



(11) **EP 3 290 773 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
01.05.2019 Bulletin 2019/18

(51) Int Cl.:
F21K 9/90^(2016.01) F21K 9/23^(2016.01)

(21) Application number: **16187181.9**

(22) Date of filing: **05.09.2016**

(54) **LED LIGHT BULB AND FABRICATION METHOD THEREOF**
LED-GLÜHLAMPE UND HERSTELLUNGSVERFAHREN DAFÜR
AMPOULE À DEL ET SON PROCÉDÉ DE FABRICATION

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

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(43) Date of publication of application:
07.03.2018 Bulletin 2018/10

(56) References cited:
EP-A2- 2 108 880 WO-A1-2013/014821
CN-A- 101 968 181 CN-B- 102 980 054
CN-U- 203 907 532 US-A1- 2012 098 429
US-A1- 2013 155 683 US-A1- 2015 069 442

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Description**BACKGROUND OF THE INVENTION**Field of the Invention

[0001] The invention relates to lighting fields, and more particularly, to an LED light bulb and a fabrication method thereof.

Descriptions of the Related Art

[0002] It is known that light-emitting diode (LED) light bulbs have many advantages such as lasting longer, more energy-efficient, more environmental friendly and reacting more rapidly, which make LED lighting gradually replace traditional lighting.

[0003] A fabrication method of a conventional LED light bulb is shown in Figure 1. First in step S21, a stem 21, an LED filament 22 and two power wires 23 shown in Figure 2-1 are provided. The stem 21 is used to support the LED filament 22. The stem 21 includes an exhaust tube 211 and a horn-shaped tube 212, wherein the exhaust tube 211 and the two power wires 23 pass through the horn-shaped tube 22. Then in step S22, as shown in Figure 2-2, two ends of the LED filament 22 are soldered to the two power wires 23 passing through the stem 21 to form a semi-finished LED light bulb 24. Then in step S23, as shown in Figure 2-3, a glass envelope 25 is provided to cover and protect a head part of the semi-finished LED light bulb 24. Then in step S24, as shown in Figure 2-4, a sealer is used to seal the glass envelope 25, and an exhausting machine is used to discharge redundant gas from the glass envelope 25 through the exhaust tube 211. Then in step S25, any unnecessary portion of the exhaust tube 211 is removed, and a screw base 26 is provided, making the two power wires 23 electrically connected to the screw base 26 respectively, thereby forming a finished LED light bulb 2 shown in Figure 2-5.

[0004] Therefore in the conventional LED light bulb 2, the stem 21 must be provided to support the LED filament 22, making the fabrication method of the LED light bulb 2 complicated and not cost-effective. As shown in Figure 2-5, the LED light bulb 2 also requires an internal space 22 for accommodating a front end 213 of the stem 21, such that the LED light bulb 2 cannot be significantly reduced in length and cannot replace all the small-size traditional light bulbs.

[0005] US 2015/069442 A1 discloses a method of molding a component including the steps of providing a plurality of fibers, applying the fibers with a low temperature sizing to form a plurality of sized fibers, forming a preform from the plurality of sized fibers, placing the preform in a mold, and de-sizing the preform by heating the mold to an initial temperature.

[0006] CN 203 907 532 U discloses a LED filament comprising multiple substrates, flexible wires capable of connecting the substrates in series, pins at the ends of

the substrates at the two ends of the LED filament, and light emitting units arranged on the substrates.

[0007] US 2013/155683 A1 discloses a light bulb shaped lamp including a hollow globe having an opening; an LED module having a base platform and an LED chip mounted on the base platform, the LED module being housed in the globe; a stem extending from the opening of the globe to the vicinity of the LED module; and a regulating component.

[0008] WO 2013/014821 A1 discloses a photovoltaic module, which includes a photovoltaic member, a moisture-resistant layer, a mounting frame covering and a buffer layer.

[0009] CN 101 968 181 A discloses LED bulbs, which include a light-transmissive blister, with a vent pipe, electrical lead wires and brackets stem, at least one LED light bar, a drive, an electrical connector; LED light bar is fixed core column, and electric lead and drive it through the stem of the electrode.

[0010] CN 102 980 054 B discloses a LED bulb, including lamp, lamp shells, constant current power supply, wires, lamp and LED light source, the wire is at least 2 LED light source between the wires within cavity shade.

SUMMARY OF THE INVENTION

[0011] The present invention is provided by appended claims 1 and 4. Beneficial embodiments are provided in the dependent claims. The following disclosure is provided to facilitate understanding the invention. Accordingly, in view of the shortages of prior technologies mentioned above, the disclosure provides an LED light bulb, including: a power wire support set, an LED filament, a glass envelope and a screw base. The power wire support set includes a first power wire, a second power wire and at least one fixed block. The fixed block fixes the first and second power wires to make them form a power wire supporting structure. An LED filament having two ends respectively soldered to a first end of the first power wire and a first end of the second power wire, making the LED filament supported by the power wire supporting structure; a glass envelope including a head part having a receiving space for receiving the LED filament, and a tail part tapered to clamp and fix second ends of the first and second power wires in position; and a screw base electrically connected to the second ends of the first and second power wires.

[0012] Optionally, the LED light bulb has a plurality of fixed blocks. The fixed block is made of glass. The first and second power wires are dumet wires. The screw base is soldered to the second ends of the first and second power wires.

[0013] Moreover, the invention further provides A fabrication method of an LED light bulb, including the steps of: providing an LED filament and a power wire support set, wherein the power wire support set includes a first power wire, a second power wire and at least one fixed block, and the fixed block fixes the first and second power

wires to make them form a power wire supporting structure; soldering two ends of the LED filament to a first end of the first power wire and a first end of the second power wire respectively to form a semi-finished LED light bulb; providing a glass envelope, wherein the glass envelope has a receiving space in a head part thereof and a passage in a tail part thereof, allowing the LED filament to pass through the passage to be received in the receiving space; tapering the tail part of the glass envelope and sealing the passage to clamp second ends of the first and second power wires; and providing a screw base, and electrically connecting the second ends of the first and second power wires respectively to the screw base, to form a finished LED light bulb.

[0014] Optionally, the fabrication method further includes the step of: discharging redundant gas from the receiving space through the passage. Removing an unnecessary portion of the tail part of the glass envelope.

