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(54) ELECTRODELESS FLUORESCENT LAMP AND ITS OPERATING DEVICE

(57) In an electrodeless fluorescent lamp, even when it is lighted in a state that a temperature in a bulb is not increased sufficiently such as in use in a cool-temperature environment or in dimming lighting, deterioration of light output of the electrodeless fluorescent lamp due to insufficiency of mercury on a surface of an amalgam which is to be supplied to a discharge space is prevented. Therefore, a metal container (7) is disposed inside an induction coil (13). A high frequency current on which a current for induction heating is superimposed is applied to the induction coil (13) so that the metal container (7) is heated with induction heating, and thereby, the amalgam therein is heated. The heated amalgam becomes a mixture of liquid-phase and solid-phase, and thus, an amount of mercury enough for supplying it into a discharge space inside the bulb can be maintained on the surface of the amalgam.

FIG. 1A

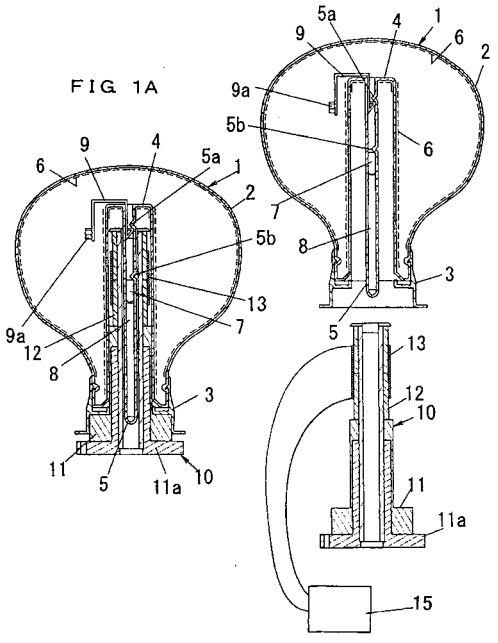

FIG. 1B

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Description

Technical Field

[0001] The present invention relates to an electrodeless fluorescent lamp and a lighting apparatus thereof.

Background Art

[0002] In an electrodeless fluorescent lamp, no electrode is provided in a bulb which is made of a glass, so that non-lighting due to blowout of electrode or erosion of emitter (thermo-electronic emission material) may not occur, and thereby, it has a characteristic of longer operating life in comparison with a general fluorescent lamp in which a pair of electrodes is arranged in a glass tube.

[0003] A constitution of a conventional electrodeless fluorescent lamp which is, for example, shown in Japanese Laid-Open Patent Publication No. 7-272688 is shown in FIG. 3. This electrodeless fluorescent lamp has a bulb 20 formed of a transparent material such as a glass, and into which a rare gas and a metal (for example, mercury) that can be vaporized are filled. An outer shape of the bulb 20 is a rotation symmetric body of substantially spherical, and a cavity 21 of substantially cylindrical shape is formed around an axis of the rotation symmetry. A power coupler unit 27, in which an induction coil 24 is wound around an outer periphery of a rod shaped core 23, is fitted to the cavity 21. Furthermore, a fluorescent material film 22 is formed on an inner wall of the bulb 20.

[0004] A high frequency electromagnetic field occurs in the bulb 20 by applying a high frequency current to the induction coil 24 from a high frequency power source 25 through cables 26, so that rare gas filled in the bulb 20 discharges electricity due to the high frequency electromagnetic field. The bulb 20 is heated by the electric discharge, and thereby mercury is evaporated (vaporized), and mercury vapor is further excited in a discharge space of the bulb 20, so that ultra-violet rays are emitted. Ultraviolet rays are further converted to visible lights with the fluorescent material film 22 formed on the inner wall of the bulb 20.

