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(54) METAL HALIDE LAMP

(57) A mercury-free metal halide lamp for a vehicle includes a light emitting section that has a discharge space inside; a light emitting tube that includes a pair of seal sections formed on both sides of the light emitting section; metal halide and an inert gas enclosed in the discharge space; and a pair of electrodes that is provided so that one end sides thereof are sealed in the seal sections and the other end sides thereof face each other in the discharge space. In addition, electric power of 23 W to 27 W is supplied between the pair of electrodes during stable lighting. The discharge space includes a cylindrical section, and a pair of cone-shaped sections which are formed on both end sections of the cylindrical section and of which diameters decrease in a direction from the cylindrical section to the seal portions. Then, when a thickness of a maximum outer diameter section of the light emitting section is d1, and a thickness of the light emitting section between a point on the cone-shaped section when a perpendicular line is drawn from a boundary point between the light emitting section and the seal section to the cone-shaped section, and the boundary point is d2, 1.6 mm ≤ d1 ≤ 1.8 mm, and 0.75 ≤ d2/d1 ≤ 0.95 are satisfied.

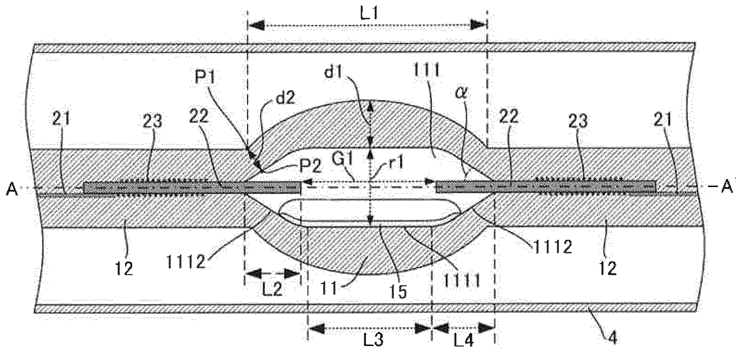

FIG. 3

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Description

Technical Field

[0001] An embodiment of the present invention relates to a metal halide lamp used in a headlight of a vehicle such as an automobile.

Background Art

[0002] The metal halide lamp is obtained by enclosing metal halide or an inert gas in a light emitting tube, and is used in a headlight of an automobile. In the related art, this kind of metal halide lamp is generally turned on with electric power of 35 W for the stable lighting. However, recently, a metal halide lamp which is turned on with electric power of 25 W has been developed. In addition, a so-called D5 type metal halide lamp integrated with an igniter that initiates the metal halide lamp and ballast that stably lights the metal halide lamp has been developed.

[0003] The metal halide lamp such as the D5-type igniter and ballast integrated with the metal halide lamp is very compact. Therefore, the distance between the light emitting tube and the circuit is shortened. As a result, the heat load increases and a radiation space decreases, and thus it becomes difficult to design in terms of the temperature. In the metal halide lamp for the vehicle, a method of accelerating the rise of the supply of higher electric power at the time of initiation rather than at the time of stable lighting is employed. However, since the electric current value which is input at the time of the initiation is limited, there is a problem in that the predetermined electric power is not supplied, and the luminous flux start-up of the lamp is slow.

Patent Literature

[0004] [PTL 1] JP-T-2010-521771

Summary of Invention

Technical Problem

[0005] A problem to be solved by the invention is to provide a metal halide lamp of which luminous flux start-up is fast. Solution to Problem

[0006] In order to achieve the object described above, there is provided a mercury-free metal halide lamp for a vehicle, including a light emitting section that has a discharge space inside; a light emitting tube that includes a pair of seal sections formed on both sides of the light emitting section; metal halide and an inert gas enclosed in the discharge space; and a pair of electrodes that is provided so that one end sides thereof are sealed in the seal sections and the other end sides thereof face each other in the discharge space. In addition, electric power of 23 W to 27 W is supplied between the pair of electrodes during stable lighting. The discharge space includes a cylindrical section, and a pair of cone-shaped sections which are formed on both end sections of the cylindrical section and of which diameters decrease in a direction from the cylindrical section to the seal portions. Then, when a thickness of a maximum outer diameter section of the light emitting section is d1, and a thickness of the light emitting section between a point on the cone-shaped section when a perpendicular line is drawn from a boundary point between the light emitting section and the seal section to the cone-shaped section, and the boundary point is d2, $1.6\ \text{mm} \leq d1 \leq 1.8\ \text{mm}$, and $0.75 \leq d2/d1 \leq 0.95$ are satisfied.

