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

(11) EP 3 327 751 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
30.05.2018 Bulletin 2018/22

(51) Int Cl.:
***H01J 61/34** (2006.01)* ***H01J 61/82** (2006.01)*

(21) Application number: **17185718.8**

(22) Date of filing: **10.08.2017**

(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
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(30) Priority: **24.11.2016 JP 2016227439**

(71) Applicant: **Toshiba Lighting & Technology Corporation**
Yokosuka-shi, Kanagawa 237-8510 (JP)

(72) Inventor: **Aibara, Kazuya**
Yokosuka-shi, Kanagawa (JP)

(74) Representative: **Awapatent AB**
Junkersgatan 1
582 35 Linköping (SE)

(54) DISCHARGE LAMP, VEHICLE LAMP, AND VEHICLE LIGHTING DEVICE

(57) A discharge lamp 100 includes a light emitting portion 11 that has a discharge space 111 in which a metal halide and inert gas are sealed on an inside thereof; and a pair of electrodes 32 that protrudes to an inside of the discharge space and faces each other at a predetermined distance L1.

Electric power applied to the discharge lamp during a low beam is 24 W or more and 30 W or less, and electric power applied to the discharge lamp during a high beam is 32 W or more and 38 W or less, and the following formula is satisfied where a maximum wall thickness of the light emitting portion is t (mm) and a sealing pressure of the inert gas at room temperature (25°C) is P (atm):

7.2 (atm/mm) <= P/t (atm/mm) <= 10.0 (atm/mm)

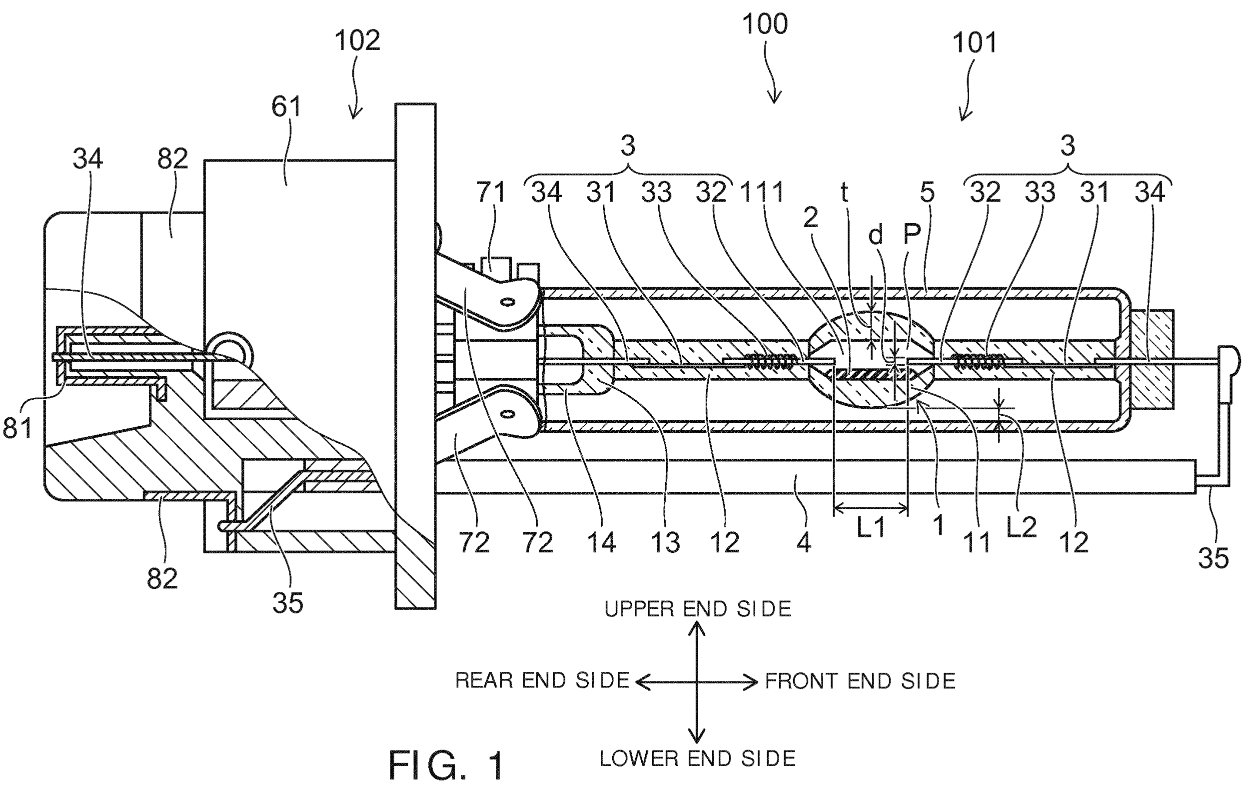

FIG. 1

EP 3 327 751 A1

Description

FIELD

[0001] Embodiments described herein relate generally to a discharge lamp, a vehicle lamp, and a vehicle lighting device.

BACKGROUND

[0002] There is a discharge lamp including a light emitting portion having a discharge space in which a discharge medium is sealed on an inside thereof, and a pair of electrodes protruding into the discharge space and disposed to face each other at a predetermined distance.