[0015] Compared to the conventional technology, the invention provides an LED light bulb and a fabrication method thereof, wherein two power wires for supplying electricity are used in place of the stem in the conventional LED light bulb. The power wires support and fix an LED filament in position. Besides eliminating the need of making the stem, the invention desirably simplifies fabrication processes of the LED light bulb and thereby reduces its fabrication costs. Moreover, the LED light bulb of the invention does not require an internal space for accommodating the stem, and thus its length may be significantly reduced, making the LED light bulb ideally used as a small-size light bulb.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The above and other aspects, features and other advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

Figure 1 is a flowchart showing a fabrication method of a conventional LED light bulb.

Figures 2-1 to 2-5 are schematic diagrams showing an embodiment of the LED light bulb fabricated by the steps shown in Figure 1.

Figure 3 is a flowchart showing a fabrication method of an LED light bulb according to the invention.

Figures 4-1 to 4-5 are schematic diagrams showing an embodiment of the LED light bulb fabricated by the steps shown in Figure 3.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0017] Embodiments of the present invention will now be described in detail with reference to the accompanying drawings. The invention may, however, be embodied in many different forms and should not be construed as

being limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. In the drawings, the shapes and dimensions of elements may be exaggerated for clarity, and the same reference numerals will be used throughout to designate the same or like components.

[0018] An embodiment of an LED light bulb according to the invention and a fabrication method thereof are disclosed with reference to Figures 3 to 4-5.

[0019] The fabrication method of the LED light bulb according to the invention includes the following steps shown in Figure 3.

[0020] In step S11, as shown in Figure 4-1, an LED filament 12 and a power wire support set 11 are provided. The power wire support set 11 includes a first power wire 111, a second power wire 112 and at least one fixed block 113. The first and second power wires 111, 112 are electrical conductors and can be dumet wires. There may be provided one or more fixed blocks 13, which can be made of glass. The fixed block 13 is used to fix the first and second power wires 111, 112 to integrally combine them to form a power wire supporting structure.

[0021] In step S12, as shown in Figure 4-2, the LED filament 12 has two ends thereof respectively soldered to a first end E1 of the first power wire 111 and a first end E1 of the second wire 112, such that the LED filament 12 may obtain electricity through the first and second power wires 111, 112 and support from the power wire supporting structure to be properly fixed in position. This forms a semi-finished LED light bulb 15.

[0022] In step S13, as shown in Figure 4-3, a glass envelope 13 is provided, wherein a head part 131 of the glass envelope 13 has a receiving space 1311, and a tail part 132 of the glass envelope 13 has a passage 1321 connected to the receiving space 1311. The LED filament 12 and the fixed block 113 may pass through the passage 1321 to be received in the receiving space 1311 and thus be protected by the glass envelope 13.

[0023] In step S14, as shown in Figure 4-4, redundant gas in the receiving space 1311 is discharged through the passage 1321 so as to prevent moisture from staying in the operating environment of the LED filament 12. Then the tail part 132 of the glass envelope 13 is tapered and the passage 1321 is sealed in a manner to clamp second ends E2 of the first and second power wires 111, 112. Any unnecessary portion of the tail part 132 of the glass envelope 13 is removed.

[0024] In step S15, as shown in Figure 4-5, a screw base 14 is provided. The second ends E2 of the first and second power wires 111, 112 are electrically connected to the screw base 14 respectively, thereby forming a finished LED light bulb 16.

[0025] Figure 4-5 also shows the structure of the LED light bulb according to the invention. The LED light bulb 1 includes: a power wire support set 11, an LED filament 12, a glass envelope 13 and a screw base 14. The LED

filament 12 has an operating voltage of from 8V to 240V. The power wire support set 11 includes a first power wire 111, a second power wire 112 and at least one fixed block 113. The first and second power wires 111, 112 provide a path of electricity to the LED filament 12. The screw base 14 is used to electrically connect an external power source. The first and second power wires 111, 112 may be made of dumet wires. The first and second power wires 111, 112 have first ends E1 thereof being soldered to two ends of the LED filament 12 respectively and have second ends E2 thereof being electrically connected to the screw base 14 respectively.

[0026] The fixed block 113 may be, for example, a glass ball, for fixing the first and second power wires 111, 112 to make them form a power wire supporting structure, which is used to provide support for the LED filament 12. The fixed block 113 can have a ball shape or any other shape that is easily made. A head part 131 of the glass envelope 13 has a receiving space 1311 where the LED filament 12 and the fixed block 113 are received. The receiving space 1311 may be filled with inert gas. A tail part 132 of the glass envelope 13 is tapered to clamp the second ends E2 of the first and second power wires 111, 112 so as to properly fix the first and second power wires 111, 112 in position and keep the receiving space 1311 intact.

[0027] Therefore, the invention provides an LED light bulb and a fabrication method thereof, wherein power wires for supplying electricity to an LED filament are used to support and fix the LED filament in position, such that a stem used in a conventional LED light bulb is not needed. This desirably simplifies fabrication processes of the LED light bulb and thereby reduces its fabrication costs. Moreover, the LED light bulb of the invention does not require an internal space for accommodating the stem, and thus its length may be significantly reduced, making the LED light bulb ideally used as a small-size light bulb.

[0028] The examples above are only illustrative to explain principles and effects of the invention, but not to limit the invention. It will be apparent to those skilled in the art that modifications and variations can be made without departing from the scope of the invention. Therefore, the protection range of the rights of the invention should be as defined by the appended claims.

Claims

1. An LED light bulb (1), including:

a power wire support set (11) including a first power wire (111), a second power wire (112) and at least one fixed block (113), wherein the fixed block (113) fixes the first and second power wires (111, 112) to make them form a power wire supporting structure;
an LED filament (12) having two ends respectively soldered to a first end (E1) of the first power

wire (111) and a first end (E1) of the second power wire (112), making the LED filament (12) supported by the power wire supporting structure, the LED light bulb (1) being **characterized in that** the LED filament (12) does not require an internal space for accommodating a stem provided to support the LED filament, and that the fixed block (113) is made of glass, and the first and second power wires (111, 112) are dumet wires;

a glass envelope (13) including a head part (131) having a receiving space (1311) for receiving the LED filament (12) and the fixed block (113), and a tail part (132) tapered to clamp and fix second ends (E2) of the first and second power wires (111, 112) in position; and
a screw base (14) electrically connected to the second ends (E2) of the first and second power wires (111, 112).

