed at the center of the main body 1, and a reflection cover 22 is placed at a location corresponding to the opening 21. Although there are no limitation in the diameter of the tube of each lamp other than it should not exceed 21 mm, a lamp having a tube diameter of less than 15 mm is not practical, because it is weak and requires excessive care when being handled. Therefore, in actual use, the lamps may desirably have a tube diameter of 15 mm or more. None of the fluorescent lamps FL1,FL2,FL3 is provided with a ring for preventing the blackening.

[0053] Fig. 8 is a circuit diagram of a discharge lamp lighting equipment. The discharge lamp lighting equipment 31 shown in Fig. 8 includes a power input circuit 33 comprising a 50Hz/60Hz commercial AC power source e having a source voltage of 100 V and a full-wave rectifying circuit 32 connected to the commercial AC power source e. A filter circuit may be connected to the input end of the full-wave rectifying circuit 32, in other words the end where the commercial AC power source e is located.

[0054] An inverter unit 34_1 for the fluorescent lamp FL1, an inverter unit 34_2 for the fluorescent lamp FL2 and an inverter unit 34_3 for the fluorescent lamp FL3 are connected to the power input circuit 33. These inverter units 34_1,34_2,34_3 are connected in parallel with one another and share the power input circuit 33.

[0055] The inverter units 34_1,34_2,34_3 are formed as composite devices, each of which has a capacity of output at 45kHz and includes a low-distortion circuit 35_1/35_2/35_3 for reducing high harmonics and a reactive power recycling inverter circuit 36_1/36_2/36_3, which may be of a 1-crystal type.

[0056] The low-distortion circuits 35_1,35_2,35_3 are practically identical in configuration; each comprises a series circuit consisting of a choke coil L11 serving as an inductor element, a diode D11 for rectifying a current and a first condenser C11, a second condenser C12, a choke coil L12 serving as another inductor element, and a smoothing condenser C13, wherein the series circuit of the choke coil L11, the diode D11 and the first condenser C11 is connected to a point between the output terminals of the full-wave rectifying circuit 32; the second condenser C12, too, is connected to the full-wave rectifying circuit 32 via the choke coil L11, the second condenser C12 being disposed at a location closer to the input end of the low-distortion circuit than is the first condenser C11; and the choke coil L12 and the condenser C13 are connected in parallel with the first condenser C11. The first condenser C11 has a relatively small capacity so as to present virtually no function of smoothing low frequency waves, which correspond to the frequency of the commercial AC power source e. The second condenser C12 serves to improve the power factor and has a capacity substantially larger than that of the first condenser C11.

[0057] The inverter circuits 36_1,36_2,36_3, too, are practically identical in configuration and adapted to respectively light the fluorescent lamps FL1,FL2,FL3 at the same frequency. Each inverter circuit includes & transistor Q11, which serves as a switching element, and a discharge detecting circuit (not shown) serving as a discharge detecting means. Each transistor Q11 may be of a 1-crystal type that calls for recycling the current through a current transformer.

[0058] Each inverter circuit 36_1/36_2/36_3 is connected to the filaments FL1a,FL1b/FL2a,FL2b/FL3a,FL3b of the fluorescent lamp FL1/FL2/FL3 via a DC output line 38, which does not interrupt a direct current, and a DC interrupting line 39 that is connected to the circuit through a condenser (not shown) adapted to shut a direct current.

[0059] Next, how the discharge lamp lighting equipment 31 is mounted is explained, referring to Fig. 9.

[0060] Fig. 9 is a schematic top view of a circuit base on which a discharge lamp lighting equipment is mounted. As shown in Fig. 9, a circuit base 41 having a shape resembling a U that fits the main body 1 and the opening 21 is attached to the upper surface of the main body 1. Circuit components respectively constituting the power input circuit 33 and the inverter sits 34_1,34_2,34_3 are mounted on the circuit base 41 in the state where they are separated into blocks B1,B2,B3,B4 and arranged on the circuit base in this order.

[0061] Aluminum heat sinks 42,43 protruding towards the opening 21 and serving as heat sinking plates are disposed near the opening 21 of the main body 1, the heat sinks 42,43 respectively located at two of the borders between the blocks B1,B2,B3,B4 of the circuit base 41, and attached to the main body 1 in the state where they are grounded to the main body. A heat-emitting element 44 of the power input circuit 33 and transistors Q1 of the inverter units 34_1,34_2,34_3 are attached to the heat sinks 42,43. Therefore, when the heat-emitting element 44 and the transistors Q1 generate heat, the heat is radiated by the heat sinks 42,43. Inside the main body 1, the temperature is considered to be lowest near the opening 21. Therefore, the heat sinks 42,43 are capable of effectively discharging heat and, as a result, limiting increase of temperature of the heat-emitting element 44 and the transistors Q1 as well as limiting mutual interference among the heat-emitting element 44 and the transistors Q1, which may otherwise be caused by the heat.

[0062] Even in cases where the inverter units

34_1,34_2,34_3 individually and therefore tend to interfere with one another, the influence of the interference is limited to a minimum, because they are mounted on the circuit base 41 in the state where they are separated into the blocks B2,B3,B4 respectively. Although the heat-emitting elements 44 and the transistor Q1 mounted on the circuit base are respectively positioned inside the blocks B1,B2,B3,B4, in other words located to one side with respect to the center, wiring can be done easily.

[0063] Next, the function of the embodiment described above is explained.

[0064] First, full-wave rectification of the AC voltage from the commercial AC power source e is conducted by the full-wave rectifying circuit 32, and the distortion is reduced by reducing high harmonics by means of the low-distortion circuits 35_1,35_2,35_3.

[0065] To be more specific, by using a high frequency current generated by each inverter circuit 36_1/36_2/36_3, a high frequency ripple voltage is generated on the corresponding first condenser C11 through series resonance of the first condenser C11 with the choke coil L12 so as to cause the diode D11 to perform the switching function at a high frequency and thereby improve the power factor. Meanwhile, the current is smoothed by the condenser C3 throughout the entire flowing period of the input current. Given that the voltage on both ends of each first condenser C11 is VC11 and that the voltage on both ends of the corresponding second condenser C12 is VC12, the high frequency ripple voltage of the voltage VC11 causes the rectifying diode D11 to perform the switching function. Given that the capacities of the first condenser C11 and the second condenser C12 are CC11 and CC12 respectively, the relationship between the two condensers is represented by $CC11 \ll CC12$, which means that no actual problem would arise if the voltage VC12 on the second condenser C12 is considered to be equal to the voltage on the power input circuit 33. Therefore, the voltage VC 12 shall be regarded as equal to the voltage on the power input circuit 33.

[0066] In the period where the voltage VC12 on the second condenser C12 connected to one of the inverter circuits 36_1/36_2/36_3 is equal to the voltage VC11 of the first condenser C11 associated therewith, in other words in the period where a diode D11 is in the 'on' state, the current flows from the full-wave rectifying circuit 32 to the inverter circuit 36_1/36_2/36_3. Therefore, even in the so-called trough portion, i.e. the portion where the input voltage is low, of a waveform after full-wave rectification, the current flows when the diode D11 is turned on. Thus, the power factor is improved.

[0067] In the period where the voltage VC12 is lower than the voltage VC11, in other words in the period where the diode D11 connected to one of the inverter circuits 36_1/36_2/36_3 is in the 'off' state, there is no flow of current from the full-wave rectifying circuit 32 to the inverter circuit 36_1/36_2/36_3. Therefore, if the duration of the 'on' state of the diode D11 is reduced in the so-called crest portion, i.e. the portion where the input voltage is high, of a waveform after full-wave rectification, the peak current to the condenser C13 is limited. In short, if the period where the voltage VC12 is lower than the voltage VC 11 is lengthened, distortion in the input current can be reduced.

[0068] By setting a sufficiently small capacity for a first condenser C11 and causing series resonance of the first condenser C11 with the corresponding choke coil L12 to generate high frequency ripples, and thus repeating increase and reduction of its voltage VC11, periods where the voltage VC12 is lower than the voltage VC11 and periods where the voltage VC12 is equal to the voltage VC11 are formed so that the voltage VC11 is increased by recycling of a reactive power from the inverter circuit 36_1/36_2/36_3 and reduced as a result of the power returning to the inverter circuit 36_1/36_2/36_3. As the high frequency impedance of the choke coil L12 is substantially larger than that of the first condenser C11, the reactive power from the inverter circuit 36_1/36_2/36_3 is recycled to the first condenser C11 so that the voltage on the first condenser C11 is increased. As there is also the voltage that has been charged from the condenser C13 through the choke coil L12 onto the first condenser C11, the voltage on the first condenser C11 is further increased by the amount corresponding to the charged voltage. In contrast, when the current resulting from the charge of the voltage VC11 flows to the inverter circuit 36_1/36_2/36_3 acting as a load, the voltage VC11 is reduced. When the voltage VC11 is reduced to the same level as the voltage VC12, i.e. VC11 = VC12, the diode D11 is turned on, and the current flows from the full-wave rectifying circuit 32 to the inverter circuit 36_1/36_2/36_3.