[0003] Here, in general, a light source for low beam (beam for passing) and a light source for high beam (beam for running) are provided in a headlamp for an automobile, and the low beam and the high beam are switched as necessary. For example, a discharge lamp is used as the light source for low beam and another discharge lamp or another type of lamp is used for the light source for high beam.

[0004] Although the low beam and the high beam are necessary for an operation of the automobile, since two light sources are necessary, a manufacturing cost of the headlamp is increased, and a size or design of the headlamp is limited.

[0005] For this reason, it is preferable to be able to cope with both the low beam and the high beam with one discharge lamp. Therefore, a discharge lamp is proposed in which a light emitting portion is moved in a predetermined direction so that the discharge lamp can cope with both the low beam and the high beam. In addition, a discharge lamp including a magnetic field generating unit for applying a magnetic field including a magnetic force line component is also proposed.

[0006] However, in such a manner, a configuration of the discharge lamp becomes complicated.

[0007] Therefore, it is desired to develop a discharge lamp capable of coping with low beam and high beam with a simple configuration.

DESCRIPTION OF THE DRAWINGS

[0008]

FIG. 1 is a schematic view illustrating a discharge lamp according to an embodiment.
FIG. 2 is a schematic view illustrating a vehicle lamp and a vehicle lighting device.
FIG. 3 is a block view of the vehicle lighting device.

DETAILED DESCRIPTION

[0009] In general, according to one embodiment, a discharge lamp includes a light emitting portion that has a discharge space in which a metal halide and inert gas are sealed on an inside thereof; and a pair of electrodes that protrudes to an inside of the discharge space and faces each other at a predetermined distance.

[0010] Electric power applied to the discharge lamp during a low beam is 24 W or more and 30 W or less, and electric power applied to the discharge lamp during a high beam is 32 W or more and 38 W or less. The following formula is satisfied where a maximum wall thickness of the light emitting portion is t (mm) and a sealing pressure of the inert gas at room temperature (25°C) is P (atm).

$$7.2\ (\text{atm/mm}) \leq P/t\ (\text{atm/mm}) \leq 10.0\ (\text{atm/mm})$$

[0011] Hereinafter, embodiments will be described with reference to the drawings.

[0012] The discharge lamp according to the embodiments can be, for example, a High Intensity Discharge (HID) lamp used for a headlamp of an automobile. In addition, for example, if the discharge lamp is the HID lamp used for the headlamp of the automobile, so-called horizontal lighting can be performed.

[0013] It is preferable that the discharge lamp according to the embodiments is used for the headlamp of the automobile. However, the discharge lamp according to the embodiments may be used for other purposes. Here, a case where the discharge lamp according to the embodiments is the HID lamp used for the headlamp of the automobile is exemplified.

[0014] FIG. 1 is a schematic view illustrating a discharge lamp 100 according to an embodiment.

[0015] Moreover, in FIG. 1, if the discharge lamp 100 is attached to an automobile, a forward direction is a front end side, a rearward direction is a rear end side, an upward direction is an upper end side, and a downward direction is a lower end side.

[0016] As illustrated in FIG. 1, the discharge lamp 100 is provided with a burner 101 and a socket 102.

[0017] The burner 101 is provided with an outer tube 5, an inner tube 1, an electrode mount 3, a support wire 35, a sleeve 4, and a metal band 71.

[0018] The outer tube 5 is provided coaxially with the inner tube 1 on an outside of the inner tube 1. That is, the burner 101 has a double-tube structure configured of the outer tube 5 and the inner tube 1. The outer tube 5 is joined (welded) to the vicinity of a cylindrical portion 14 of the inner tube 1.

[0019] Gas is sealed in a closed space formed between the inner tube 1 and the outer tube 5. The sealed gas may be gas capable of performing dielectric barrier discharge.

[0020] It is preferable that the gas sealed in the closed space formed between the inner tube 1 and the outer tube 5 is either nitrogen, argon, or a mixed gas of nitrogen and argon, and a sealing pressure of the gas is 0.1 atm or less at room temperature (25°C).

[0021] It is preferable that the outer tube 5 is formed of a material having a thermal expansion coefficient close to a thermal expansion coefficient of a material of the inner tube 1 and having ultraviolet blocking properties. The outer tube 5 can be formed from, for example, quartz glass doped with an oxide such as titanium, cerium, or aluminum.

[0022] The inner tube 1 has a light emitting portion 11, a sealing portion 12, a boundary portion 13, and the cylindrical portion 14. The light emitting portion 11, the sealing portion 12, the boundary portion 13, and the cylindrical portion 14 can be integrally formed.

[0023] The inner tube 1 (light emitting portion 11, the sealing portion 12, the boundary portion 13, and the cylindrical portion 14) is formed of a material having translucency and heat resistance. The inner tube 1 can be formed of, for example, quartz glass or the like.

[0024] The light emitting portion 11 has a substantially elliptical outer shape. The light emitting portion 11 is provided in the vicinity of a center of the inner tube 1. A dimension (spherical length) of the light emitting portion 11 in an axial direction of the inner tube 1 can be, for example, substantially 8 mm. A dimension of the light emitting portion 11 in a direction orthogonal to the axial direction of the inner tube 1 can be, for example, substantially 6 mm.