Brief Description of Drawings

[0007]

Fig. 1 is a diagram illustrating a metal halide lamp according to a first embodiment.

Fig. 2 is a cross-sectional view illustrating the metal halide lamp according to the first embodiment.

Fig. 3 is a diagram illustrating a portion near a light emitting section of the metal halide lamp in Fig. 2.

Fig. 4 is a diagram illustrating an external appearance of the metal halide lamp near the light emitting section according to the first embodiment.

Fig. 5 is a diagram illustrating a lamp voltage right after the initiation of the metal halide lamp according to the first embodiment.

Fig. 6 is a diagram illustrating lamp voltages right after initiation, luminous flux start-up, and life spans when thicknesses d1 and d2 of the light emitting section are changed.

Fig. 7 is a diagram illustrating a metal halide lamp according to another embodiment.

Description of Embodiments

[0008] Hereinafter, an embodiment for carrying out the invention is described.

(First embodiment)

[0009] A metal halide lamp according to a first embodiment is described with reference to the drawings.

[0010] Fig. 1 is a diagram illustrating a metal halide lamp according to the first embodiment.

[0011] Fig. 2 is a cross-sectional view of the metal halide lamp according to the first embodiment.

[0012] Fig. 3 is a diagram illustrating a portion near a light emitting section of the metal halide lamp in Fig. 2.

[0013] Further, in the specification, for convenience, a direction of an arrow F illustrated in Fig. 2 which becomes the forward side when the metal halide lamp is arranged in a vehicle, is referred to as a front end, and a direction of an arrow B is referred to as a rear end.

[0014] The metal halide lamp of Fig. 1 is an HID lamp that can be used as a light source for a headlight of an automobile, and includes a burner BN and a flange FL.

[0015] The burner BN has a double tube structure, and a light emitting tube 1 is provided inside thereof, as an internal tube. The light emitting tube 1 has a long and narrow shape, and in a portion near the center in the longitudinal direction thereof, a light emitting section 11 that emits light when turned on is formed. The light emitting section 11 is substantially elliptical, and, plate-shaped seal sections 12 formed with a pinch seal are formed on both ends thereof. Further, on both ends of the seal section 12, a cylinder section 14 is continuously formed through a boundary section 13. Since the light emitting tube 1 includes a light emitting portion as described above, and also becomes a high temperature when turned on, the light emitting tube 1 is preferably made of a material that has translucency and heat resistance such as quartz glass.

[0016] A discharge space 111 is formed in the light emitting section 11. The discharge space 111 has a long and narrow shape along the tube axis A-A'. The discharge space 111 includes a cylindrical section 1111 in the center portion in the longitudinal direction, and a pair of cone-shaped sections 1112 on both ends. The cone-shaped section 1112 has a shape in which the diameter decreases as it moves from the end portion of the cylindrical section 1111 along the direction of the seal section 12, specifically, from the cylindrical section 1111 to a shaft surface of an electrode, to be described below. An internal diameter r1 of the discharge space 111 is 1.9 mm to 2.3 mm, and a volume thereof is 16 mm^3 to 21 mm^3, and preferably 17 mm^3 to 20 mm^3.

[0017] Metal halide 15 and an inert gas are enclosed in the discharge space 111. The metal halide 15 is configured with sodium halide, scandium halide, zinc halide, and indium halide. The metal halide 15 is, for example, sodium iodide, scandium iodide, zinc iodide, and indium bromide. A total enclosed amount of the metal halide 15 is preferably 0.1 mg to 0.3 mg.

[0018] Xenon is used as an inert gas. The enclosure pressure of the inert gas can be adjusted depending on the purpose. For example, in order to enhance the characteristic of total luminous flux or the like, the enclosed pressure may be set to be equal to or greater than 12 atm, and preferably be equal to or greater than 13 atm at room temperature (25°C). However, the upper limit of the enclosing pressure is about 20 atm during the manufacturing at present.