[0005] By the way, in the above mentioned electrodeless fluorescent lamp, an amalgam comprised of an alloy of a base substance metal and mercury is enclosed in the bulb for a purpose of getting stable quantity of light in a broad temperature environment. Mercury vapor pressure in the discharge space is controlled with saturated vapor pressure at a temperature of a point where the amalgam is disposed. If the temperature of the base substance metal is constant, mercury vapor pressure in the discharge space does not vary. However, there are going out and coming in of mercury on a surface of the amalgam even in the saturated state, so that evaporation and liquefaction of mercury are repeated. Thus, when the electrodeless fluorescent lamp has been lighted for a long time, mercury included in the amalgam is consumed, and an amount of mercury corresponding to the consumption is evaporated from the surface of the amalgam and supplied to the discharge space. Hereupon, a quantity of the amalgam enclosed in the bulb is generally several tens to several hundreds mg, and a rate of content of mercury is several %. In contrast, since an amount of mercury necessary for maintaining the mercury vapor pressure in the discharge space is several _g, there is enough amount of mercury for consumption.

[0006] However, when the electrodeless fluorescent lamp is lighted under a state where the temperature in the bulb is not sufficiently increased such as for use in cool-temperature environment or in dimming lighting, or when the amalgam is enclosed at a position where the temperature is lower in the bulb, the temperature of the amalgam may be lower and the amalgam may be in solid-phase even though the electrodeless fluorescent lamp is lighted. When the electrodeless fluorescent lamp has been lighted continuously under such condition for a long time, mercury may evaporate from the surface of the amalgam to be supplied as mercury consumed in the discharge space. However, since the amalgam is in solid-phase, diffusion of mercury is slower, and suppliance of mercury from inside to surface of the amalgam needs long time. Thus, mercury on the surface of the amalgam which is to be supplied to the discharge space becomes insufficient, and output of light of the electrodeless fluorescent lamp may be deteriorated.

Disclosure of Invention

[0007] A purpose of the present invention is to solve the above-mentioned problem and to provide an electrodeless fluorescent lamp and a lighting apparatus thereof with which enough quantity of metal vapor can be supplied to a discharge space in a bulb from an amalgam, even when the electrodeless fluorescent lamp is lighted in a state where the temperature in the bulb is not increased sufficiently such as for use in cool-temperature environment or in dimming lighting.

[0008] An electrodeless fluorescent lamp in accordance with an aspect of the present invention is characterized by comprising:

a bulb formed of a transparent material, into which a rare gas and a metal which can be vaporized are filled, and having a cavity protruding inward;

a tubular shaped portion formed in the cavity that an inside thereof is communicated to an inside of the bulb;

a fluorescent material film formed on an inner wall of the bulb;

an induction coil wound around a periphery of the tubular portion along an axial direction and contained in the cavity;

an amalgam containing the metal and disposed in the tubular portion; and

a heating means for heating the amalgam so that the amalgam becomes a mixture of liquid-phase and

solid-phase in a state where electric discharge occurs in a discharge space in the bulb.

[0009] According to such a constitution, even when the electrodeless fluorescent lamp is lighted under the state where the temperature in the bulb is not increased sufficiently such as for use in cool-temperature environment or in dimming lighting, the amalgam becomes the mixture of liquid-phase and solid-phase because the amalgam is heated, so that mercury can be evaporated from a surface of the amalgam and enough amount of mercury can be supplied to the discharge space in the bulb. Consequently, deterioration of light output of the electrodeless fluorescent lamp due to insufficiency of mercury on the surface of the amalgam which is to be supplied to the discharge space can be prevented.

Brief Description of Drawings

[0010]

FIG. 1A is a sectional view showing a constitution of an electrodeless fluorescent lamp in accordance with an embodiment of the present invention, and FIG. 1B is a sectional view showing a state where a lamp unit and a power coupler unit of it are departed.

FIG. 2 is a sectional view showing a constitution of a main portion of the electrodeless fluorescent lamp in accordance with the above embodiment.

FIG. 3 is a sectional view showing a constitution of a conventional electrodeless fluorescent lamp.

Best Mode for Carrying Out the Invention

[0011] An electrodeless fluorescent lamp and a lighting apparatus thereof in accordance with an embodiment of the present invention are described with reference to drawing. In the electrodeless fluorescent lamp and the lighting apparatus thereof, an amalgam is heated to be mixture of liquid-phase and solid-phase even when the electrodeless fluorescent lamp is lighted under a state where a temperature in a bulb is not increased sufficiently such as for use in cool-temperature environment or in dimming lighting, so that deterioration of light output of the electrodeless fluorescent lamp is prevented with evaporation of mercury from a surface of the amalgam and suppliance of enough amount of mercury to a discharge space in the bulb, as mentioned above.