2. The LED light bulb (1) according to claim 1, wherein the LED light bulb (1) has a plurality of fixed blocks (113).

3. The LED light bulb (1) according to claim 1, wherein the screw base (14) is soldered to the second ends (E2) of the first and second power wires (111, 112).

4. A fabrication method of an LED light bulb (1), including the steps of:

providing an LED filament (12) and a power wire support set (11), wherein the power wire support set (11) includes a first power wire (111), a second power wire (112) and at least one fixed block (113), and the fixed block (113) fixes the first and second power wires (111, 112) to make them form a power wire supporting structure; soldering two ends of the LED filament (12) to a first end (E1) of the first power wire (111) and a first end (E1) of the second power wire (112) respectively to form a semi-finished LED light bulb (15), the fabrication method being **characterized in**

making the LED filament (12) supported by the power wire supporting structure such that the LED filament (12) does not require an internal space for accommodating a stem provided to support the LED filament, and **in that** the fixed block (113) is made of glass, and the first and second power wires (111, 112) are dumet wires; providing a glass envelope (13), wherein the glass envelope (13) has a receiving space (1311) in a head part (131) thereof and a passage (1321) in a tail part (132) thereof, allowing the LED filament (12) and the fixed block (113) to pass through the passage (1321) to be received in the receiving space (1311);

tapering the tail part (132) of the glass envelope (13) and sealing the passage (1321) to clamp second ends (E2) of the first and second power wires (111, 112); and

providing a screw base (14), and electrically connecting the second ends (E2) of the first and second power wires (111, 112) respectively to the screw base (14), to form a finished LED light bulb (16).

5. The fabrication method according to claim 4, further including the step of: discharging redundant gas from the receiving space (1311) through the passage (1321).
6. The fabrication method according to claim 4, further including the step of: removing an unnecessary portion of the tail part (132) of the glass envelope (13).

Patentansprüche

1. LED Glühbirne (1), einschließend:

einen Stromdraht-Tragsatz (11), der einen ersten Stromdraht (111), einen zweiten Stromdraht (112) und wenigstens einen festen Block (113) einschließt, wobei der feste Block (113) den ersten und den zweiten Stromdraht (111, 112) befestigt, sodass diese eine Stromdraht-Tragstruktur ausbilden;

ein LED Filament (12), welches zwei Enden aufweist, die jeweils an ein erstes Ende (E1) des ersten Stromdrahts (111) und an ein erstes Ende (E1) des zweiten Stromdrahts (112) gelötet sind,

wobei das LED-Filament (12) so gemacht wird, sodass es von der Stromdraht-Tragstruktur gestützt wird, wobei die LED Glühbirne (1) **dadurch gekennzeichnet ist, dass** das LED Filament (12) keinen Innenraum benötigt, um einen Stamm aufzunehmen, der zur Stützung des LED-Filaments vorgesehen ist, und dass der feste Block (113) aus Glas hergestellt ist, und der erste und der zweite Stromdraht (111, 112) Dumet-Drähte sind;

eine Glashülle (13), die einen Kopfteil (131), welcher einen Aufnahmeraum (1311) aufweist, zur Aufnahme des LED Filaments (12) und des festen Blocks (113), und einen Endteil (132) einschließt, der sich verjüngt, um die zweiten Enden (E2) des ersten und des zweiten Stromdrahts (111, 112) in Position einzuklemmen und zu befestigen; und

einen Schraubsockel (14), der elektrisch mit den zweiten Enden (E2) des ersten und zweiten Stromdrahts (111, 112) verbunden ist.

2. LED Glühbirne (1) gemäß Anspruch 1, wobei die LED Glühbirne (1) eine Vielzahl an festen Blöcken (113) aufweist.

3. LED Glühbirne (1) gemäß Anspruch 1, wobei der Schraubsockel (14) an die zweiten Enden (E2) des ersten und zweiten Stromdrahts (111, 112) gelötet ist.

4. Herstellungsverfahren einer LED Glühbirne (1), das die Schritte einschließt:

Bereitstellen eines LED Filaments (12) und eines Stromdraht-Tragsatzes (11), wobei der Stromdraht-Tragsatz (11) einen ersten Stromdraht (111), einen zweiten Stromdraht (112) und wenigstens einen festen Block (113) einschließt, und der feste Block (113) den ersten und den zweiten Stromdraht (111, 112) befestigt, dass diese eine Stromdraht-Tragstruktur ausbilden;

Löten zweier Enden des LED Filaments (12) an ein erstes Ende (E1) des ersten Stromdrahts (111) bzw. an das erste Ende (E1) des zweiten Stromdrahts (112), um eine halbfertige LED Glühbirne (15) auszubilden,

wobei das Herstellungsverfahren, **gekennzeichnet ist, durch** Einrichten, dass das LED-Filament (12) **durch** die Stromdraht-Tragstruktur derart gestützt wird, dass das LED-Filament (12) keinen Innenraum zur Aufnahme eines Stamms benötigt, der zur Stützung des LED-Filaments vorgesehen ist, und **dadurch** dass der feste Block (113) aus Glas hergestellt ist und der erste und der zweite Stromdraht (111, 112) Dumet-Drähte sind;

Bereitstellen einer Glashülle (13), wobei die Glashülle (13) einen Aufnahmeraum (1311) in einem Kopfteil (131) davon und in einen Durchgang (1321) in einem Endteil (132) davon aufweist,

Zulassen, dass das LED-Filament (12) und der feste Block (113) den Durchgang (1321) durchlaufen, um in dem Aufnahmeraum (1311) aufgenommen zu werden;

Verjüngen des Endteils (132) der Glashülle (13) und Abdichten des Durchgangs (1321), um die zweiten Enden (E2) des ersten und zweiten Stromdrahts (111, 112) einzuklemmen;

und Bereitstellen eines Schraubsockel (14), und elektrisches Verbinden der zweiten Enden (E2) des ersten und zweiten Stromdrahts (111, 112) jeweils mit dem Schraubsockel (14), um eine fertige LED-Glühbirne (16) auszubilden.

5. Herstellungsverfahren gemäß Anspruch 4, weiterhin den Schritt einschließend:
Abführen von redundantem Gas aus dem Aufnah-

meraum (1311) durch den Durchgang (1321).