[0019] Here, the metal halide lamp according to the embodiment is a mercury free metal halide lamp. The expression of "mercury free" means that mercury is not substantially included. In the specification, the expression of "mercury is not substantially included" is not limited to a case where the enclosed amount of mercury is 0 mg. That is, the expression should be interpreted to include a case where mercury is enclosed in an amount that can be considered where almost no mercury is enclosed compared with a mercury-containing discharge lamp in the related art, for example, an amount of less than 2 mg for each 1 ml, or preferably equal to or less than 1 mg.

[0020] In the seal sections 12, electrode mounts 2 are sealed. The electrode mounts 2 each include metal foil 21, an electrode 22, a coil 23, and a lead 24.

[0021] The metal foils 21 are, for example, thin metal plates formed of molybdenum. The metal foils 21 are arranged so that the plate-shaped surfaces of the metal foils 21 are parallel to the plate-shaped surfaces of the seal sections 12.

[0022] The electrodes 22 are, for example, rod-shaped members configured with tungsten doped with thorium oxide, which is so-called thoriated tungsten. A diameter R of the electrode 22 is 0.23 mm to 0.33 mm, and preferably 0.26 mm to 0.31 mm. One ends of the electrodes 22 are welded in a state of being mounted on end portions of the metal foils 21 on the light emitting section 11 side. The electrodes 22 are arranged so that other ends of the electrodes 22 protrude into the discharge space 111, and the distal end sections thereof face each other to have a predetermined distance. The predetermined distance is a range of 3.7 mm to 4.2 mm when viewed through an outer tube 4. Further, the shapes of the electrodes 22 are not limited to a straight rod shape in which the diameter is substantially constant in a tube axis direction. For example, the shapes of the electrodes 22 may be an unstraight rod shape in which a diameter in a distal end section is greater than a diameter of a base end section, a shape in which a distal end is a sphere, and a shape in which an electrode diameter on one end is different from that on the other end, like a direct current lighting type. In addition, a material of the electrode 22 may be pure tungsten, doped tungsten, or rhenium tungsten.

[0023] The coils 23 are formed of, for example, metal wires formed of doped tungsten. It is recommended that the coils 23 be wound around shaft sections of the electrodes 22 sealed with the seal sections 12 in a spiral shape.

[0024] The leads 24 are, for example, metal wires formed of molybdenum. One ends of the leads 24 are connected in a state of being mounted on end sections of the metal foils 21 on a far side from the light emitting section 11. The other ends of the leads 24 extend to the outside of the light emitting tube 1 substantially parallel to the tube axis. For example, one end of an L-shaped support wire 25 formed of nickel is connected to the leads 24 extending to the front end side of the metal halide lamp by laser welding. For example, a sleeve 3 formed of ceramic is installed on the support wire 25 in a portion extending parallel to the light emitting tube 1.

[0025] The cylindrical outer tube 4 is provided on the outside of the light emitting tube 1 configured as described above in a concentric shape with the light emitting tube 1. The connection between the light emitting tube 1 and the outer tube 4 is performed by welding the outer tube 4 around the cylinder section 14 of the light emitting tube 1. That is, a welding section 41 is formed on both end sections of the burner BN, and an air tightly kept space is formed between the light emitting tube 1 and the outer tube 4. In this space, a kind of gas selected from neon, argon, xenon, and nitrogen, or a mixture thereof is enclosed at a pressure of equal to or less than 1 atm, and preferably equal to less than 0.2 atm. Further, as a material of the outer tube 4, it is preferable to use a material of which the thermal expansion coefficient is close to that of the light emitting tube 1, and which has an ultraviolet screening property, such as quartz glass to which oxides such as titanium, cerium, or aluminum are added.

[0026] A metal band 5 is provided on the rear end side of the burner BN configured as described above. The metal band 5 is obtained by molding, for example, a metal plate formed of stainless steel along the outer peripheral surface of the outer tube 4. The metal band 5 is fixed to the burner BN by welding metal sections overlapped with each other.

[0027] The disk-shaped flange FL having a diameter of about 31 mm and a thickness of about 2.5 mm is arranged near the metal band 5. The flange FL is configured with the resin section 6 and the metal section 7.