[0012] As shown in FIG. 1A and FIG. 1B, the electrodeless fluorescent lamp in accordance with this embodiment is constituted by a lamp unit 1 and a power coupler unit 10, and the lamp unit 1 is detachably attached to the power coupler unit 10. The lamp unit 1 has a bulb 2 formed of a transparent material such as a glass, and a ferule 3 of a substantially tubular shape fixed on a neck portion of the bulb 2.

[0013] An outer shape of the bulb 2 is rotation symmetry of a substantially spherical shape, and a cavity 4 of a tubular shape having a bottom is formed around an axis of the rotation symmetry. Specifically, a tubular shaped body serving as the cavity 4 is adhered to a substantially spherical shaped body which is formed to be opened at a bottom of a neck portion, so as to close the bottom of the neck portion and to protrude inwardly toward the inside of the bulb 2. A ventilation pipe 5 is further adhered on the bottom of the tubular shaped body so as to be coaxial with the center axis of the tubular shaped body. The inside of the bulb 2 is communicated with an exterior through the ventilation pipe 5, so that air in the inside of the bulb 2 is exhausted and a rare gas (for example, argon gas) is filled into the inside of the bulb 2 through the ventilation pipe 5. A fluorescent material film 6 is formed on inner peripheral faces of the bulb 2 (an inner peripheral surface of the substantially spherical shaped body and an outer peripheral surface of the substantially cylindrical shaped body (SIC)) with spreading a fluorescent material. Then, the inside of the bulb 2 serves as a discharge space.

[0014] Lower end portion of the ventilation pipe 5 is drawn outward from the bottom of the neck portion of the bulb 2. After exhausting air from and filling the rare gas into the bulb 2 as mentioned above, a metal container 7 containing the amalgam and a glass rod 8 are put into the inside of the ventilation pipe 5, and the lower end thereof is sealed under such state. Thereby, the bulb 2 is air-tightly sealed. Furthermore, protrusions 5a and 5b respectively protruding inward are formed at upper and middle portions of the exhausting pipe 5, and the metal container 7 is held between the protrusion 5b at the middle portion and the rod 8.

[0015] Material of the ventilation pipe 5 is not limited in particular, it, however, is preferable to be formed of a material, which has a higher thermal conductivity than that of a glass, such as a metal or a ceramic (for example, aluminum oxide, aluminum nitride, boron nitride, silicon carbide, silicon nitride, beryllium oxide). Thereby, heat generation of an induction coil 13 or heat generation due to electric discharge can be conducted to the metal container 7 effectively, and thus, the amalgam in the metal container 7 can be heated. In case of metal ventilation pipe 5, the coefficient of thermal expansion of the metal should be coincided with that of a glass of the tubular shaped body forming the cavity 4, and the pipe should be adhered on the bottom face of the tubular shaped body with heat welding. Alternatively, in case of ceramic ventilation pipe 5, it should be joined on the bottom face of the tubular shaped body with frit of low-melting glass.

[0016] The metal container 7 is formed in a shape of capsule inside of which is hollowed, and through-holes (not illustrated) are formed on a side face thereof. The amalgam is contained in the inside of the metal container 7, and mercury goes out from and comes into a surface of the amalgam through the through-holes. The amalgam

contains mercury at component proportion of 3.5% to base substance metal consisting of an alloying with, for example, bismuth and indium.

[0017] An end portion of a supporting member 9, which is formed in a shape of substantially horse shoe shape with square corners, is engaged with the protrusion 5a formed at the upper portion of the ventilation pipe 5. A flag 9a, to which a metallic compound (for example, hydration cesium) having a small work function is applied, is fixed at another end portion of the supporting member 9 drawn from the ventilation pipe 5 toward the inside space of the bulb 2. The metallic compound applied to the flag 9a bears a function for increasing a number of electrons at starting up of the electrodeless fluorescent lamp.