[0069] Thus, the longer the period VC12 < VC11 in a portion where the crest value of an input voltage on the power input circuit 33, in other words the lower the on-duty of the diode D11, the more limited the charge current flowing into the condenser C13. In order to perform this function, whether the duration of the 'off' state of the diode D11 can be made sufficiently long is an important factor, because the increase of the voltage on the first condenser C11 for that purpose depends on charge from the choke coil L12 and the condenser C13 onto the first condenser C11 and also depends on recovery of the reactive power of the first condenser C11 from the inverter circuit 36_1/36_2/36_3 for regeneration of power.

[0070] Each inverter circuit 36_1/36_2/36_3 is designed such that the lighting frequency for the fluorescent lamp FL1/FL2/FL3 is changed by changing the on-off frequency for the transistor Q11; the voltage applied to the fluorescent lamp FL1/FL2/FL3 is reduced by increasing the on-off frequency of the transistor Q11, and increased by reducing the on-off frequency of the transistor Q11.

[0071] Sharing the power input circuit 33, the composite-type inverter units 34_1,34_2,34_3 respectively light the fluorescent lamps FL1,FL2,FL3 by using the low-distortion circuits 35_1,35_2,35_3 in the state where they are connected in parallel with one another, the low-distortion circuits 35_1,35_2,35_3 respectively disposed in front of the inverter circuits 36_1,36_2,36_3.

[0072] The respective circuit constants of the inverter circuits 36_1,36_2,36_3 are set such that the differences among the frequencies of the inverter units 34_1,34_2,34_3 are zero, in other words, the frequencies for lighting the respective lamps are identical.

[0073] By unifying the frequencies of the inverter circuits 36_1,36_2,36_3 as described above, generation of disagreeable beat noises, which may otherwise be generated as a result of differences among frequencies, is prevent. Should the inverter circuits 36_1,36_2,36_3 be set to have different lighting frequencies, the differences among their frequencies appear as differences in the frequencies of the respective diodes D11, which are switched at the corresponding lighting frequencies. This causes differences in currents that are input to the inverter circuits 36_1,36_2,36_3; for example, while a great amount of current may flow through one of the diodes D11 to the corresponding inverter circuit 36_1/36_2/36_3, the amount of the current flowing through another diode D11 to the corresponding inverter circuit 36_1/36_2/36_3 may be relatively small. As such a difference in conditions, i.e. an influence of the difference in frequencies, causes oscillation through the power input circuit 33, which is shared by all the low-distortion circuits 35_1,35_2,35_3, beat noises are generated and emitted to the outside.

[0074] In the preheating stage, which is conducted prior to the lighting of each fluorescent lamp FL1/FL2/FL3 by using arc discharge, a discharge breakdown voltage that is not high enough to damage its filaments FL1a,FL1b/FL2a,FL2b/FL3a,FL3b is continuously applied to the filaments to initiate glow discharge, which is a form of microdischarge. After the glow current acting as the preheating current is thus fed into the filaments FL1a,FL1b/FL2a,FL2b/FL3a,FL3b so that the filaments emit glow-light, the discharge mode is shifted to the arc discharge.

[0075] In cases where the voltage applied between each pair of the filaments FL1a,FL1b/FL2a,FL2b/FL3a,FL3b is at a preset level, the fluorescent lamp FL1/FL2/FL3 continues the glow discharge. If the voltage becomes too high, however, the fluorescent lamp FL1/FL2/FL3 shifts to the arc discharge mode so that the actual lighting stage starts. Should arc discharge begin before the filaments FL1a,FL1b/FL2a,FL2b/FL3a,FL3b are sufficiently warmed up, there arises the danger of damage to the filaments FL1a,FL1b/FL2a,FL2b/FL3a,FL3b. On the other hand, in cases where the amount of the glow current that flows into the filaments FL1a,FL1b/FL2a,FL2b/FL3a,FL3b as a result of the glow discharge is insufficient, the amount of the light emitted by the phosphors is too small to cancel the red color of the filaments FL1a,FL1b/FL2a,FL2b/FL3a,FL3b. For this reason, it is important to appropriately continue the microdischarge at a current level corresponding to the glow discharge before shifting the mode to the arc discharge. Accordingly, the duration of preheating (to be more specific the values of breakdown voltages, i.e. voltages applied to maintain the glow discharge that starts at the initiation of preheating, and the respective lengths of time for application of such voltages) are sequentially set beforehand.

[0076] Therefore, even in cases where lamps that are of the slender tube type and have no rings around the filaments FL1a,FL1b,FL2a,FL2b,FL3a,FL3b are used as the fluorescent lamps FL1,FL2,FL3, the red color generated by the heating up of the filaments FL1a,FL1b,FL2a,FL2b,FL3a,FL3b during the preheating process is not conspicuous when viewed from the outside.

[0077] Next, yet another embodiment is explained, referring to Fig. 10.

[0078] Fig. 10 is a circuit diagram principally illustrating a single inverter unit. To be more specific, it illustrates only the inverter unit 34_1, which is one of the three inverter units 34_1,34_2,34_3 shown in Fig. 8, and omits the other inverter units 34_2,34_3. In Fig. 10, elements and portions corresponding to those shown in Fig. 8 are represented by the same reference numerals as those in Fig. 8.

[0079] A filter circuit 52 is connected to a commercial AC power source e via terminal blocks 50,51 and a fuse F. The filter circuit 52 includes a constant-voltage element Z1, a condenser C21 and a transformer Trl1. Connected to the filter circuit 52 is an input terminal of a full-wave rectifying circuit 32, which comprises four diodes D21,D22,D23,D24 arranged in the form of a bridge. A constant-voltage element Z2 and a condenser C22 are connected to a point between the output terminals of the full-wave rectifying circuit 32. A power-input circuit 33 is principally formed of the commercial AC power source e, the filter circuit 52 and the full-wave rectifying circuit 32 described above.

[0080] The aforementioned inverter unit 34_1 is connected to the power input circuit 33. The inverter unit 34_1 is of a composite type having a full-smoothing type low-distortion circuits 35_1, which is provided in order to deal with the problem of high harmonics, and an inverter circuit 36_1 of a reactive-power recovering type. The inverter circuit 36_1, may be of a 1-crystal type.

[0081] The low-distortion circuits 35_1 includes a series circuit consisting of a choke coil L11 serving as an inductor element, a current-rectifying diode D11 and a first condenser C11. The low-distortion circuits 35_1 is also includes a second condenser C12, a choke coil L12 serving as another inductor element, and a smoothing condenser C13. The series circuit of the choke coil L11, the diode D11 and the first condenser C11 is connected to a point between the output terminals of the full-wave rectifying circuit 32; the second condenser C12 is disposed at a location closer to the input end of the low-distortion circuit and also connected to the full-wave rectifying circuit 32 via the choke coil L11; and the choke coil L12 and the condenser C13 are connected in parallel with the first condenser C11. The first condense, C11 has a relatively small capacity so as to present virtually no function of smoothing low frequency waves, which correspond to the frequency of the commercial AC power source e. The second condenser C12 functions to improve the power factor and designed to have a capacity substantially larger than that of the first condenser C11.

[0082] The inverter circuit 36_1 is provided with a series resonance circuit 53, which is comprised of a series circuit consisting of a resonance inductor L21 and a resonance condense, C25 and connected in parallel with the first condense, C11. A transistor Q11 serving as a switching element and a diode D25 for circulating current are connected in parallel with the condenser C25. A series circuit consisting of a diode 26 and a condenser C26 is connected to a point between a junction point where the inductor L21 and the transistor Q11 are connected and a junction point where the choke coil L12 and the condenser C13 are connected. A series circuit consisting of a resistor R21, a resistor R22 and a resistor R23 is connected in parallel with the condenser C26.

[0083] A series circuit consisting of a resistor R24, a condense, C27 and a resistor R25 is connected in parallel with the condenser C12, with a junction point between the resistor R24 and the condense, C27 being connected to the base of the transistor Q11 via a trigger element Q21.

[0084] An end of the inductor L21 is connected to a terminal 54 via a DC output line 38, and a junction point between the resistor R24 and the trigger element Q21 is also connected to the terminal 54 via a diode D27 of a DC interrupting line 39, an input winding CT11a of a current transformer CT11, a condenser C28 for interrupting direct current, and a ballast choke L25. An end of each one of the two filaments FL1a,FL1b of the fluorescent lamp FL1 is connected to the terminal 54, while the other end of each filament FL1a/FL1b is connected to a start-up condenser C29 via the terminal 54.