[0025] A discharge space 111 is provided on an inside of the light emitting portion 11. A center portion of the discharge space 111 has a substantially cylindrical shape. Both end portions of the discharge space 111 have a substantially conical shape.

[0026] A discharge medium is sealed in the discharge space 111. The discharge medium contains a metal halide 2 and an inert gas.

[0027] In addition, from the viewpoint of environmental protection, the discharge medium is substantially free of mercury. Moreover, in the present specification, the phrase "substantially free of mercury" includes not only mercury but also mercury contained in an extent of impurities. For example, the discharge medium may contain mercury if it is less than 2 mg/cc in the discharge space 111.

[0028] The metal halide 2 can be, for example, a halide of scandium, a halide of indium, a halide of sodium, and a halide of zinc. Illustrative examples of the halogen include iodine. However, instead of iodine, bromine, chlorine, or the like can be used.

[0029] The inert gas sealed in the discharge space 111 may be, for example, xenon. In addition, besides xenon, neon, argon, krypton, or the like can be used, or a mixed gas of these can also be used. However, it is more preferable that the inert gas is xenon.

[0030] The sealing portion 12 has a form of a plate and is joined to both end portions of the light emitting portion 11. The sealing portion 12 can be formed, for example, by using a pinch seal method. In addition, the sealing portion 12 may be formed by a shrink seal method, and may have a cylindrical shape. The cylindrical portion 14 is joined to one sealing portion 12 via the boundary portion 13.

[0031] The boundary portion 13 and the cylindrical portion 14 are joined to an end portion of the sealing portion 12 on a side opposite to a light emitting portion 11 side.

[0032] The electrode mount 3 is provided on an inside of the sealing portion 12.

[0033] The electrode mount 3 has a metal foil 31, an electrode 32, a coil 33, and a lead wire 34. Two sets of the electrode mount 3 (metal foil 31, the electrode 32, the coil 33, and the lead wire 34) are provided.

[0034] The metal foil 31 is provided on the inside of the sealing portion 12. The metal foil 31 is joined to the vicinity of an end portion of the electrode 32 on a side opposite to the discharge space 111 side.

[0035] The metal foil 31 has a form of a thin plate and can be made of, for example, molybdenum, rhenium molybdenum, tungsten, rhenium tungsten, or the like.

[0036] The electrode 32 has a cylindrical shape.

[0037] One end portion of the electrode 32 protrudes into the discharge space 111. That is, one end of the electrode 32 is provided on the inside of the discharge space 111 and the other end is provided on the inside of the sealing portion 12. A pair of the electrodes 32 is provided so as to face each other at a predetermined distance. The other end of the electrode 32 is joined to the vicinity of an end portion of the metal foil 31 on the light emitting portion 11 side. Joining between the electrode 32 and the metal foil 31 can be performed by, for example, laser welding.

[0038] The electrode 32 can be formed of, for example, pure tungsten, doped tungsten, rhenium tungsten, or the like.

The electrode 32 may contain thorium or may not contain thorium.

[0039] The coil 33 is provided to suppress occurrence of cracks in the sealing portion 12. The coil 33 can be formed from, for example, a metal wire made of doped tungsten. The coil 33 is provided on the inside of the sealing portion 12. The coil 33 is wound around an outside of the electrode 32. For example, a wire diameter of the coil 33 is substantially 30 μm to substantially 100 μm and a coil pitch can be 600% or less.

[0040] The lead wire 34 has a linear shape. A cross-sectional shape of the lead wire 34 can be, for example, circular. The lead wire 34 can be formed of, for example, molybdenum or the like. One end portion of the lead wire 34 is joined to the vicinity of an end portion of the metal foil 31 on a side opposite to the light emitting portion 11 side. Joining between the lead wire 34 and the metal foil 31 can be performed by laser welding. The other end of the lead wire 34 extends to the outside of the inner tube 1.

[0041] The support wire 35 has an L shape and is joined to an end portion of the lead wire 34 extending from a front end side of the discharge lamp 100. Joining between the support wire 35 and the lead wire 34 can be performed by laser welding. The support wire 35 can be formed of, for example, nickel.

[0042] The sleeve 4 covers a portion of the support wire 35 extending parallel to the inner tube 1. The sleeve 4 has, for example, a cylindrical shape. The sleeve 4 can be formed of, for example, ceramics.

[0043] The metal band 71 is fixed to the vicinity of an end portion of the outer tube 5 on a rear end side.

[0044] The socket 102 has a body portion 61, an attachment fitting 72, a bottom terminal 81, and a side terminal 82.

[0045] The body portion 61 is formed of an insulating material such as resin. A rear end side of the lead wire 34, a rear end side of the support wire 35, and a rear end side of the sleeve 4 are provided on an inside of the body portion 61.

[0046] The attachment fitting 72 is provided at an end portion of the body portion 61. The attachment fitting 72 is provided on a front end side of the body portion 61. The attachment fitting 72 protrudes from the body portion 61. The attachment fitting 72 holds the metal band 71. The metal band 71 is held by the attachment fitting 72 so that the burner 101 is held in the socket 102.

[0047] The bottom terminal 81 is provided on the inside of the body portion 61. The bottom terminal 81 is provided on a rear end side of the body portion 61. The bottom terminal 81 is formed of a conductive material. The bottom terminal 81 is electrically connected to the lead wire 34.