[0018] The power coupler unit 10 comprises a heat radiation cylinder 11 of substantially cylindrical shape and having an outward flange portion 11a formed at a lower end thereof, a cylindrical ferrite core 12 fixed on an upper end face of the heat radiation cylinder 11, and the induction coil 13 wound around an outer periphery of the ferrite core 12. Then, as shown in FIG. 1A, the power coupler unit 10 is attached to the lamp unit 1 in a manner so that the ventilation pipe 5 is inserted into an inside of the ferrite core 12, the heat radiation cylinder 11, the ferrite core 12 and the induction coil 13 of the power coupler unit 10 are fit into the cavity 4 of the lamp unit 1. In a state that the power coupler unit 10 is attached to the lamp unit 1, as shown in FIG. 2, the metal container 7 containing the amalgam is located between an upper end A and a bottom end B of the induction coil 13 inside the induction coil 13.

[0019] Since the metal container 7 containing the amalgam is located inside the induction coil 13 in the ventilation pipe 5, that is, in the vicinity of a position where electric discharge occurs in the inside space of the bulb 2, the amalgam contained in the metal container 7 is heated by heat generation of the induction coil 13 or heat generation due to electric discharge under a state that the induction coil 13 is energized, that is, in a state that the electrodeless fluorescent lamp is lighted. Therefore, the amalgam can easily become a mixture of liquid-phase and solid-phase. Thus, even when the electrodeless fluorescent lamp is lighted in a state that the temperature in the bulb is not increased sufficiently such as for use in cool-temperature environment or in dimming lighting, the temperature of the amalgam in the metal container 7 is increased during a relatively short time, and the amalgam becomes the mixture of liquid-phase and solid-phase, so that mercury can be evaporated from a surface of the amalgam for supplying mercury consumed in the discharge space.

[0020] The induction coil 13 of the power coupler unit 10 is connected to a lighting apparatus 15 which comprises a high frequency power source, and a high-frequency current (for example, a sinusoidal current of frequency 130 kHz) is applied to the induction coil 13 from the high frequency power source. Thereby, electric discharge occurs in the discharge space inside the bulb 2, and the electrodeless fluorescent lamp is lighted. In this embodiment, a high-frequency current for induction heating is superimposed on an output current of the high frequency power source with applying amplitude modulation of high frequency (for example, 500 kHz), according to need. According to the superimposed high frequency current, it is possible to heat the metal container 7 directly by induction heating with high frequency magnetic field generated in the induction coil 13. Therefore, even in the cool-temperature environment, the amalgam contained in the metal container 7 can be heated with induction heating of the metal container, so that the amalgam can become the mixture of liquid-phase and solid-phase, and can easily be maintained in such state. In particular, since the metal container 7 is located inside the induction coil 13, the induction heating can be performed effectively.

[0021] Since mercury is easily diffused in liquid-phase, it is possible to maintain enough amount of mercury on the surface of the amalgam for supplying mercury vapor to the discharge space. Consequently, even when the electrodeless fluorescent lamp is lighted under the state that the temperature in the bulb is not increased sufficiently such as for use in cool-temperature environment or in dimming lighting, mercury is evaporated from the surface of the amalgam for supplying consumed mercury in the discharge space, so that enough quantity of mercury is supplied to the discharge space. As a result, the light output of the electrodeless fluorescent lamp is not deteriorated.

[0022] Besides, with respect to the superposition of current for superimposing the high frequency current for induction heating on the output current of the high frequency power source with amplitude modulation, it can be realized with using a known modulation circuit, so that illustration and description of detailed constitution are omitted. Furthermore, although timing and term for superimposing the high frequency current for induction heating on the output current of the high frequency power source is mot limited in particular, it may be performed in, for example, a constant term from starting up of lighting of the electrodeless fluorescent lamp, or it may be performed when a detected temperature of a sensor is equal to or lower than a predetermined threshold with using the sensor such as a thermistor.

[0023] Still furthermore, the electrodeless fluorescent lamp in accordance with the present invention is not limited to the above mentioned embodiment. It is sufficient to comprise: a bulb formed of a transparent material, into which a rare gas and a metal which can be vaporized are filled, and having a cavity protruding inward; a tubular shaped portion formed in the cavity that an inside thereof is communicated to an inside of the bulb; a fluorescent material film formed on an inner wall of the bulb; an induction coil wound around a periphery of the tubular portion along an axial direction and contained in the cavity; an amalgam containing the metal and disposed in the tubular portion; and a heating means for heating the