[0085] A series circuit of a diode D31 and a resistor R26 is connected to a point between the base and the emitter of the transistor Q11. A series circuit of an output winding CT11b of the current transformer CT11, a condenser C32 and a field-effect transistor Q22 is also connected to a point between the base and the emitter of the transistor Q11. A series circuit of a condense, C33 and a condense, C34 is also connected to a point between the base and the emitter of the transistor Q11. A junction point between the condense, C33 and the condense, C34 is connected to the base of a transistor Q23. A diode D35 is connected to a point between the base and the emitter of the transistor Q23, while the collector is connected to the transistor Q11 via a diode D36. The drain and the source of a field-effect transistor Q24 are connected to a point between the collector and the emitter of the transistor Q23. A series circuit of a resistor R27 and a Zener diode ZD11 is also connected to a point between the collector and the emitter of the transistor Q23, in parallel with the C13. The gate of the field-effect transistor Q24 is connected to a junction point between the resistor R27 and the Zener diode ZD11.

[0086] Via a resistor R31 and a resistor R32, the DC interrupting line 39 is connected to a series circuit of a condense, C36 and the diode D36. With a series circuit of a diode D37 and a condenser C37 connected to the diode D36, these components constitute an AC voltage-detecting element 55.

[0087] A first DC voltage-detecting element 56 comprises a series circuit of a resistor R34 and a resistor R35, and a condenser C38 that is connected in parallel with the resistor R35. A DC voltage-detecting element 57 to be used for dimming is comprised of a series circuit of a resistor R36, a resistor R37, a variable resistor R38 and a resistor R39, and a condense, C39, which is connected in parallel with the resistor R36, the resistor R37, the variable resistor R38 and the resistor R39.

[0088] Furthermore, a DC voltage-detecting element 58 to be used during full-intensity illumination comprises a series circuit of a resistor R41, a resistor R42, a resistor R43, a resistor R44 and a Zener diode ZD12 that serves as a changeover means for changing disregard levels depending on whether the current mode is the dimming mode or the full-intensity illumination.

[0089] A second DC voltage-detecting element 59 is formed by connecting a series circuit of a resistor R48 and a resistor R49 through a series circuit of a resistor R45, a resistor R46, a resistor R47 and the filament FL1a of the fluorescent lamp FL1 to the DC output line 38, and connecting a condense, C40 in parallel to the resistor 49.

[0090] The embodiment includes a terminal 61, which is connected to the commercial AC power source e via a jumper line 62, an all-night lamp 63 and a fuse F.

[0091] Also included is a mode changeover terminal 64, which has a dimming terminal element (DIM), an on/off terminal element (ON/OFF) and a ground terminal element (GND). The dimming terminal element is connected to the jumper line 62 via the resistor R41; a condenser C42 is connected to a point between the on/off terminal element and the ground terminal element; the condenser C42 and a condenser C43 are connected in parallel with each other to a point between the dimming terminal element and the ground terminal element; a series circuit of a resistor R52 and a resistor R53 is connected in parallel with the condense, C43; the base of a transistor Q26 is connected to a junction point between the resistor R52 and the resistor R53; the emitter of the transistor Q26 is connected to the ground terminal element of the terminal 64; the collector is connected to the base of a transistor Q27; the base of said transistor Q27 is connected to a junction point between a resistor R54 and a resistor R55; and the resistor R54 is connected to the dimming terminal of the terminal 64 via a resistor R56 and a diode D41.

[0092] A series circuit of a programmable unijunction transistor Q28 and a resistor R57 is connected via the diode D41 to a point between the on/off terminal element and the ground terminal element of the terminal 64; a parallel circuit of a condenser C44 and a resistor R58 is connected to a point between the cathode and the gate of the programmable unijunction transistor Q28; the gate of the programmable unijunction transistor Q28 is connected to the collector of a transistor Q29 via a resistor R59; the emitter of the transistor Q29 is connected to the ground terminal of the terminal 64; a parallel circuit of a condense, C45 and a resistor R61 is connected to a point between the base and the emitter of the transistor Q29; a series circuit of a resistor R62 and a Zener diode ZD13 is connected to the base of the transistor Q29; and a condenser C46 is also connected to the base of the transistor Q29, in parallel with a series circuit of the Zener diode ZD 13, the resistor R62 and the resistor R61. A junction point between the Zener diode ZD13 and the condenser C46 is connected via the diode D42 to a junction point between the resistor R34 and the resistor R35; a junction point between the Zener diode ZD13 and the diode D42 is connected to the collector of a transistor Q31; and the base of the transistor Q31 is connected via a diode D43 to a junction point between the resistor R34 and the resistor R35. Thus, a life-span end detecting circuit 65 is formed.

[0093] A condenser C47 is connected to a point between the ground terminal element of the terminal 64 and a junction point where the diode D41 and the resistor R56 are connected. Another junction point between the diode D41 and the resistor R56 is connected to the gate of the field-effect transistor Q22 via a resistor R65 and also to the negative electrode of the full-wave rectifying circuit 32 via a condense, C48. Yet another junction point between the diode D41 and the resistor R56 is connected to the base of the transistor Q31 via a resistor R66, and a parallel circuit of a resistor R67 and a condenser C51 is connected to the base and the emitter of the transistor Q31.

[0094] A condenser C52 and a series circuit which consists of a Zener diode ZD15 and a Zener diode ZD16 and serves as a reference power source are connected in parallel to the condense, C47 via the resistor R56, wherein the condenser C52 and the series circuit of the Zener diodes ZD15,ZD16 are arranged and connected in parallel to each other. A resistor R71 is connected to a point between the resistor R56 and the Zener diode ZD13.

[0095] A series circuit of a resistor R72 and a resistor R73 is connected in parallel with the condense, C47; a condenser C53 is connected in parallel with the resistor R73; a series circuit of a resistor R74 and a condenser C54 is connected in parallel with the condenser C52; the base of a transistor Q32 is connected to a junction point between the resistor R72 and the resistor R73; the collector of the transistor Q32 is connected to a junction point between the resistor R74 and the condense, C54; and the emitter of the transistor Q32 is connected to the ground terminal element of the terminal 64.

[0096] Furthermore, a series circuit of a condenser C55 and a condense, C56 is connected in parallel with the condense, C52; the diode D41 is connected in parallel with the condense, C55; and a resistor R76 is connected in parallel with the condenser C56. The base of a transistor Q33 is connected to a junction point between the condense, C55 and the condenser C56; the emitter of the transistor Q33 is connected to the resistor R56 via a resistor R77 and also to a junction point between the resistor R47 and the resistor R48; and the collector is connected to the ground terminal element of the terminal 64 via a resistor R78 and the diode D42.

[0097] A junction point between the diode D37 and the condense, C37 is connected to the base of the transistor Q33 via the diode D43 and a Zener diode ZD17; a series circuit of a diode D44 and a condense, C57 is also connected, in parallel with the resistor R76, to the base of the transistor Q33; and a condenser C58 is also connected to the base of the transistor Q33 in parallel with the condense, C57. The condense, C58 is also connected to the variable resistor R38 and the collector of the transistor Q27.

[0098] The base of the transistor Q33 is also connected via a diode D45 to the variable resistor R42. The diode D43, the diode D44 and the diode D45 constitute an OR circuit adapted to detect the respective disregard levels in the dimming mode, the full-intensity illumination mode and the preheating mode, wherein the respective disregard levels become lower in descending order of the preheating mode, the dimming mode and the full-intensity illumination mode, and the disregard levels are respectively given priorities in descending order so that the highest disregard level, i.e. the disregard level in the preheating mode, is given the highest priority.

[0099] The AC voltage-detecting element 55, the DC voltage-detecting element 57 to be used in the dimming mode and the DC voltage-detecting element 58 to be used in the full-intensity illumination mode constitute a start-up control circuit 66.

[0100] Next, the function of the embodiment shown in Fig. 10 described above is explained hereunder. The basic function of the present embodiment is similar to that of the embodiment shown in Fig.8.

[0101] In the full-intensity illumination mode, the mode changeover terminal 64 connects its dimming terminal to the ground terminal, and a base current is prevented from being fed to the base of the transistor Q26. The base current is fed to the base of the transistor Q27 to turn on the transistor Q27 so that the current bypasses the diode D44, thereby nullifying the disregard level detected by the diode D44.