[0048] The side terminal 82 is provided at a side wall of the body portion 61. The side terminal 82 is provided on the rear end side of the body portion 61. The side terminal 82 is formed of a conductive material. The side terminal 82 is electrically connected to the support wire 35.

[0049] The bottom terminal 81 and the side terminal 82 are electrically connected to a lighting circuit 301. In this case, the bottom terminal 81 is electrically connected to a high voltage side of the lighting circuit 301. The side terminal 82 is electrically connected to a low voltage side of the lighting circuit 301.

[0050] If the discharge lamp 100 is used for the headlamp of the automobile, the discharge lamp 100 is attached such that a center axis (tube axis) thereof is in a substantially horizontal state and the support wire 35 is positioned on a substantially lower end side (downward). Moreover, turning on the discharge lamp 100 attached in such a direction is referred to as horizontal lighting.

[0051] Here, if one discharge lamp 100 can cope with both the low beam and the high beam, it is possible to reduce a manufacturing cost of the headlamp. In addition, it is possible to reduce the size of the headlamp, or to increase a degree of freedom of design of the headlamp.

[0052] In this case, if electric power applied to the discharge lamp 100 is changed, it is possible to cope with both the low beam and the high beam. However, a general discharge lamp is used as the light source of the low beam. Therefore, if applied electric power is increased to cope with the high beam, since a temperature of the light emitting portion becomes too high, there is a concern that the light emitting portion may swell. If the light emitting portion swells, there is a concern that the service life of the discharge lamp is shortened. In this case, if electric power applied to the discharge lamp is reduced during the high beam in order to suppress swelling of the light emitting portion, there is a concern that all luminous flux necessary for the high beam cannot be obtained.

[0053] As a result of studies, the inventor found that if electric power (electric power during stable lighting) applied to the discharge lamp 100 during the low beam is 24 W or more and 30 W or less, electric power (electric power during stable lighting) applied to the discharge lamp 100 during the high beam is 32 W or more and 38 W or less, when a maximum wall thickness t of the light emitting portion 11 and a sealing pressure P of the inert gas sealed in the discharge space 111 at room temperature (25°C) are as follows, it is possible to suppress swelling of the light emitting portion 11 and to obtain all luminous flux necessary for the high beam.

[0054] Table 1 is a table illustrating a relationship between the maximum wall thickness t of the light emitting portion 11, the sealing pressure P of the inert gas sealed in the discharge space 111 at room temperature (25°C), and the all luminous flux, and swelling of the light emitting portion 11.

Table 1

Maximum wall thickness of light emitting portion 11 t (mm)	Sealing pressure of inert gas P (atm)	P/t (atm/mm)	All luminous flux		Swelling		Overall determination
			high	low	high	low	
1.3	10	7.7	○	○	○	○	○
1.3	11	8.5	○	○	○	○	○
1.3	12	9.2	○	○	○	○	○
1.3	13	10.0	○	○	○	○	○
1.3	14	10.8	○	○	X	○	X
1.3	15	11.5	○	○	X	○	X
1.8	10	5.6	○	X	○	○	X
1.8	11	6.1	○	X	○	○	X
1.8	12	6.7	○	X	○	○	X
1.8	13	7.2	○	○	○	○	○
1.8	14	7.8	○	○	○	○	○
1.8	15	8.3	○	○	○	○	○

[0055] Moreover, in general, the maximum wall thickness t of the light emitting portion 11 is a wall thickness in the vicinity of the center of the light emitting portion 11 in an axial direction of the inner tube 1.

[0056] An internal volume (volume of the discharge space 111) of the light emitting portion 11 was 22 μL.

[0057] The inert gas sealed in the discharge space 111 was xenon.

[0058] A composition ratio of the metal halide 2 was ScI_3:NaI:ZnI_2:InBr = 45wt%:49wt%:4.9wt%:0.1wt%.

[0059] A weight of the metal halide 2 was 0.4 mg.

[0060] A material of the electrode 32 was tungsten.

[0061] An applied electric power during the low beam was 27 W. Moreover, "low" in Table 1 indicates the low beam.

[0062] An applied electric power during the high beam was 34 W. Moreover, "high" in Table 1 indicates the high beam.

[0063] In an evaluation of the all luminous flux, a case where the all luminous flux was 2,000 lumen (lm) or more was indicated by "○" and a case where the all luminous flux was less than 2,000 lumen (lm) was indicated by "X".

[0064] In the evaluation of swelling of the light emitting portion 11, a case where a change in dimension of the light emitting portion 11 in a direction orthogonal to the axial direction of the inner tube 1 was 28% or less was indicated by "○" and a case where the change in dimension of the light emitting portion 11 exceeded 28% was indicated by "X".

[0065] In addition, in an overall evaluation, a case where at least one of the evaluation of the all luminous flux and the evaluation of the swelling of the light emitting portion 11 was "X" was indicated by "X", and a case where both the evaluation of the all luminous flux and the evaluation of the swelling of the light emitting portion 11 were "○" was indicated by "○".