amalgam so that the amalgam becomes a mixture of liquid-phase and solid-phase in a state where electric discharge occurs in a discharge space inside the bulb. Other shapes and constitutions are not limited in particular. Thereby, even when the electrodeless fluorescent lamp is lighted in a state that temperature in the bulb is not increased sufficiently such as for use in cool- temperature environment or in dimming lighting, the amalgam becomes a state of mixture of liquid-phase and solid-phase due to the amalgam is heated, so that mercury is evaporated from a surface of the amalgam and enough quantity of mercury is supplied to a discharge space inside the bulb. As a result, deterioration of light output of the electrodeless fluorescent lamp caused by insufficiency of mercury on the surface of the amalgam which is to be supplied to the discharge space can be prevented.

[0024] This application is based on Japan Patent Application No. 2004-000557, and contents of which should be consequently incorporated with the present invention with reference to the description and drawings of the above Patent Application.

[0025] Although the present invention has been fully described by way of example with reference to the accompanying drawings, it is to be understood that various changes and modifications will be apparent to those skilled in the art. Therefore, unless otherwise such changes and modifications depart from the scope of the present invention, they should be construed as being included therein.

Claims

1. An electrodeless fluorescent lamp comprising:

a bulb formed of a transparent material, into which a rare gas and a metal which can be vaporized are filled, and having a cavity protruding inward;
a tubular shaped portion formed in the cavity that an inside thereof is communicated to an inside of the bulb; a fluorescent material film formed on an inner wall of the bulb;
an induction coil wound around a periphery of the tubular portion along an axial direction and contained in the cavity;
an amalgam containing the metal and disposed in the tubular portion; and
a heating means for heating the amalgam so that the amalgam becomes a mixture of liquid-phase and solid-phase in a state where electric discharge occurs in a discharge space inside the bulb.

2. The electrodeless fluorescent lamp in accordance with claim 1, wherein the amalgam is located inside the induction coil, and the induction coil serves as a part of the heating means and heats the amalgam with heat generation thereof.

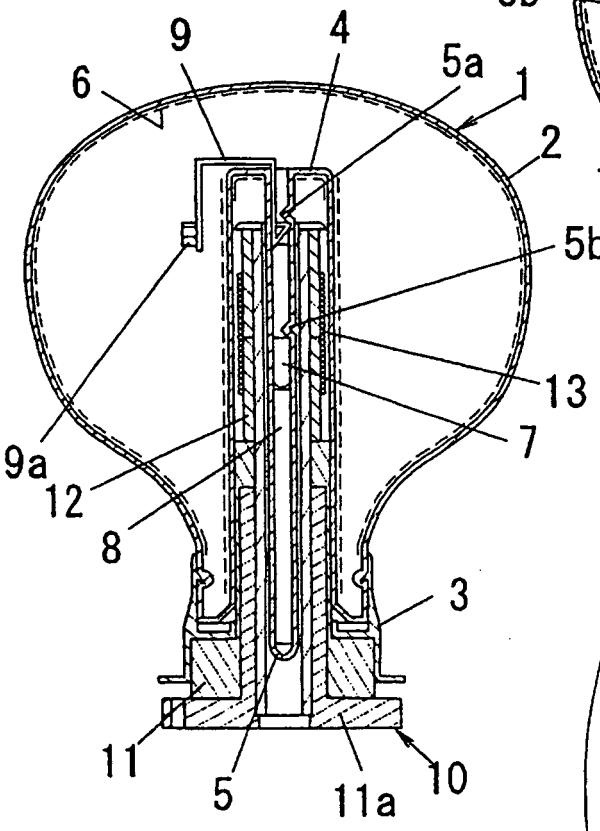
3. The electrodeless fluorescent lamp in accordance with claim 1, wherein the tubular shaped portion is formed of a material having higher heat-conductivity in comparison with that of a transparent material used for forming the bulb, serves as a part of the heating means so as to conduct heat generation of the induction coil or heat generation due to electric discharge to the amalgam effectively, and thereby to heat the amalgam.

4. The electrodeless fluorescent lamp in accordance with claim 3, wherein metal or ceramic is used as the material having higher heat-conductivity of the tubular shaped portion.