[0102] When the source power is input, the power charges the condenser C44. In the period of the preheating mode until the voltage on the condenser C44 reaches a given level, transistor Q33 is in the 'on' state so that the Zener diode ZD12 of the DC voltage-detecting element 58 for the full-intensity illumination mode is effectuated and that the disregard level to be detected by the variable resistor R42 corresponds to the disregard level for the preheating mode.

[0103] In the state described above, the inverter circuit 361 performs a given oscillating function and thereby applies high-frequency voltage through the DC output line 38 and the DC interrupting line 39 to the fluorescent lamp FL1. As no voltage is applied to the gate of the field-effect transistor Q22, the impedance between the source and the drain of the field-effect transistor Q22 becomes very high. As the condenser C33 alone is electrically connected, the condense, C32 being not electrically connected, the apparent combined capacity is reduced so that the frequency of the inverter circuit increases while the output voltage decreases. Therefore, the inverter circuit 36_1 applies a voltage equivalent to the discharge breakdown voltage to the fluorescent lamp FL1 and cause glow discharge between the filaments FL1a,FL1b of the fluorescent lamp FL1. As a result of this glow discharge, a preheating current flows between the filaments FL1a,FL1b of the fluorescent lamp FL1 via the preheating condenser C29, while the glow discharge occurs in the fluorescent lamp FL1. Although the filaments FL1a,FL1b of the fluorescent lamp FL1 are preheated by said preheating current and become reddish, the glow discharge causes the phosphor of the fluorescent lamp FL1 to emit light and thus cancels the red color and make it inconspicuous when viewed from the outside. Thus, according to the embodiment of the invention, the red color of the filaments FL1a,FL1b is not conspicuous when viewed from the outside and, therefore, is prevented from giving discomfort to the user.

[0104] As the impedance between the source and the drain of the field-effect transistor Q22 of the inverter circuit 36_1 increases due to the decrease in the gate voltage of the field-effect transistor Q22, the combined capacity of the condense, C31 and the condense, C32 decreases so that the time required for saturation of the current transformer CT11 is reduced. As a result, the lighting frequency of the transistor Q11 is reduced, and the high-frequency output from the inverter 36_1 is reduced. When the voltage on the gate of the field-effect transistor Q22 increases, the impedance between the source and the drain of the field-effect transistor Q22 of the inverter circuit 36_1 is reduced, and the combined capacity of the condense, C31 and the condense, C32 is increased so that the time required for saturation of the current transformer CT11 is increased. As a result, the lighting frequency of the transistor Q11 is reduced, and the high-frequency output from the inverter 36_1 is increased.

[0105] Thereafter, when the preheating is completed with the electric potential of the condenser C54 reaching a given level, the base current is fed to the base of the transistor Q33, thereby turning on the transistor Q33 and short-circuiting the Zener diode ZD12. As a result, the disregard level of the DC voltage-detecting element 58 for the full-intensity illumination mode is shifted down to the disregard level for full-intensity illumination. The gate voltage on the field-effect transistor Q22 may be increased by increasing the base current fed to the transistor Q33, or reduced by reducing the base current fed to the transistor Q33. Before the fluorescent lamp FL1 starts arc discharge, no DC component flows through the DC interrupting line 39 so that the disregard level is not increased. Therefore, the base of the transistor Q33 is controlled based on detection by the AC voltage-detecting element 55, and the output from the inverter circuit 361 is controlled in such a way that a secondary voltage is applied to a point between the filaments FL1a,FL1b of the fluorescent lamp FL1 based on the detected disregard level.

[0106] When the fluorescent lamp FL1 is shifted to the arc discharge mode and lit with a voltage applied as described above, the voltage on the fluorescent lamp FL1 becomes equivalent to the resistance so that the AC component is eliminated. The elimination of the AC component is detected by the AC voltage-detecting element 55. In other words, the control mode is switched from the control based on the disregard level to the control of the lamp voltage based on the disregard level for full-intensity lighting, wherein the base of the transistor Q33 is controlled by the disregard level to control the gate voltage of the field-effect transistor Q22, thereby changing the apparent combined capacity of the condenser C21 and the condense, C32 to control the output from the inverter circuit 36_1.

[0107] In the dimming mode, the transistor Q27 is in the 'off' state so that the disregard level for the dimming mode is effective. As the disregard level for the dimming mode is higher than the disregard level for the full-intensity lighting mode, the former is given the priority in control of the base of the transistor Q33. Therefore, based on said disregard level, the inverter circuit 36_1 is controlled by controlling the gate voltage of the field-effect transistor Q22 through the transistor Q33. At the initiation of the dimming mode, the increase in the disregard level is lagged due to the discharge from the condense, C39. Therefore, after glow discharge, the dimming mode can be initiated in the state where the output is sufficiently high.

[0108] Next, the state where the FL1 is close to the end of its life span is explained hereunder.

[0109] Normally, when the fluorescent lamp FL1 is on, there is virtually no difference in electrical potential between the first DC voltage-detecting element 56 and the second DC voltage-detecting element 59, because the current flows in two directions with respect to the fluorescent lamp FL1. As both the transistor Q31 and Zener diode ZD13 are maintained in the 'off' state, the base current does not flow to the transistor Q29 so that the programmable unijunction transistor Q28, too, is maintained in the 'off' state.

[0110] When the fluorescent lamp FL1 comes close to the end of its life span, emission of electron from either the filament FL1a or the filament FL1b is reduced, which causes a half-wave discharge. Such a half-wave discharge produces a difference in electrical potential between the first DC voltage-detecting element 56 and the second DC voltage-detecting element 59, turning on the transistor Q31 and the Zener diode ZD13, so that the base current flows to the transistor Q29, thereby turning on the programmable unijunction transistor Q28. Therefore, the transistor Q31 is turned off due to the discontinuation of the base current, and the Zener diode ZD11 is turned on. As a result, the field-effect transistor Q24 is turned on so that the base current of the transistor Q11 is forced to by-pass the inverter circuit 36_1, thereby inactivating the inverter circuit 36_1 to protect the transistor Q11 and other elements from the stress.

[0111] Although the discharge lamps of all the embodiments described above are comprised of annular fluorescent lamps, straight tube lamps having any desired lamp powers may be used. Accordingly, the main body of any type, including a ceiling light adapted to be directly mounted on a ceiling and a pendant type, may be used.

[0112] The inverter circuits are not limited to be of a 1-crystal type; they may be of a 2-crystal half-bridge type, a 4-crystal full-bridge type or any other appropriate types, as long as they serve to light the respective fluorescent lamps at high frequencies and are capable of changing high-frequency outputs. It is sufficient that the inverter circuits are capable of causing microdischarge, such as glow discharge, from the corresponding fluorescent lamps at the beginning of a lighting process.

[0113] Furthermore, the disregard levels may respectively be set at desired levels by means of series connection or parallel connection of resistors, Zener diodes or other relevant elements.

INDUSTRIAL APPLICABILITY

[0114] As described above, the present invention is applicable to a discharge lamp lighting equipment for lighting discharge lamps having filaments that need to be preheated.

Claims

1. A discharge lamp lighting equipment including:

   a discharge lamp lighting means for lighting a discharge lamp having filaments;
   a discharge detecting means for detecting a discharge from said discharge lamp; and
   a control means adapted to cause the filaments to be preheated by reducing the output from said discharge lamp lighting means when the discharge detecting means has detected a discharge.

2. A discharge lamp lighting equipment as claimed in claim 1, wherein the discharge detecting means is not connected to said discharge lamp lighting means via direct current.

3. A discharge lamp lighting equipment as claimed in claim 1 or claim 2, wherein the discharge lamp lighting means is adapted to preheat the filaments in such a manner as to maintain generation of microdischarge in the discharge lamp.

4. A discharge lamp lighting equipment of which the discharge detecting means is provided with a filter for removing the lighting frequency at which the discharge lamp is lit.

5. A discharge lamp lighting equipment including:

   an output-variable inverter circuit having a switching element for performing a switching function, said inverter circuit adapted to apply voltage to and between a pair of filaments of a discharge lamp which has a tube diameter of not more than 21 mm and is provided with said filaments and phosphor;
   an inverter control circuit for changing the output from said inverter circuit by controlling the switching function of said switching element;
   and a start-up control circuit having a discharge detecting means for detecting a discharge from said discharge lamp, the start-up control circuit adapted to cause said inverter control circuit to function such that:
   discharge breakdown voltage is applied between the filaments of the discharge lamp throughout a given period of preheating, thereby generating a glow discharge from the lamp;
   secondary lamp voltage for shifting the mode of discharge to the arc discharge mode is applied between the filaments of said discharge lamp when said preheating period has elapsed; and
   the voltage between the filaments of the discharge lamp is reduced when the discharge is detected by said discharge detecting means.