[0066] As can be seen from Table 1, if the sealing pressure P of the inert gas at room temperature (25°C)/maximum wall thickness t of the light emitting portion 11 are set to the following formula, it is possible to suppress the swelling of the light emitting portion 11 and to obtain the all luminous flux necessary during the high beam.

[0067] That is, the discharge lamp 100 capable of coping with the low beam and the high beam can be formed with a simple configuration.

$$7.2\ (\text{atm/mm}) \leq P/t\ (\text{atm/mm}) \leq 10.0\ (\text{atm/mm})$$

[0068] Moreover, in Table 1, although the applied electric power during the low beam was 27 W and the applied electric power during the high beam was 34 W, even if the applied electric power during the low beam is 24 W or more and 30 W or less, and the applied electric power during the high beam is 32 W or more and 38 W or less, it is possible to obtain the same effect.

[0069] In addition, as can be seen from Table 1, it is preferable that the sealing pressure P of the inert gas at room temperature (25°C) satisfies the following formula.

$$10.0\ (\text{atm}) \leq P\ (\text{atm}) \leq 15.0\ (\text{atm})$$

[0070] In addition, as can be seen from Table 1, it is preferable that the maximum wall thickness t of the light emitting portion 11 satisfies the following formula.

$$1.3\ (\text{mm}) \leq t\ (\text{mm}) \leq 1.8\ (\text{mm})$$

[0071] Here, if the applied electric power is changed to switch the low beam and the high beam, the temperature of the electrode 32 is likely to fall outside an appropriate range. In this case, since an arc spot becomes unstable even if the temperature of the electrode 32 is too high or too low, flickering occurs. When flickering occurs, it causes discomfort to a driver and other people.

[0072] According to the findings obtained by the inventor, the arc spot can be stabilized if the distance (distance between the electrodes) between tips of the pair of the electrodes 32 satisfies the following formula. Therefore, the occurrence of the flickering can be suppressed.

$$3.0\ (\text{mm}) \leq L1\ (\text{mm}) \leq 3.6\ (\text{mm})$$

[0073] In this case, if a thickness dimension (diameter dimension) d of the electrode 32 is set as the following formula, it is easy to suppress the occurrence of flickering.

$$0.24\ (\text{mm}) \leq d\ (\text{mm}) \leq 0.33\ (\text{mm})$$

[0074] In addition, according to the findings obtained by the inventor, a distance L2 between an outer surface of the light emitting portion 11 and an inner surface of the outer tube 5 is set as the following formula, a heat dissipation performance can be improved. Therefore, it is easy to suppress the swelling of the light emitting portion 11.

$$0.5\ (\text{mm}) \leq L2\ (\text{mm}) \leq 1.5\ (\text{mm})$$

Vehicle Lamp and Vehicle Lighting Device

[0075] FIG. 2 is a schematic view illustrating a vehicle lamp 200 and a vehicle lighting device 300.

[0076] FIG. 3 is a block view of the vehicle lighting device 300.

[0077] FIG. 2 illustrates a case where the discharge lamp 100 is attached such that the pair of the electrodes 32 provided in the discharge lamp 100 is horizontal. That is, a case of the discharge lamp 100 to be horizontal lighting is illustrated.

[0078] As illustrated in FIG. 2, the vehicle lighting device 300 is provided with the vehicle lamp 200, the lighting circuit 301, and a changeover switch 302.

[0079] The vehicle lamp 200 is provided with the discharge lamp 100, a housing 202, a light shielding control plate 203, and a lens 204.

[0080] The housing 202 reflects the light irradiated from the discharge lamp 100 to the front end side. The housing 202 is formed of, for example, a metal having high reflectance. A space is provided on an inside of the housing 202 and an inner surface has a parabolic shape.

[0081] A front end side and a rear end side of the housing 202 are opened.

[0082] The discharge lamp 100 is attached to the housing 202. The socket 102 of the discharge lamp 100 is attached to the vicinity of the opening of the rear end side of the housing 202. The burner 101 of the discharge lamp 100 is positioned at the space on the inside of the housing 202.

[0083] That is, the housing 202 has a function of holding the discharge lamp 100 and a function of a reflector.

[0084] The light shielding control plate 203 is provided on the inside of the housing 202 and is provided on the front end side of the burner 101 and on a lower end side of the burner 101.

[0085] The light shielding control plate 203 is formed of a light shielding material such as a metal. The light shielding control plate 203 is provided to form a light distribution called a cut line. The light shielding control plate 203 is movable.

[0086] The lens 204 is provided so as to close the opening on the front end side of the housing 202. The lens 204 can be a convex lens. The lens 204 condenses the light directly incident from the discharge lamp 100 and the light reflected and incident by the housing 202 to form a desired light distribution.

[0087] The lighting circuit 301 is a circuit for starting of the discharge lamp 100 and maintaining the lighting.

[0088] As illustrated in FIG. 3, the lighting circuit 301 may include, for example, an igniter circuit 301a and a ballast circuit 301b.

[0089] A DC power source DS such as a battery and a switch SW are electrically connected to an input side of the lighting circuit 301. The discharge lamp 100 is electrically connected to an output side of the lighting circuit 301.