6. Herstellungsverfahren gemäß Anspruch 4, weiterhin den Schritt einschließend: Entfernen eines unnötigen Abschnitts des Endteils (132) der Glashülle (13). 5

Revendications

1. Ampoule à DEL (1) comprenant : 10

un ensemble de support de fils électriques (11) comprenant un premier fil électrique (111), un deuxième fil électrique (112) et au moins un bloc fixe (113), le bloc fixe (113) fixant les premier et deuxième fils électriques (111, 112) pour en faire une structure de support de fils électriques ; un filament DEL (12) comportant deux extrémités respectivement soudées à une première extrémité (E1) du premier fil électrique (111) et à une première extrémité (E1) du deuxième fil électrique (112), le filament DEL (12) étant ainsi supporté par la structure de support de fils électriques, l'ampoule à DEL (1) étant **caractérisée en ce que** le filament DEL (12) ne nécessite pas d'espace intérieur pour accueillir une tige destinée à supporter le filament DEL, et **en ce que** le bloc fixe (113) est constitué de verre, et les premier et deuxième fils électriques (111, 112) sont des fils Dumet ;
 une enveloppe en verre (13) comprenant une partie de tête (131) comportant un espace de réception (1311) destiné à recevoir le filament DEL (12) et le bloc fixe (113) et une partie de queue (132) effilée pour serrer et fixer des deuxièmes extrémités (E2) des premier et deuxième fils électriques (111, 112) en position ; et
 une base de vis (14) électriquement reliée aux deuxièmes extrémités (E2) des premier et deuxième fils électriques (111, 112). 40

2. Ampoule à DEL (1) selon la revendication 1, dans laquelle l'ampoule à DEL (1) comporte une pluralité de blocs fixes (113). 45

3. Ampoule électrique (1) selon la revendication 1, dans laquelle la base de vis (14) est soudée aux deuxièmes extrémités (E2) des premier et deuxième fils électriques (111, 112). 50

4. Procédé de fabrication d'une ampoule à DEL (1), comprenant les étapes suivantes :

mise à disposition d'un filament DEL (12) et d'un ensemble de support de fils électriques (11), l'ensemble de support de fils électriques (11) comprenant un premier fil électrique (111), un

deuxième fil électrique (112) et au moins un bloc fixe (113), et le bloc fixe (113) fixant les premier et deuxième fils électriques (111, 112) pour en faire une structure de support de fils électriques ; soudage de deux extrémités du filament DEL (12) à une première extrémité (E1) du premier fil électrique (111) et à une deuxième extrémité (E1) du deuxième fil électrique (112) respectivement afin de former une ampoule à DEL semi-finie (15), le procédé de fabrication étant **caractérisé en ce que**

le filament DEL (12) est supporté par la structure de support de fils électriques de telle façon que le filament DEL (12) ne nécessite pas d'espace intérieur pour accueillir une tige destinée à supporter le filament DEL, et **en ce que** le bloc fixe (113) est constitué de verre, et les premier et deuxième fils électriques (111, 112) sont des fils Dumet ;

mise à disposition d'une enveloppe en verre (13), l'enveloppe en verre (13) comportant un espace de réception (1311) dans une partie de tête (131) de celle-ci et un passage (1321) dans une partie de queue (132) de celle-ci, permettant au filament DEL (12) et au bloc fixe (113) de passer à travers le passage (1321) pour être reçus dans l'espace de réception (1311) ;

effilage de la partie de queue (132) de l'enveloppe en verre (13) et scellement du passage (1321) pour serrer des deuxièmes extrémités (E2) des premier et deuxième fils électriques (111, 112) ; et

mise à disposition d'une base de vis (14), et connexion électrique des deuxièmes extrémités (E2) des premier et deuxième fils électriques (111, 112) respectivement à la base de vis (14) pour former une ampoule à DEL finie (16).

5. Procédé de fabrication selon la revendication 4, comprenant en outre l'étape suivante : décharge de gaz superflu venant de l'espace de réception (1311) à travers le passage (1321).

6. Procédé de fabrication selon la revendication 4, comprenant en outre l'étape suivante : retrait d'une partie inutile de la partie de queue (132) de l'enveloppe en verre (13).