6. A discharge lamp lighting equipment as claimed in claim 5, wherein:

   the inverter circuit includes a DC interrupting line and a DC output line, the DC interrupting line connected to one of the two filaments of the discharge lamp via a DC interruption condenser for removing the DC component from the current, and the DC output line connected to the other filament and adapted to pass the current without interrupting a DC component; and

the discharge detecting means is provided with a DC voltage-detecting element for detecting a DC voltage on the DC interrupting line so that the output from the discharge detecting means is controlled based on the value of the voltage on the DC interrupting line detected by the DC voltage-detecting element.

7. A discharge lamp lighting equipment as claimed in claim 6, wherein:

the inverter circuit includes a DC interrupting line and a DC output line, the DC interrupting line connected to one of the two filaments of the discharge lamp via a DC interruption condenser for removing the DC component from the current, and the DC output line connected to the other filament and adapted to pass the current without interrupting a DC component; and

the discharge detecting means is provided with a first DC voltage-detecting element for detecting the DC voltage on the DC interrupting line and a second DC voltage-detecting element for detecting the DC voltage on the DC output line so that the output from the discharge detecting means is controlled based on a difference between the voltage on the first DC voltage-detecting element and the voltage on the second DC voltage-detecting element.

8. A discharge lamp lighting equipment as claimed in claim 7, wherein:

the inverter circuit includes a DC interrupting line and a DC output line, the DC interrupting line connected to one of the two filaments of the discharge lamp via a DC interruption condenser for removing the DC component from the current, and the DC output line connected to the other filament and adapted to pass the current without interrupting a DC component; and

the discharge detecting means is provided with a AC voltage-detecting element for detecting the AC voltage on the DC interrupting line and is adapted to output, in order to control the secondary voltage on the lamp, the amount detected by the AC voltage-detecting element, said detected amount corresponding to the voltage on the DC interrupting line.

9. A discharge lamp lighting equipment as claimed in claim 8, wherein the DC voltage-detecting element of the discharge detecting means is provided with a DC voltage-detecting element adapted to function in the full-intensity illumination mode and a DC voltage-detecting element adapted to function in the dimming mode, said DC voltage-detecting elements having different disregard levels.

10. A discharge lamp lighting equipment as claimed in claim 9, wherein:

the DC voltage-detecting element for the full-intensity illumination mode includes a disregard level switching means adapted to change disregard levels depending on whether the current mode is the preheating mode or the full-intensity illumination mode; and

the respective disregard levels in the preheating mode, the dimming mode and the full-intensity illumination mode are smaller in the indicated order, i.e. the disregard level in the preheating mode > the disregard level in the dimming mode > the disregard level in the full-intensity illumination mode.

11. A discharge lamp lighting equipment as claimed in claim 10, wherein the discharge detecting means includes a current detecting element for detecting a lump current, and is adapted to output a signal from the current detecting element to the start-up control circuit upon detection of a lamp current.

12. A discharge lamp lighting equipment as claimed in claim 5, wherein:

the inverter circuit includes a DC interrupting line and a DC output line, the DC interrupting line connected to one of the two filaments of the discharge lamp via a DC interruption condenser for removing the DC component from the current, and the DC output line connected to the other filament and adapted to pass the current without interrupting a DC component; and

the discharge lamp lighting equipment further includes:

a life-end detecting circuit which is provided with a first DC voltage-detecting element connected to the DC interrupting line and a second DC voltage-detecting element connected to the DC output line, the life-end detecting circuit being adapted to output a signal representing a detected amount corresponding to the difference between the voltage on the first DC voltage-detecting element and the voltage on the second DC voltage-detecting element; and

an oscillation stopping circuit adapted to stop the switching action of the switching element of the inverter circuit based on a stop signal output from the life-end detecting circuit.

13. A discharge lamp lighting equipment as claimed in claim 5, wherein:

a plurality of inverter circuits respectively corresponding to a plurality of discharge lamps are installed, said discharge lamps having an identical lighting frequency and different lamp powers; and
the discharge lamp lighting equipment further includes:
a source power input circuit which has a full-wave rectifying circuit for performing full-wave rectification of the AC supply voltage having a low frequency, the source power input circuit so connected as to be shared by the inverter circuits that correspond to said different lamp powers; and
a plurality of low-distortion circuits connected so as to respectively form the sections located in front of said inverter circuits, each low-distortion circuit including:
a first condenser that has such a capacity as to not present a smoothing effect with respect to a low frequency voltage,
a second condenser having a capacity greater than that of the first condenser and connected to a point closer to the source power input circuit than is the first condenser,
a rectifying diode which is connected to a point between the first condenser and the second condenser and adapted to switch the cathode, which is located at the side connected to the first condenser, by means of a high-frequency current resulting from the reactive power to be recycled to the input side, and
a series circuit consisting of a smoothing condenser and an inductor element and connected in parallel with the first condenser.

14. A discharge lamp lighting equipment as claimed in claim 5, wherein:

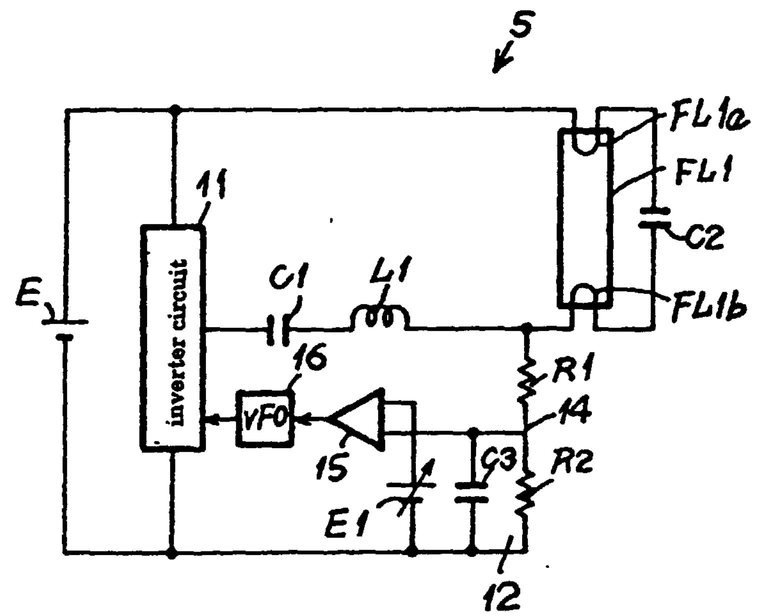
a plurality of inverter circuits respectively corresponding to a plurality of discharge lamps are installed, said discharge lamps having an identical lighting frequency and different lamp powers; and
the discharge lamp lighting equipment further includes:
a source power input circuit which has a full-wave rectifying circuit for performing full-wave rectification of the AC supply voltage having a low frequency, the source power input circuit so connected as to be shared by the inverter circuits that correspond to said different lamp powers;
a plurality of low-distortion circuits connected so as to respectively form the sections located in front of said inverter circuits, each low-distortion circuit including:
a first condenser that has such a capacity as to not present a smoothing effect with respect to a low frequency voltage,
a second condenser having a capacity greater than that of the first condenser and connected to a point closer to the source power input circuit than is the first condenser,
a rectifying diode which is connected to a point between the first condenser and the second condenser and adapted to switch the cathode, which is located at the side connected to the first condenser, by means of a high-frequency current resulting from the reactive power to be recycled to the input side, and
a series circuit consisting of a smoothing condenser and an inductor element and connected in parallel with the first condenser;
a circuit base on which said inverter circuits are mounted in such a state as to be separated into blocks; and
heat sinking plates which are mounted on said circuit base together with the switching elements of the inverter circuits, each heat sinking plate disposed at such a position as to bridge two of said blocks.

15. An illuminating system including:

a discharge lamp lighting equipment as claimed in any one of the claims from claim 1 through claim 14, and
a main body, to which said discharge lamp lighting equipment is attached.