[0090] The igniter circuit 301a is composed of, for example, a transformer, a capacitor, a resistor, a semiconductor element, and the like. The igniter circuit 301a generates a high voltage pulse of substantially 30 kV and applies the high voltage pulse to the discharge lamp 100. Insulation breakdown occurs between the pair of electrodes 32 and electric discharge occurs by applying a high voltage pulse of substantially 30 kV to the discharge lamp 100. That is, the igniter circuit 301a starts the discharge lamp 100.

[0091] The ballast circuit 301b maintains the lighting of the discharge lamp 100 started by the igniter circuit 301a.

[0092] In addition, the ballast circuit 301b has a low beam ballast circuit and a high beam ballast circuit. Each of the low beam ballast circuit and the high beam ballast circuit has, for example, a DC/DC conversion circuit, a DC/AC conversion circuit, a current and voltage detection circuit, a control circuit, and the like. The low beam ballast circuit applies electric power of 24 W or more and 30 W or less to the discharge lamp 100 during stable lighting. The high beam ballast circuit applies electric power of 32 W or more and 38 W or less to the discharge lamp 100 during stable lighting.

[0093] The changeover switch 302 performs switching between the low beam and the high beam based on an input by a driver or the like. That is, the changeover switch 302 switches the low beam ballast circuit and high beam ballast circuit based on an input by the driver or the like. Therefore, predetermined electric power is supplied from the low beam ballast circuit or high beam ballast circuit switched by the changeover switch 302 to the discharge lamp 100.

[0094] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions. Moreover, above-mentioned embodiments can be combined mutually and can be carried out.

Claims

1. A discharge lamp (100) comprising:

a light emitting portion (11) that has a discharge space (111) in which a metal halide and inert gas are sealed on an inside thereof; and
a pair of electrodes (32) that protrudes to an inside of the discharge space (111) and faces each other at a predetermined distance,
electric power applied to the discharge lamp (100) during a low beam is 24 W or more and 30 W or less, and electric power applied to the discharge lamp (100) during a high beam is 32 W or more and 38 W or less, and the following formula is satisfied where a maximum wall thickness of the light emitting portion (11) is t (mm) and a sealing pressure of the inert gas at room temperature (25°C) is P (atm).

$$7.2\ (\mathrm{atm/mm}) \leq P/t\ (\mathrm{atm/mm}) \leq 10.0\ (\mathrm{atm/mm})$$

2. The lamp (100) according to claim 1,
wherein the maximum wall thickness of the light emitting portion (11) satisfies the following formula.

$$1.3\ (\mathrm{mm}) \leq t\ (\mathrm{mm}) \leq 1.8\ (\mathrm{mm})$$

3. The lamp (100) according to claim 1 or 2,
wherein a sealing pressure of the inert gas at room temperature (25°C) satisfies the following formula.

$$10.0\ (\mathrm{atm}) \leq P\ (\mathrm{atm}) \leq 15.0\ (\mathrm{atm})$$

4. A vehicle lamp (200) comprising:

the discharge lamp (100) according to any one of claims 1 to 3; and
a housing (202) to which the discharge lamp (100) is attached.

5. A vehicle lighting device (300) comprising:

the vehicle lamp (200) according to claim 4; and
a lighting circuit (301) that is electrically connected to the discharge lamp (100) provided in the vehicle lamp (200), the lighting circuit (301) has an igniter circuit (301a), a low beam ballast circuit (301b), and a high beam ballast circuit (301b).

6. The device (300) according to claim 5, further comprising:

a changeover switch (302) that performs switching between the low beam ballast circuit (301b) and the high beam ballast circuit (301b).

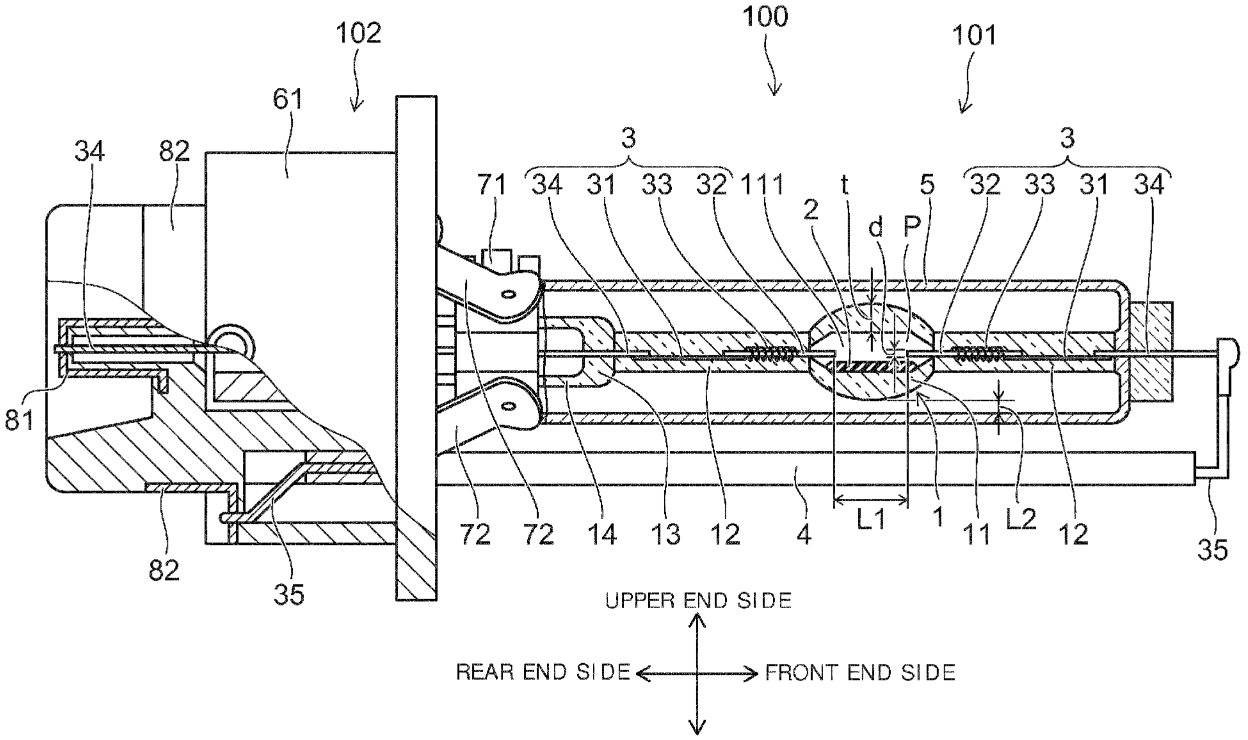
102
100
101
61
34
82
3
71
34
31
33
32
111
t
2
5
d
P
32
33
31
34
81
82
35
72
72
14
13
12
4
L1
1
11
L2
12
35
UPPER END SIDE
REAR END SIDE
FRONT END SIDE
LOWER END SIDE