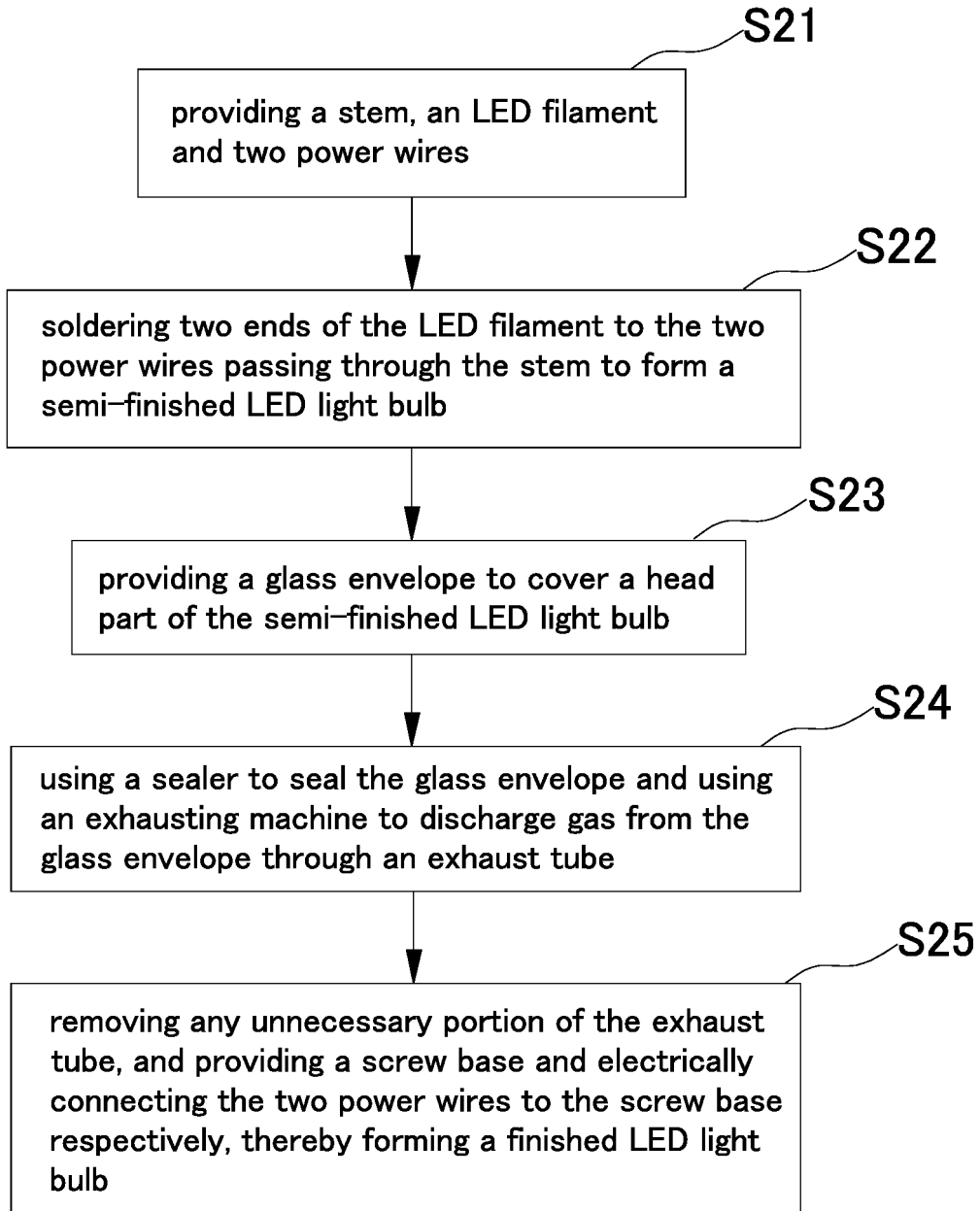


FIG . 1(Prior Art)

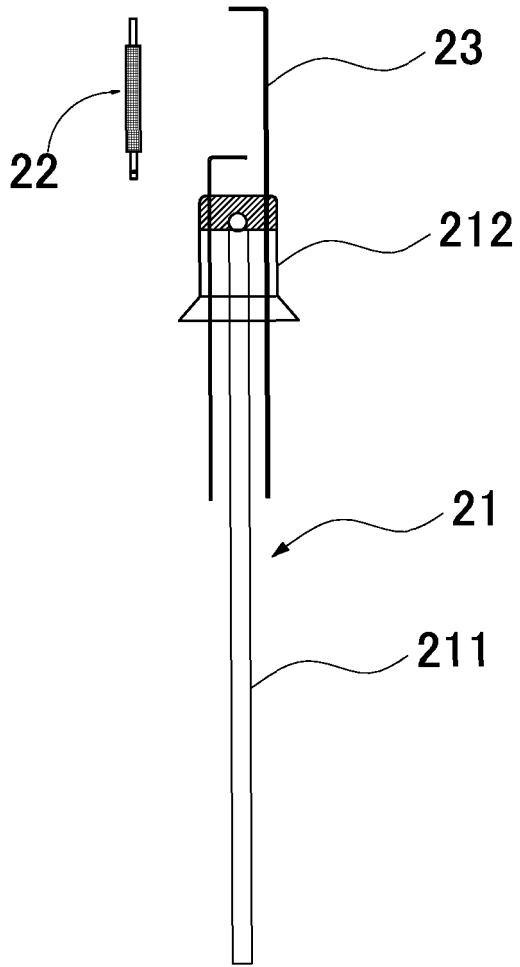


FIG.2-1(Prior Art)

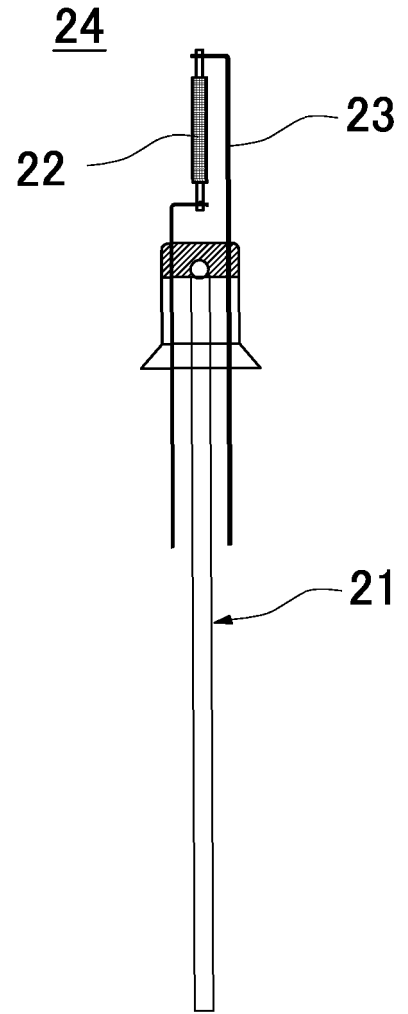


FIG.2-2(Prior Art)

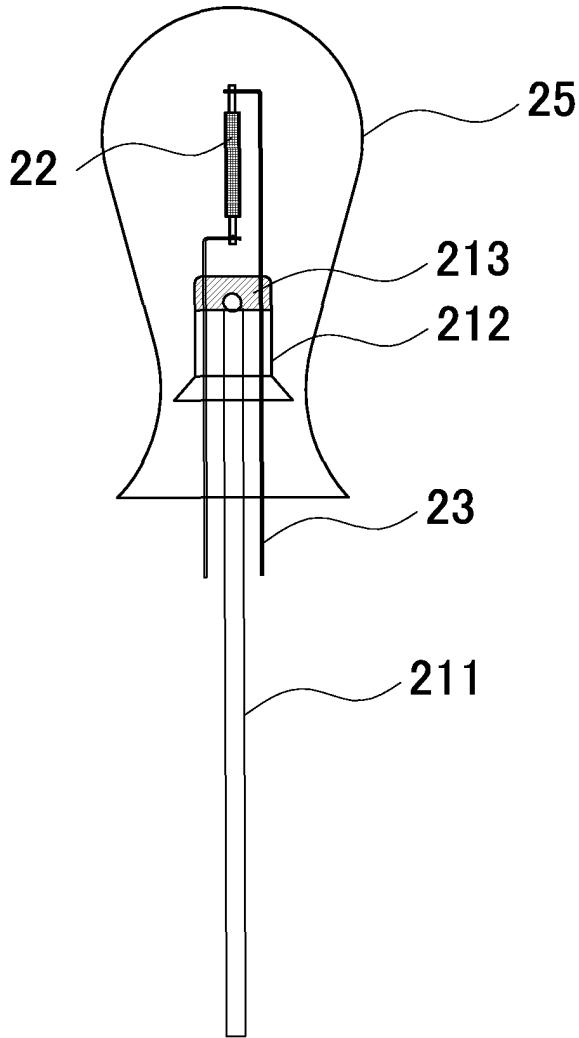


FIG.2-3(Prior Art)