5. The electrodeless fluorescent lamp in accordance with claim 1, wherein the amalgam is contained in a metal container, the metal container is located inside the induction coil, and the metal container and the induction coil serve as a part of the heating means so as to heat the metal container with induction heating by applying high frequency current for induction heating to the induction coil with superimposing on high frequency current for discharging the rare gas in the inside of the bulb.

6. A lighting apparatus of electrodeless fluorescent lamp comprising a high frequency power source for generating a high frequency current and a current superimposing means for superimposing a current for induction heating on the high frequency current outputted from the high frequency power source, and thereby, a metal portion provided inside a bulb of the electrodeless fluorescent lamp is heated with induction heating by applying the current for induction heating to an induction coil of the electrodeless fluorescent lamp.

FIG 1A


6
9
4
5a
1
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5b
13
7
9a
12
8
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11
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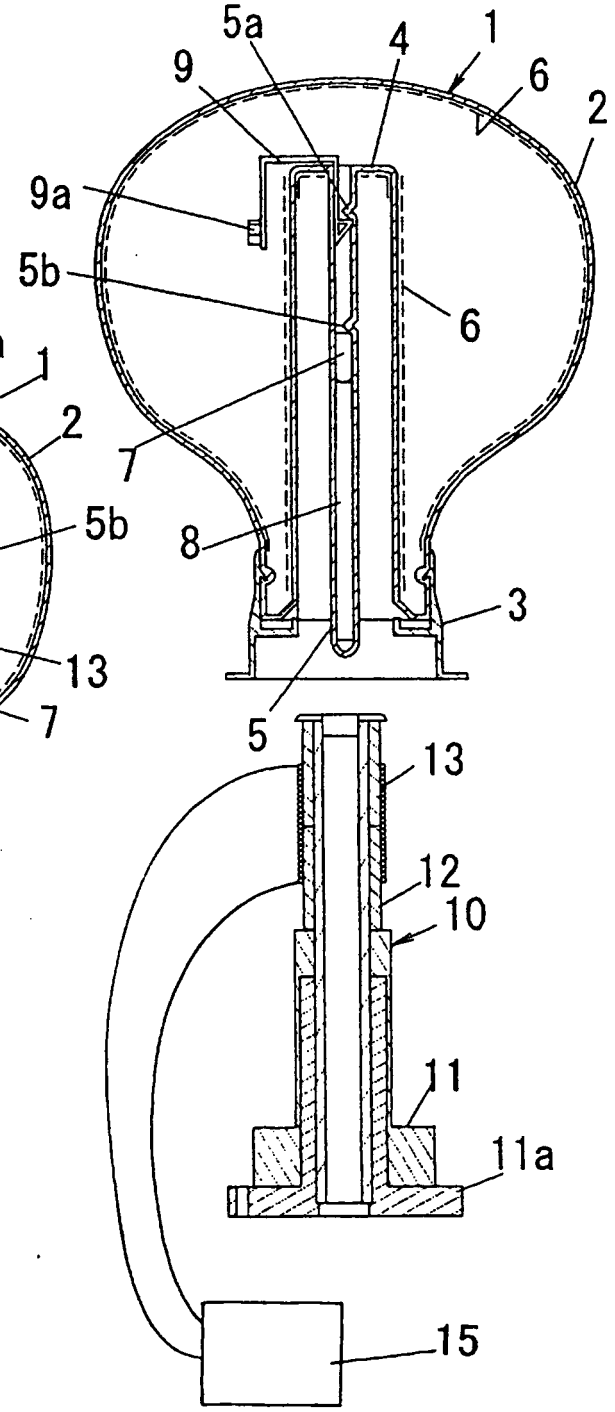
11a
10

FIG 1B


5a
4
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9a
5b
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FIG 2