16. An illuminating system as claimed in claim 15, wherein:

the discharge lamp lighting equipment is a discharge lamp lighting equipment as claimed in any one of the claims from claim 1 through claim 14;
the discharge lamps of the illuminating system consist of a plurality of annular fluorescent lamps which have different outer ring diameters and adapted to be respectively energized by the inverter circuits, each lamp formed of a tube having a diameter of not more than 21mm; and
the main body of the illuminating system is in the shape of a disk and supports the fluorescent lamps in such a state that they are concentrically arranged.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FL1
C2
FL1b
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E
C1
L1
16
VFO
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14
15
C3
R2
E1
12

Fig. 1

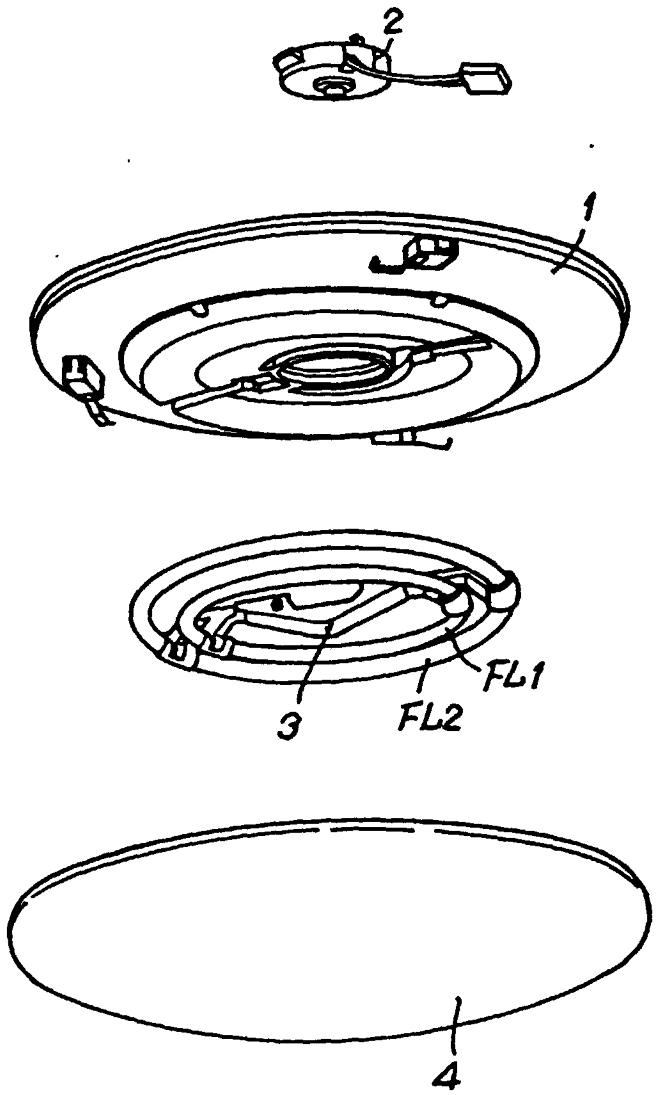
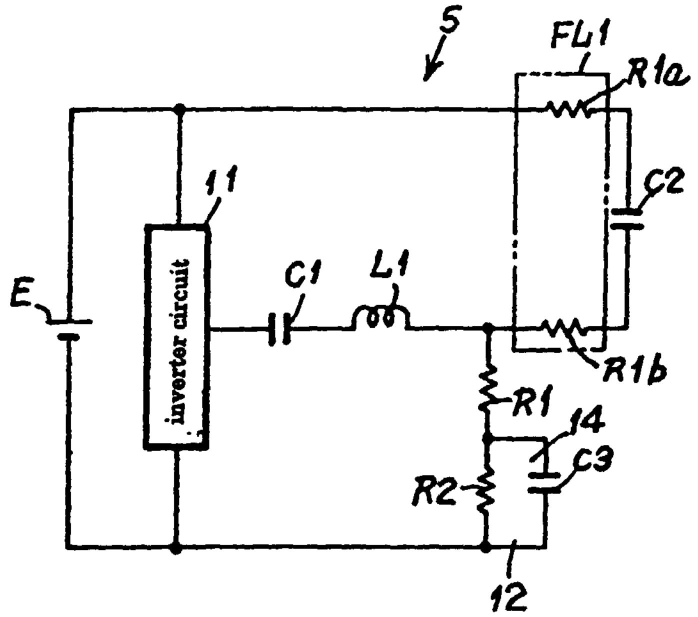


Fig. 2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C2
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inverter circuit
C1
L1
R1b
R1
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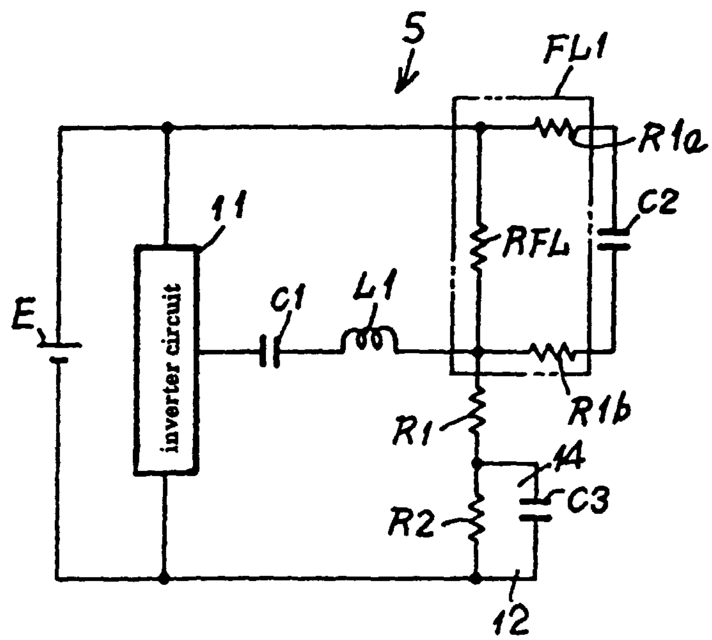
C3
R2
12

Fig. 3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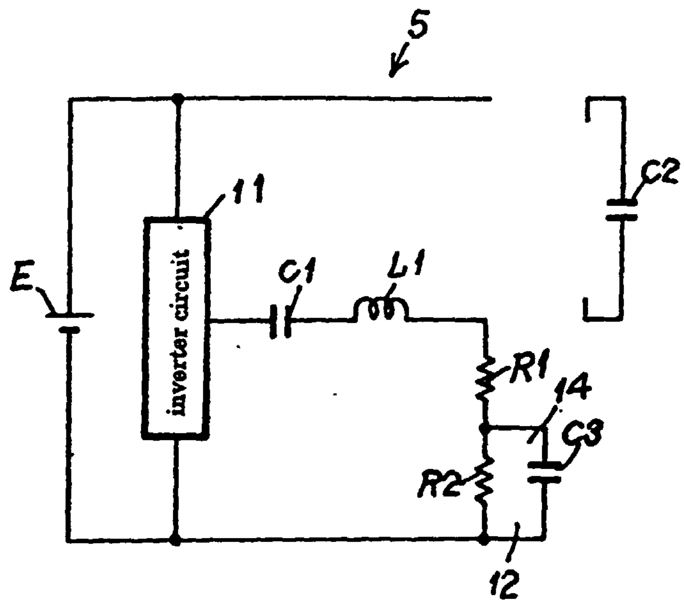
E
inverter circuit
C1
L1
R1b
R1
14
C3
R2
12

Fig. 4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inverter circuit
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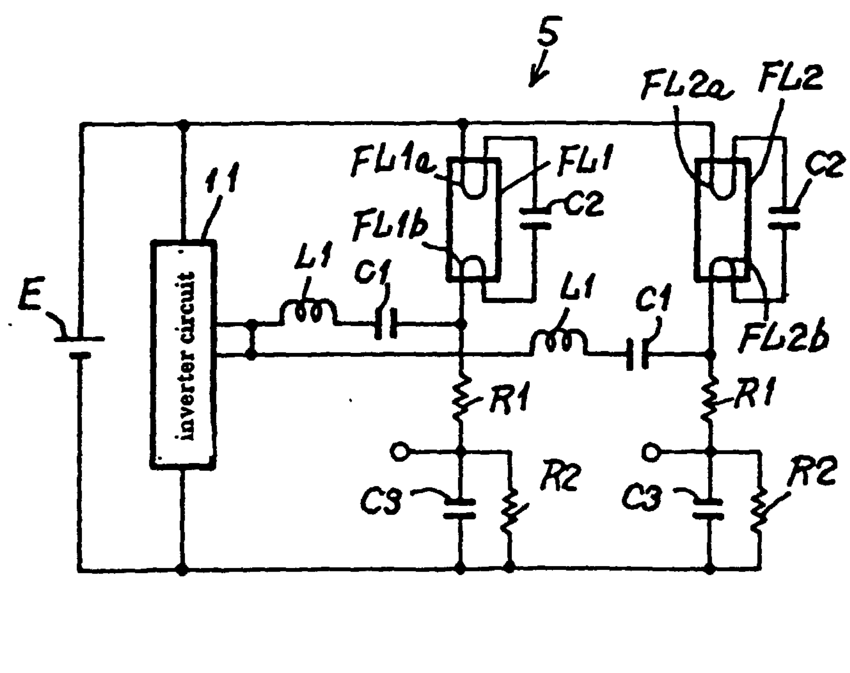
L1
C2
R1
14
C3
R2
12