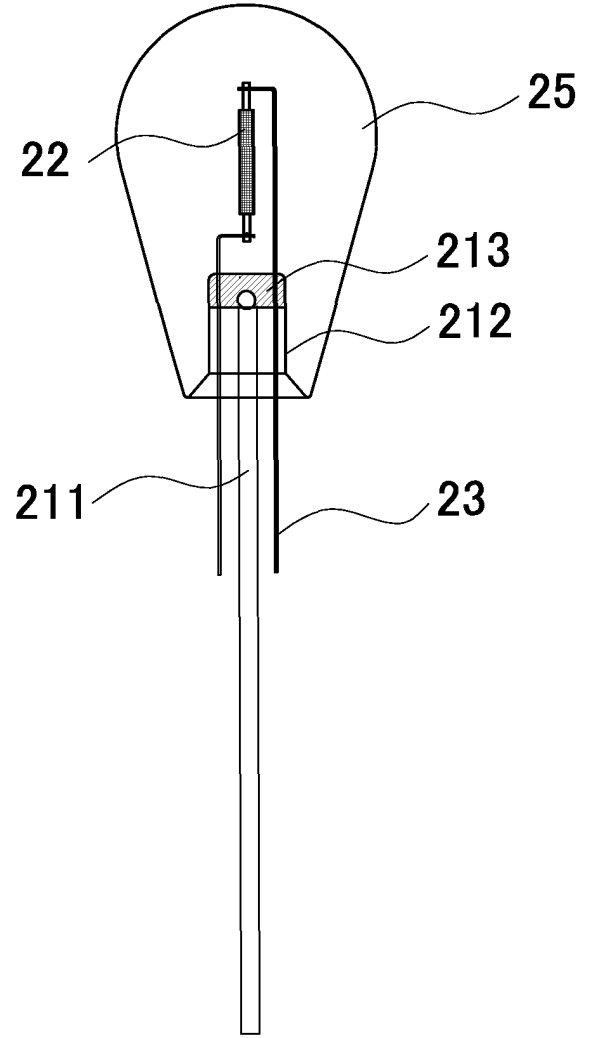


FIG.2-4(Prior Art)

2

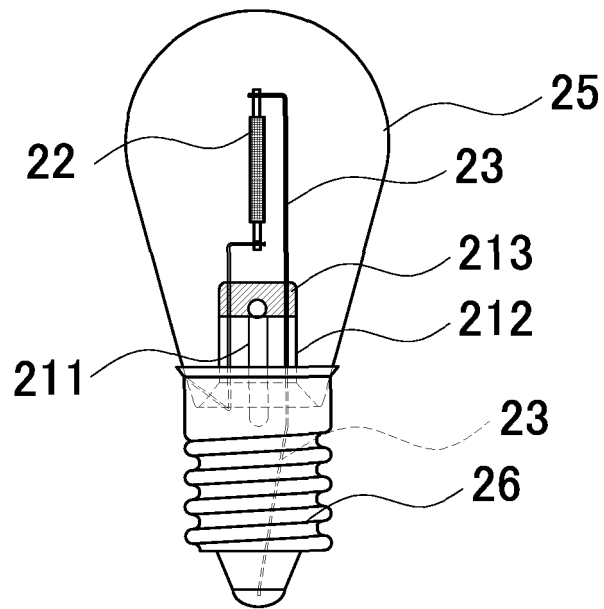


FIG.2-5(Prior Art)