FIG. 1

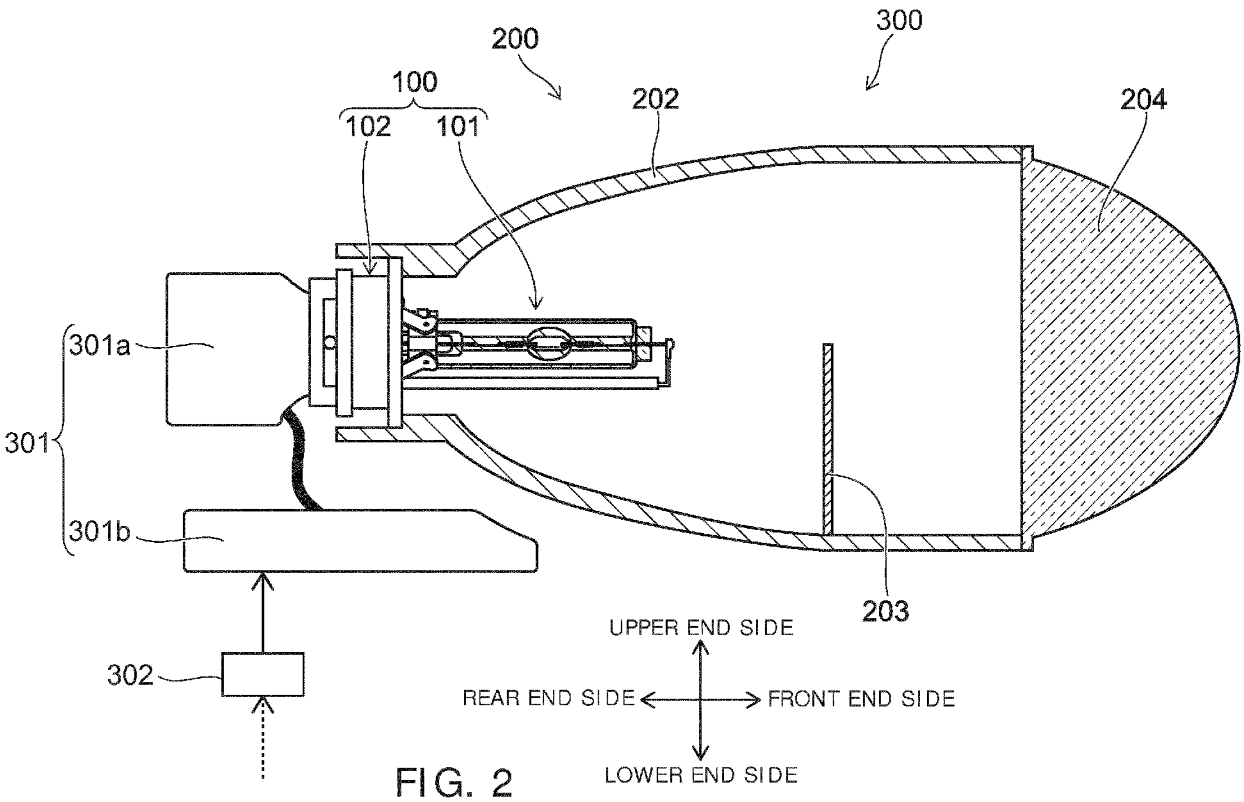
200
300
100
102
101
202
204
301a
301
301b
203
302
UPPER END SIDE
REAR END SIDE
FRONT END SIDE
LOWER END SIDE