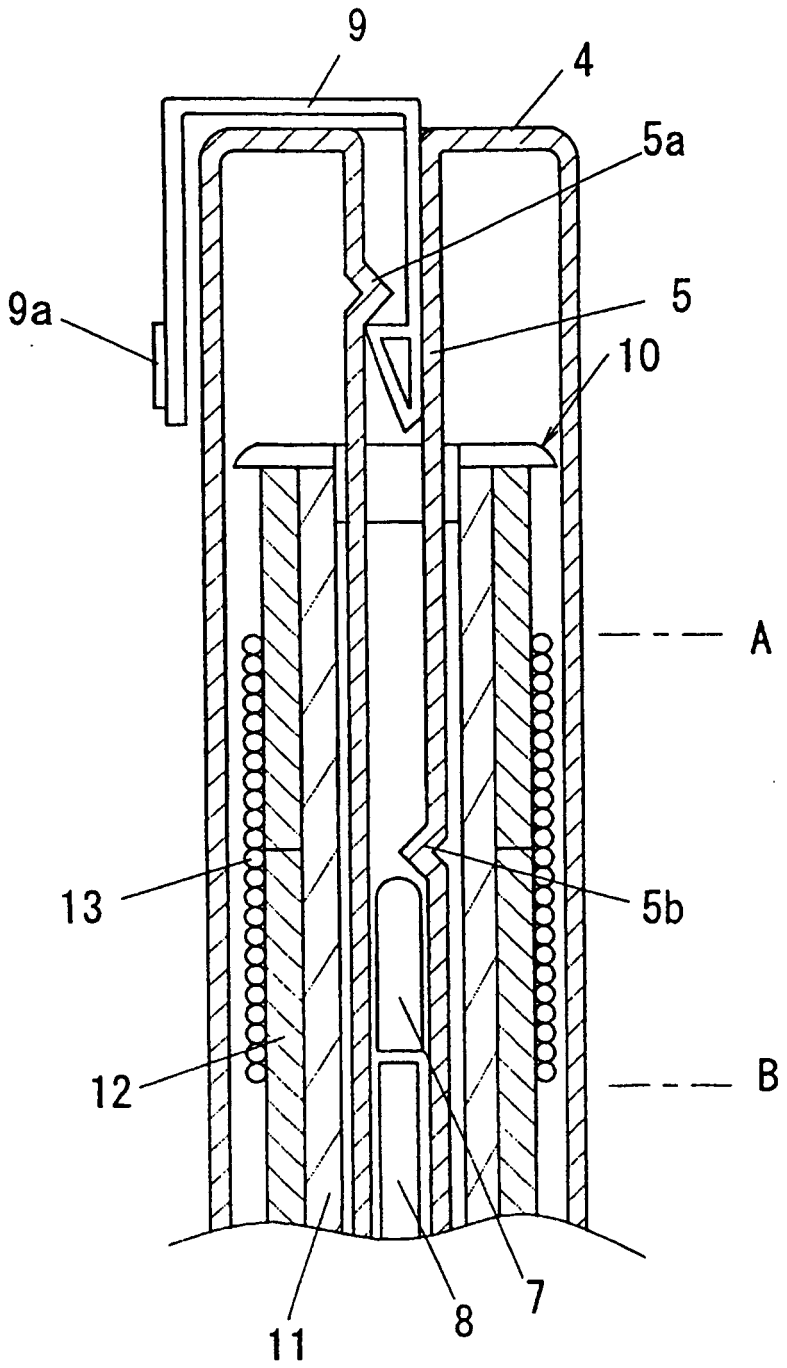
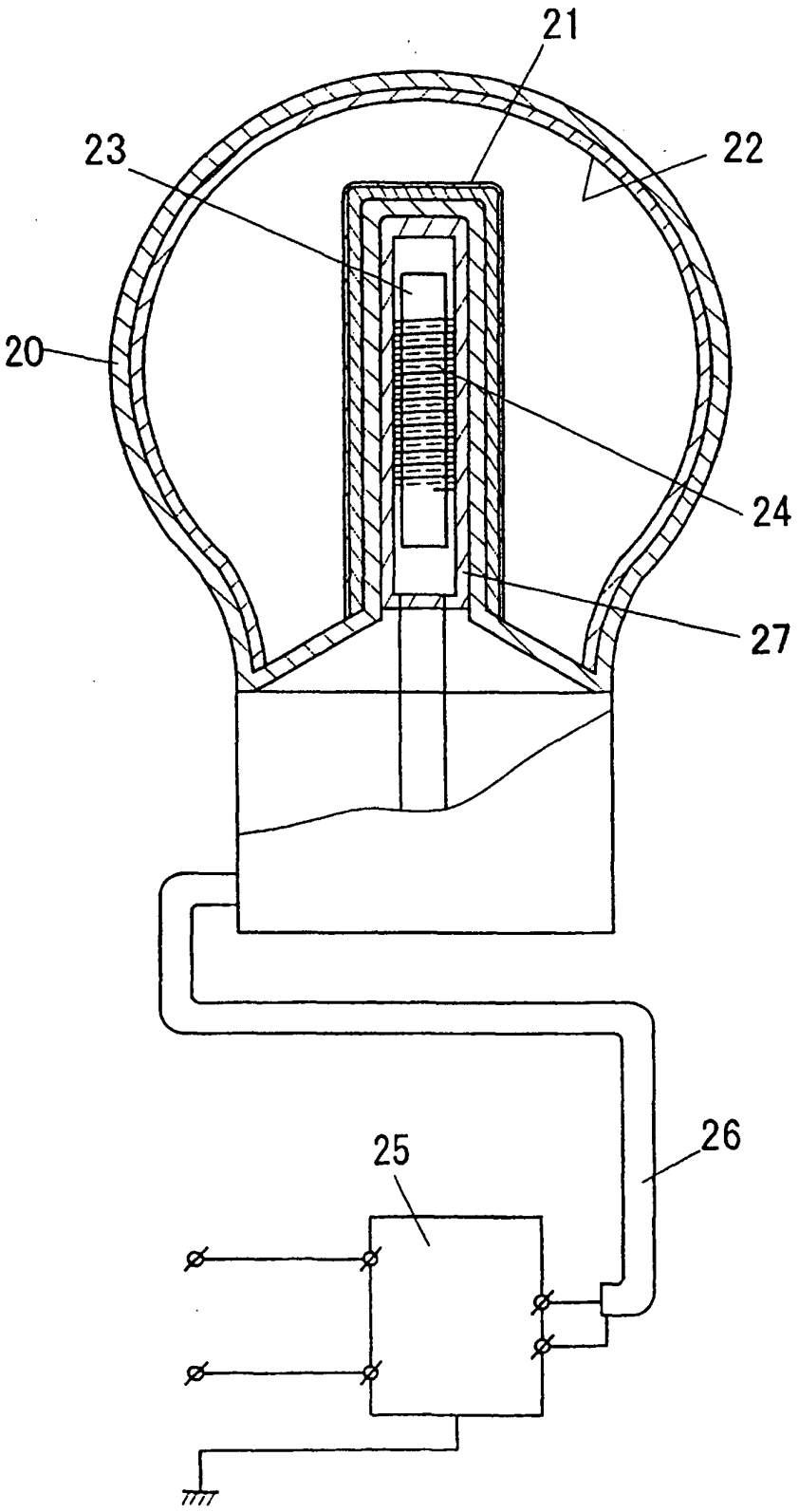