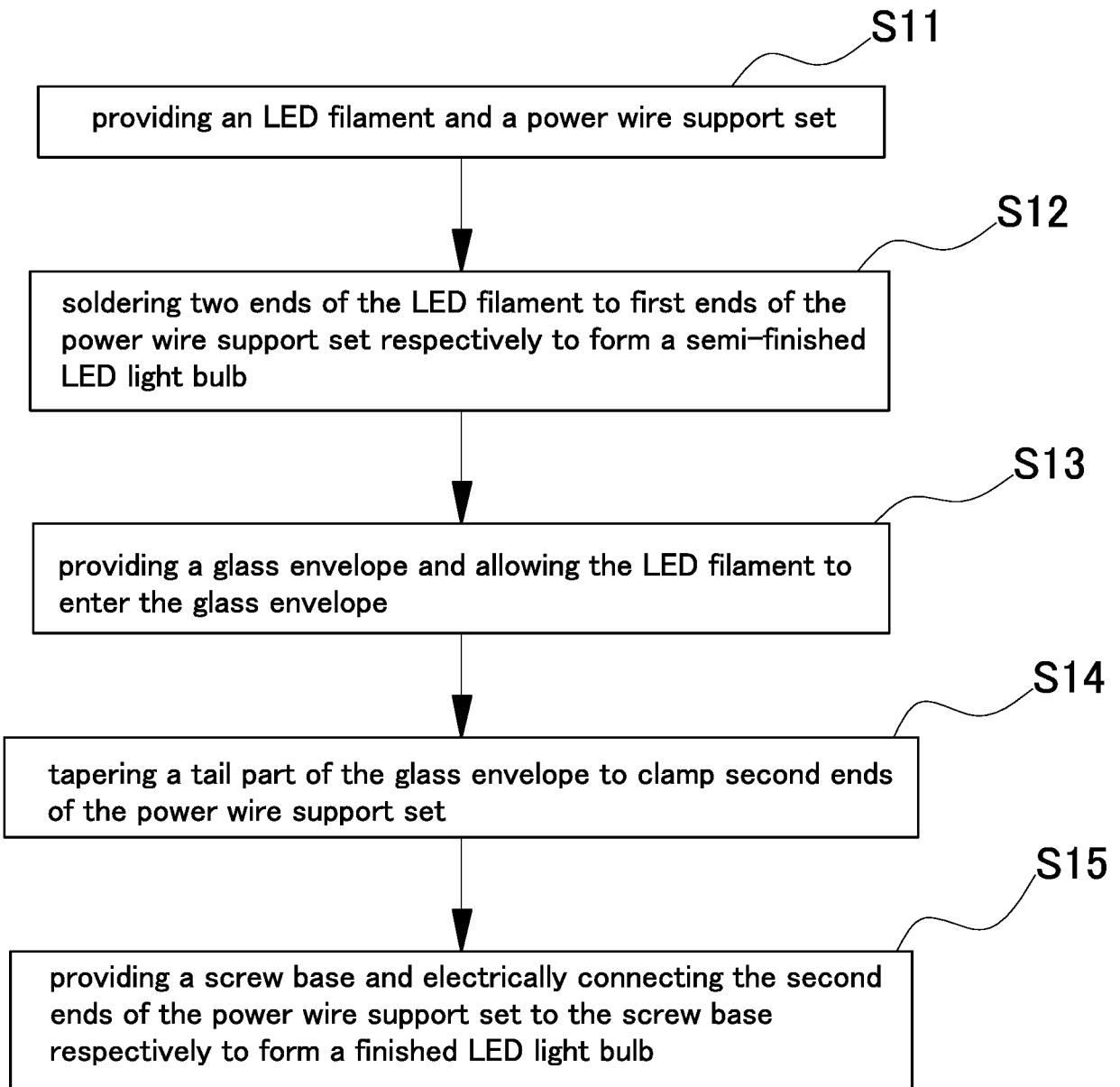


FIG . 3

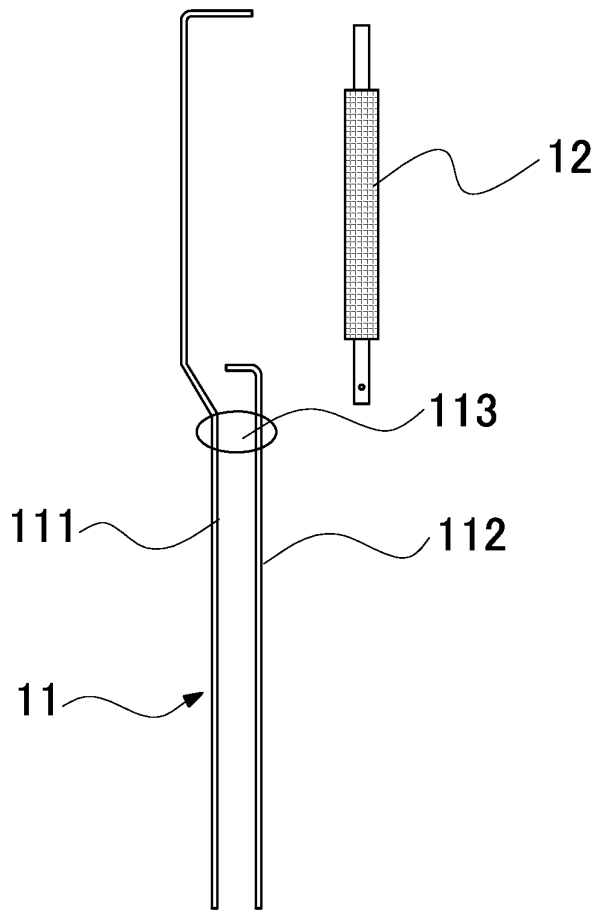


FIG . 4-1

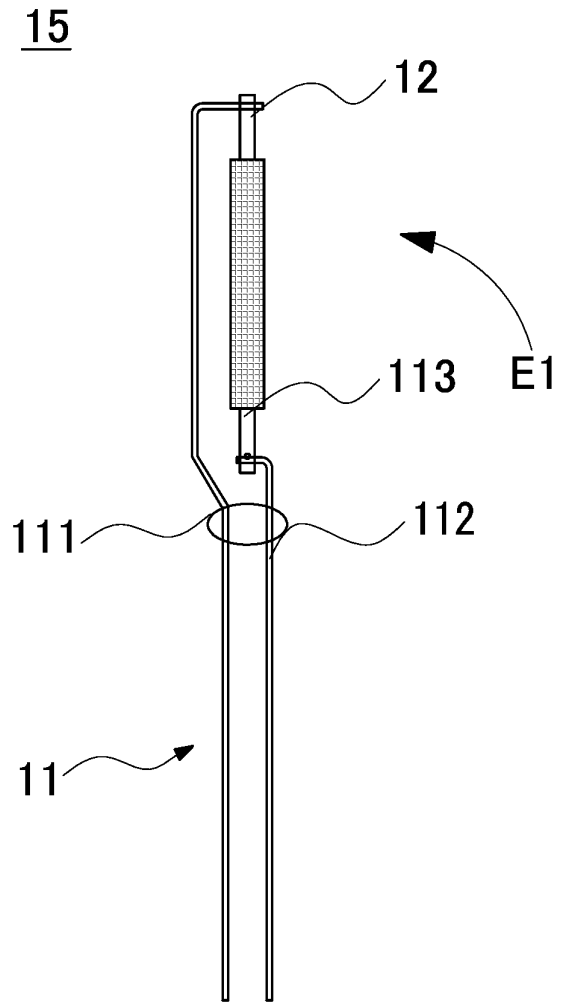


FIG . 4-2

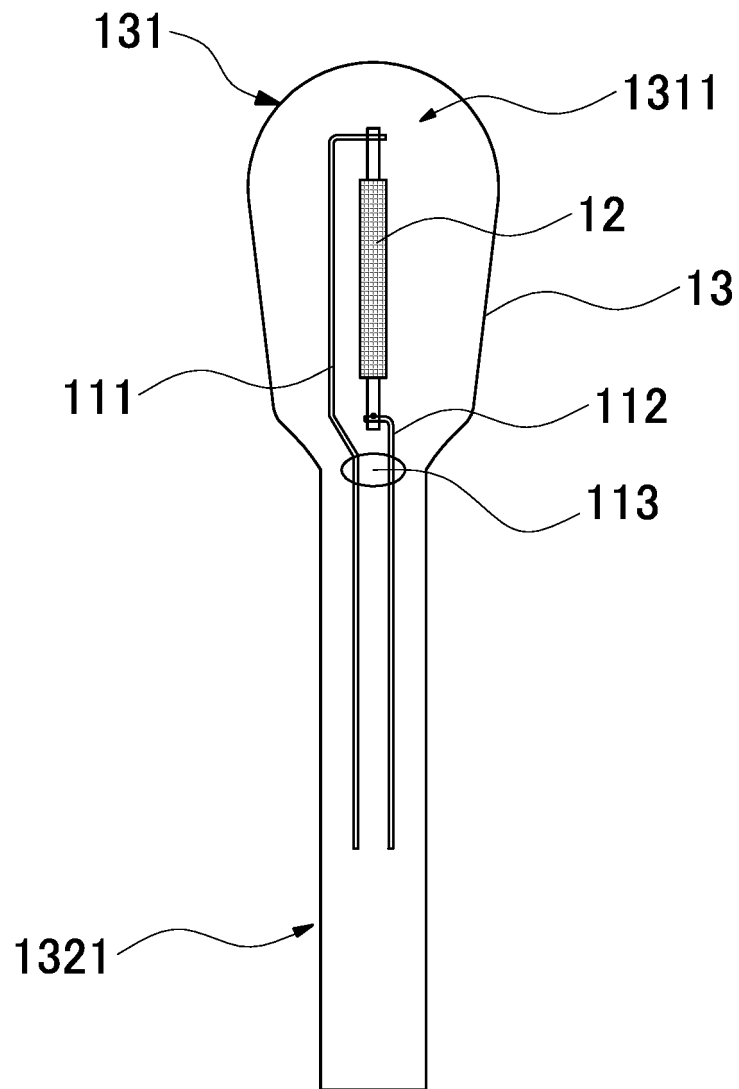


FIG . 4-3

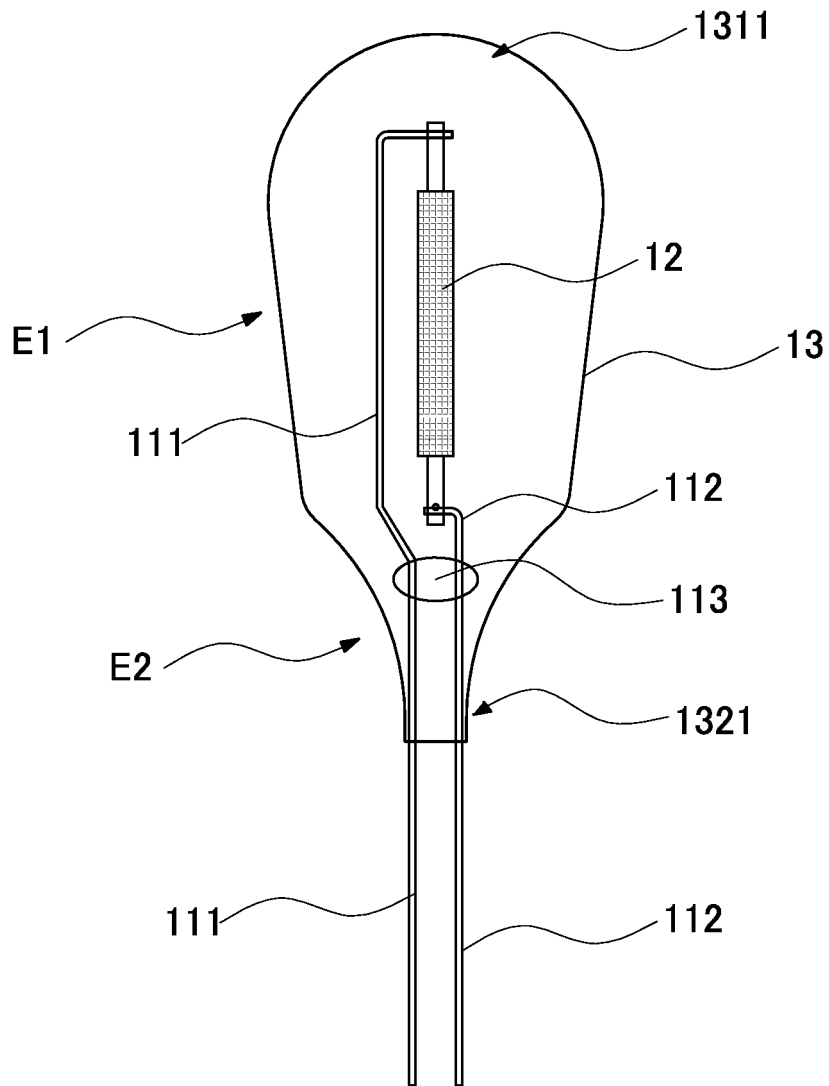