Fig. 5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FL2
FL1a
FL1
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C2
FL1b
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L1
C1
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R1
R1
C3
R2
C3
R2

Fig. 6

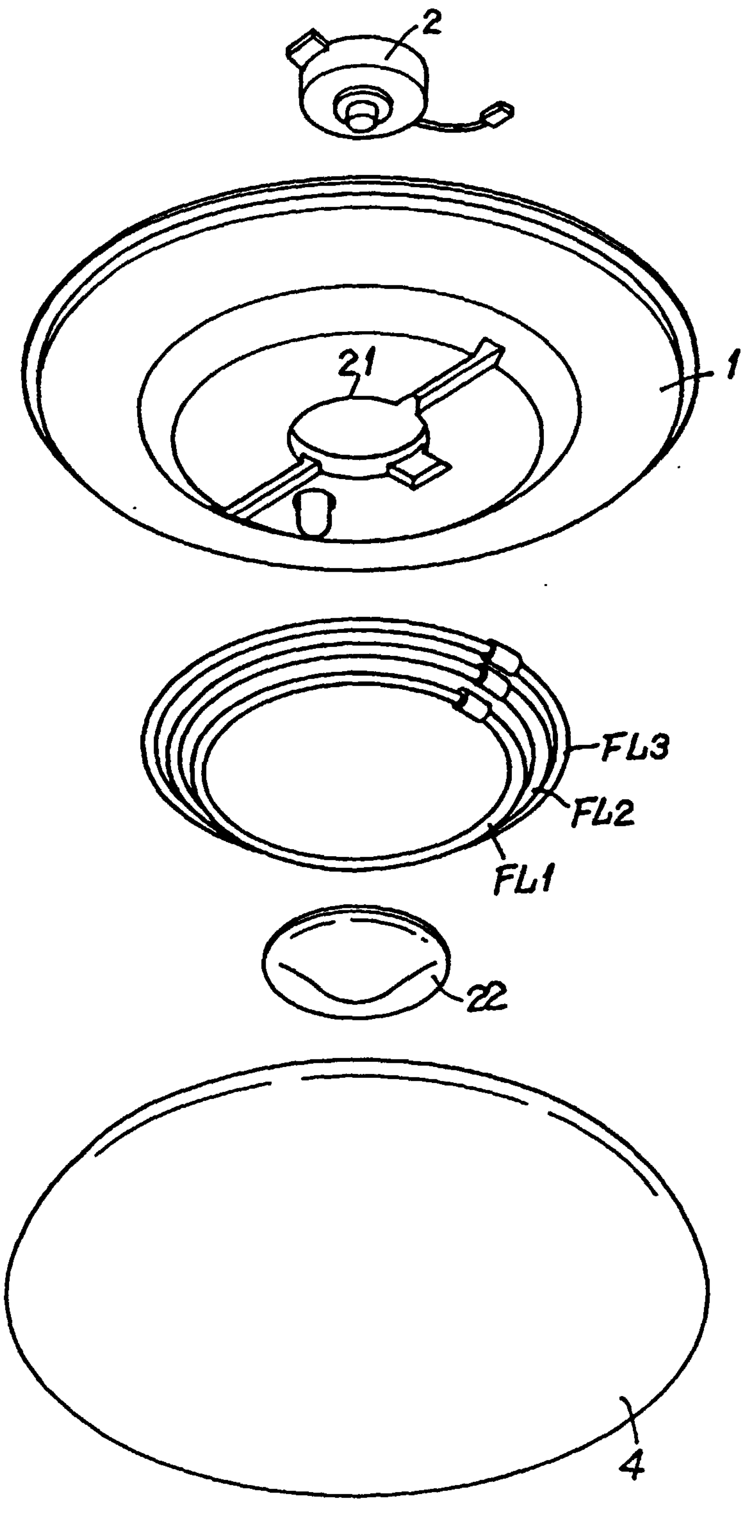
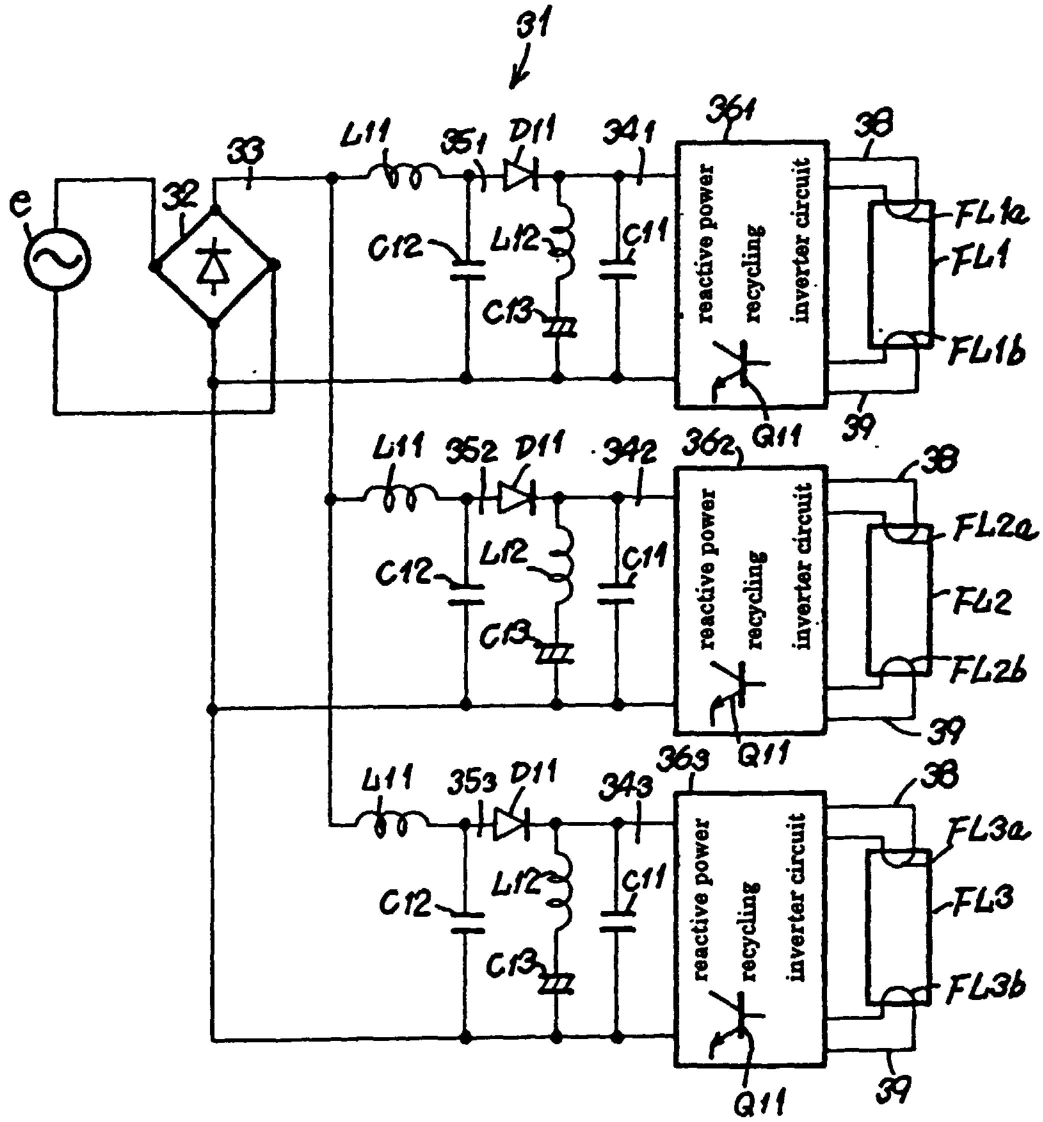


Fig. 7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C11
C13
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recycling
inverter circuit
Q11
39
L11
352
D11
342
362
38
FL2a
FL2
FL2b
C12
L12
C11
C13
reactive power
recycling
inverter circuit
Q11
39
L11
353
D11
343
363
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FL3b
C12
L12
C11
C13
reactive power
recycling
inverter circuit
Q11
39