FIG 3



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2005/000014

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] H01J65/04, F21S2/00, H05B41/24

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.Cl[7] H01J65/04, F21S2/00, H05B41/24

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2005
Kokai Jitsuyo Shinan Koho 1971-2005 Toroku Jitsuyo Shinan Koho 1994-2005

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.
X	JP 2003-234084 A (Hitachi, Ltd.), 22 August, 2003 (22.08.03), Par. Nos. [0062], [0063]; Figs. 21, 22 (Family: none)	1,2
X	WO 2001/035446 A1 (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.), 17 May, 2001 (17.05.01), Page 4, lines 6 to 22; Fig. 1A & US 6433478 B1 & US 2001/0000941 A1 & EP 1235255 A1 & CA 2390234 A1	1,2
A	JP 2000-340380 A (Matsushita Electric Works, Ltd.), 08 December, 2000 (08.12.00), Par. No. [0064]; Figs. 9, 10 (Family: none)	1-5

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
05 April, 2005 (05.04.05)	10 May, 2005 (10.05.05)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2004)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2005/000014

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2001-507509 A (Koninklijke Philips Electronics N.V.), 05 June, 2001 (05.06.01), Full text; all drawings & WO 1999/019897 A1 & US 6201347 B1	1-5
A	JP 9-17582 A (Hitachi, Ltd.), 17 January, 1997 (17.01.97), Full text; all drawings & US 5828180 A	5,6

Form PCT/ISA/210 (continuation of second sheet) (January 2004)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 7272688 A **[0003]**
- JP 2004000557 A **[0024]**