FIG. 2

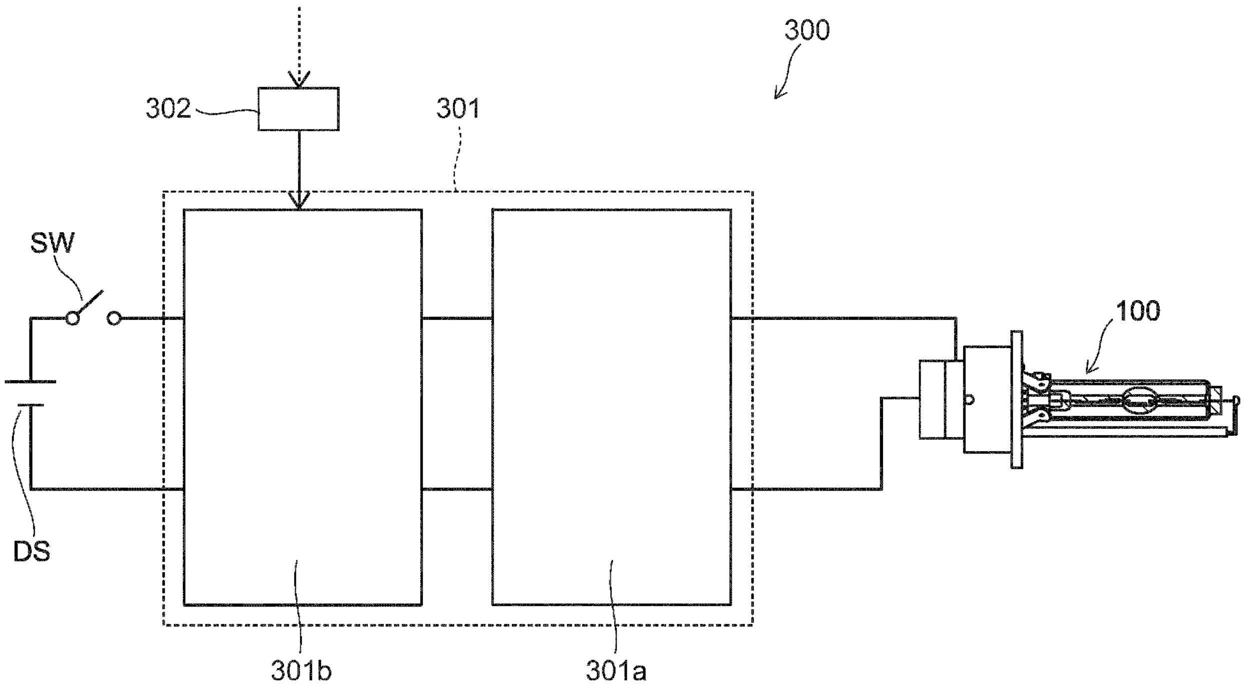

FIG. 3

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 17 18 5718

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	US 2012/056539 A1 (DEGUCHI MAKOTO [JP] ET AL) 8 March 2012 (2012-03-08) * abstract * * paragraphs [0001], [0006], [0052] - [0114], [0123] - [0131]; figures 1-4,7-9,12-13 * -----	1-4 5,6	INV. H01J61/34 H01J61/82
X Y	US 2014/125224 A1 (KATO SATOKO [JP]) 8 May 2014 (2014-05-08) * abstract * * paragraphs [0008], [0016] - [0037]; figures 1,2 * -----	1-4 5,6	
X Y	US 2014/042889 A1 (HAACKE MICHAEL [DE] ET AL) 13 February 2014 (2014-02-13) * abstract * * paragraphs [0001], [0011], [0028], [0041] - [0068]; figures 1-3 * -----	1-4 5,6	
Y	EP 2 420 407 A1 (KOITO MFG CO LTD [JP]) 22 February 2012 (2012-02-22) * abstract * * paragraphs [0009] - [0010], [0016] - [0072], [0086]; figures 1-4 * -----	5,6	TECHNICAL FIELDS SEARCHED (IPC) H01J F21S
Y	US 5 264 993 A (NEUMANN RAINER [DE] ET AL) 23 November 1993 (1993-11-23) * abstract * * column 2, lines 40-44 * * column 4, line 7 - column 5, line 3; figures 3,4 * -----	5,6	

The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
Munich	9 March 2018	Lang, Thomas

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 17 18 5718

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

09-03-2018

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2012056539 A1	08-03-2012	EP 2405464 A1	11-01-2012
		US 2012056539 A1	08-03-2012
		WO 2010100935 A1	10-09-2010
US 2014125224 A1	08-05-2014	CN 103748657 A	23-04-2014
		EP 2725604 A1	30-04-2014
		JP WO2012176493 A1	23-02-2015
		US 2014125224 A1	08-05-2014
		WO 2012176493 A1	27-12-2012
US 2014042889 A1	13-02-2014	CN 103493175 A	01-01-2014
		EP 2702605 A2	05-03-2014
		JP 6010111 B2	19-10-2016
		JP 2014512662 A	22-05-2014
		US 2014042889 A1	13-02-2014
		WO 2012147014 A2	01-11-2012
EP 2420407 A1	22-02-2012	CN 102378459 A	14-03-2012
		EP 2420407 A1	22-02-2012
		JP 5551545 B2	16-07-2014
		JP 2012040967 A	01-03-2012
US 5264993 A	23-11-1993	NONE	

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82