FIG . 4-4

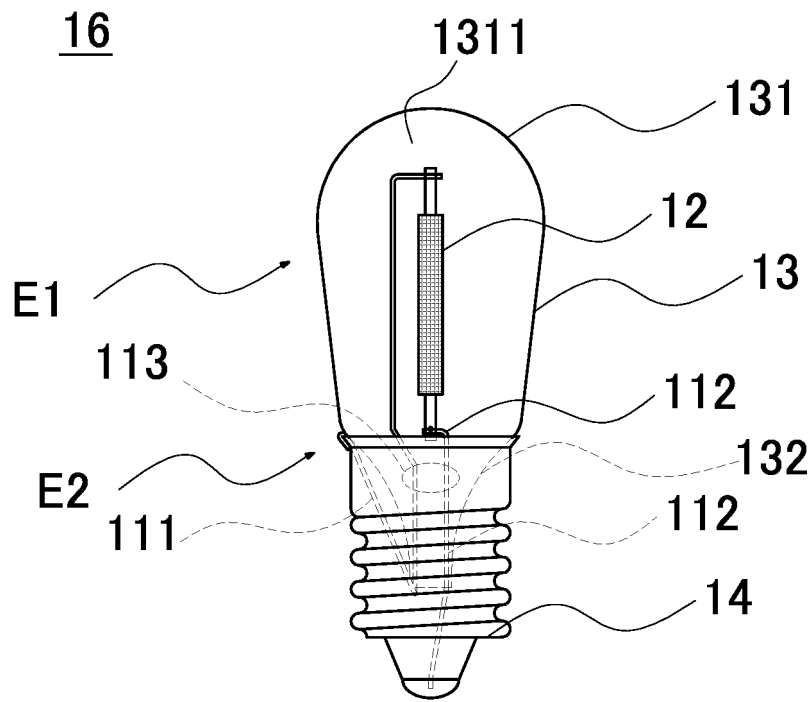


FIG . 4-5

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 2015069442 A1 [0005]
- CN 203907532 U [0006]
- US 2013155683 A1 [0007]
- WO 2013014821 A1 [0008]
- CN 101968181 A [0009]
- CN 102980054 B [0010]