Fig. 8

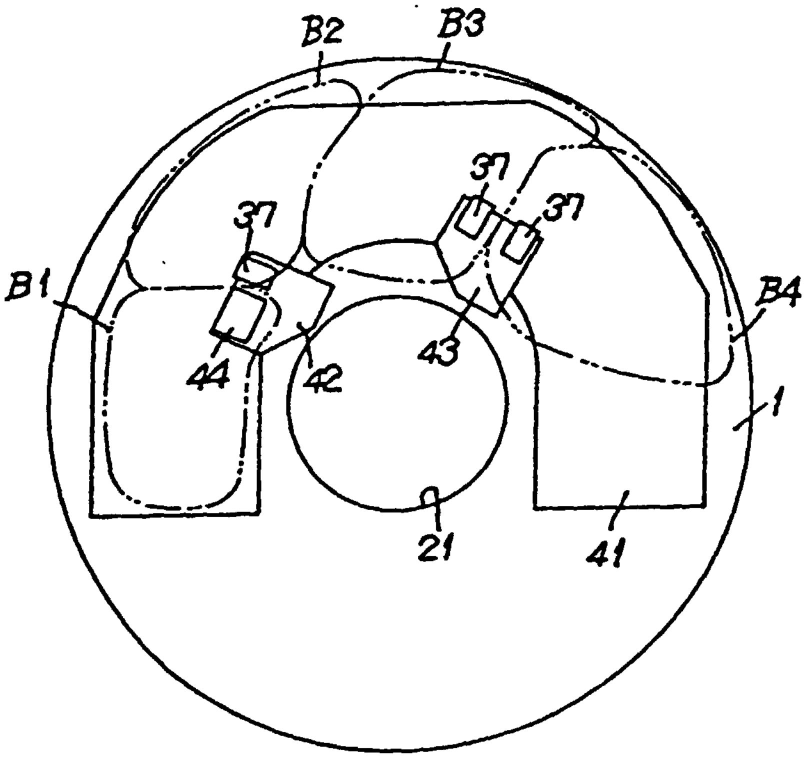
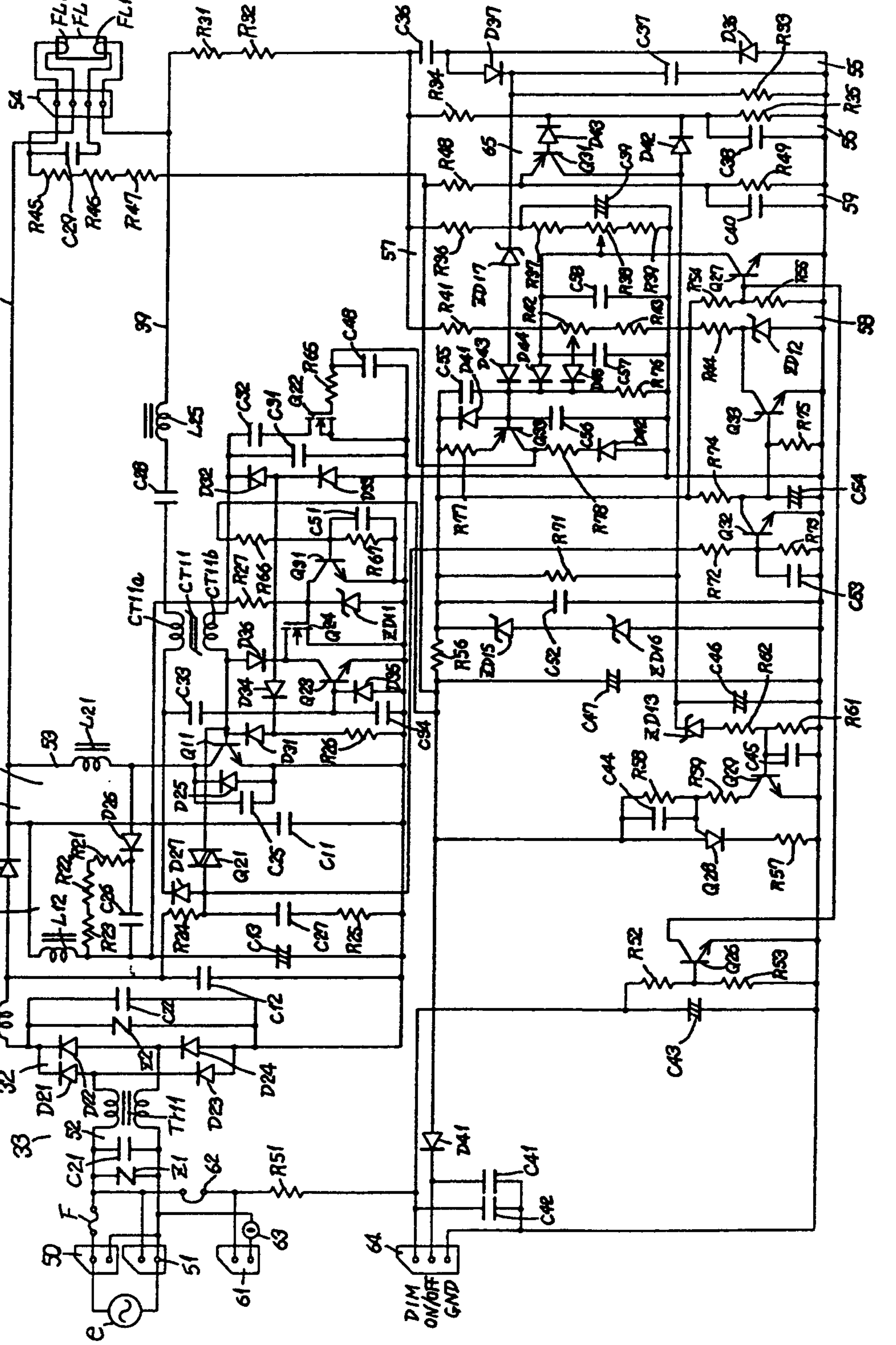


Fig. 9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FL1
FL1b
54
R31
R32
C36
D37
C37
D38
R33
55
R34
R35
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R49
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C38
C40
57
65
D43
Q31
D42
C39
R45
C29
R46
R47
33
39
L25
C32
C31
Q22
R65
C48
C28
D32
D33
CT11a
CT11
CT11b
R27
R66
C51
R67
Q31
Q24
ZD1
D36
D34
Q23
D35
C33
C34
Q11
D31
R26
L21
53
361
341
D26
D11
351
L12
R22
R21
R23
C26
D27
Q21
D25
C25
C11
R24
C13
C27
R25
L11
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C12
32
D21
D22
D23
D24
Z2
T11
C21
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Z1
62
R51
F
50
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63
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D41
C41
C42
C43
R52
Q25
R53
Q28
R57
C44
R58
R59
Q29
C45
R61
ZD13
C46
R62
C47
ZD15
ZD16
C52
R56
R71
R72
Q32
R73
C53
C54
R74
R75
Q33
ZD12
R44
R77
R78
C55
C56
C57
D41
D44
R76
R41
R36
ZD17
R37
R38
R39
R42
R43
C58
R54
Q27
R55
58

Fig. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP98/00840

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl⁶ H05B41/24, H05B41/38

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

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
Int.Cl⁶ H05B41/14-41/29, H05B41/38-41/42, F21V23/00, F21V29/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1940-1996	Toroku Jitsuyo Shinan Koho	1994-1998
Kokai Jitsuyo Shinan Koho	1971-1998	Jitsuyo Shinan Toroku Koho	1996-1998

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP, 7-65970, A (Matsushita Electric Works, Ltd.), March 10, 1995 (10. 03. 95) (Family: none)	1-16
A	JP, 5-144583, A (Matsushita Electric Works, Ltd.), June 11, 1993 (11. 06. 93) (Family: none)	1-16
A	JP, 4-126397, A (Toshiba Lighting & Technology Corp.), April 27, 1992 (27. 04. 92) (Family: none)	1-16
A	JP, 4-141993, A (Toshiba Lighting & Technology Corp.), May 15, 1992 (15. 05. 92) (Family: none)	1-16
A	JP, 62-200688, A (Matsushita Electric Works, Ltd.), September 4, 1987 (04. 09. 87) (Family: none)	12
A	JP, 1-289097, A (Matsushita Electric Works, Ltd.), November 21, 1989 (21. 11. 89) (Family: none)	12

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:
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"P" document published prior to the international filing date but later than the priority date claimed
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
May 13, 1998 (13. 05. 98)	May 26, 1998 (26. 05. 98)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP98/00840

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	JP, 1-252175, A (Toshiba Denzai K.K., Tokyo Electric Co., Ltd.), October 6, 1989 (06. 10. 89) (Family: none)	13-16
A	JP, 5-74588, A (Tokyo Electric Co., Ltd.), March 26, 1993 (26. 03. 93) (Family: none)	13-16
A	JP, 8-17583, A (Matsushita Electric Industrial Co., Ltd.), January 19, 1996 (19. 01. 96) (Family: none)	13-16
A	JP, 3-219595, A (Tokyo Electric Co., Ltd.), September 26, 1991 (26. 09. 91) & EP, 439122, A2 & KR, 9500802, B1	14, 15
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 112440/1989 (Laid-open No. 53798/1991) (Matsushita Elèctric Works, Ltd.), May 24, 1991 (24. 05. 91) (Family: none)	16

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