[0028] The resin section 6 is obtained by molding a resin such as a poly phenylene sulfide (PPS) resin or a polyetherimide (PEI) resin. The resin section 6 is positioned in the periphery of the flange FL. Three protuberance sections 61 are formed on the surface of the flange FL on the front end side. The protuberance sections 61 are portions that become base points when dimensions are measured. For example, a distance D1 from a distal end of the protuberance sections 61 to a center between electrodes in the light emitting section 11 is regulated as a light center length (LCL) of the metal halide lamp. The distance D1 is, for example, 18.0 mm. Since the distance in the related art is 27.1 mm, the distance D1 is set to be shorter.

[0029] A metal section 7 is a metal plate formed of stainless steel. The metal section 7 is formed to be embedded in a resin section 6. Projecting sections 71, and a sleeve holding section 72 are formed in the metal section 7. The projecting sections 71 are projecting parts formed to protrude in a direction toward the space provided in the center of the metal section 7, and four projecting sections 71 are provided at even intervals. The projecting sections 71 are obliquely turned downward in the rear end direction, and welded with the metal band 5 in the distal end section. That is, the burner BN is maintained in the flange FL through the projecting sections 71. The sleeve holding section 72 is a metal plate formed to protrude toward the center of the metal section 7. A circular hole is formed in the center of the sleeve holding section 72, and the sleeve 3 is inserted through the hole.

[0030] A base 8 is arranged on the rear end side of the flange FL. The base 8 is a hollow housing formed of, for example, stainless steel, iron, nickel, and aluminum. The flange FL is connected to the front end side of the base 8. The connection is performed by, for example, laser welding between a ring 81 provided so as to protrude to the front end side of the base 8 and the metal section 7 of the flange FL. A lighting initiation circuit called an igniter and a lighting stabilizing circuit called ballast are arranged in the base 8 (not illustrated). The lighting initiation circuit or the lighting stabilizing circuit is a well-known circuit including circuit elements or metal terminals such as a transformer or a capacitor required for the initiation of a discharge lamp or the stable lighting of a discharge lamp.

[0031] The metal halide lamp configured as described above is attached to a lighting tool (not illustrated) so that the tube axis A-A' of the lamp becomes substantially horizontal or the support wire 25 is downwardly positioned. The metal halide lamp at the time of initiation is lighted with electric power two times or greater than at the time of stable lighting, and is lighted with electric power of 23 W to 27 W, especially 25 W at the time of stable lighting.

[0032] Here, the metal halide lamp according to the embodiment has a structure that satisfies 1.6 mm $\leq$ d1 $\leq$ 1.8 mm, and 0.75 $\leq$ d2/d1 $\leq$ 0.95 when a thickness of a maximum outer diameter of the light emitting section 11 is d1, and a thickness of the end section is d2. According to this structure, the lens effect caused by the light emitting section 11 can be reduced. The lens effect refers to the effect in which when an actual distance between electrodes (hereinafter, actual gap) G1 illustrated in Fig. 3 is 3.7 mm, a distance between electrodes in an exterior appearance illustrated in Fig. 4 (hereinafter, exterior appearance gap) G2 becomes 4.2 mm. That is, since the metal halide lamp in the embodiment can cause a difference in length between the actual gap G1 and the exterior appearance gap G2 to be small, it is possible to expand the actual gap G1 as much as possible while causing the exterior appearance gap H2 to be within a standard upper limit value. Further, when a boundary point between the light emitting section 11 and the seal section 12 is P1, and a point on the cone-shaped section 1112 when a perpendicular line is drawn from the boundary point P1 to the cone-shaped section 1112 is P2, a thickness d2 is a thickness of the light emitting section 11 between the boundary point P1 and the point P2. The thickness d2 can be measured by, for example, an X-ray photograph.

[0033] Hereinafter, an example of the metal halide lamp according to the embodiment is described.

(Example)

[0034] The light emitting section 11 was made of quartz glass.

[0035] Dimensions of respective sections of the light emitting section 11 were as described below.

[0036] An internal volume of the discharge space 111 was 18.4 mm^3, the maximum internal diameter r1 of the discharge space 111 was 2.2 mm, the maximum outer diameter of the light emitting section 11 was 5.5 mm, the thickness d1 of the light emitting section 11 was 1.65 mm, the thickness d2 of the light emitting section 11 was

1.24 mm (accordingly, d2/d1 = 0.75), the sphere length of the light emitting section 11 in the longitudinal direction was 7.8 mm, a length L3 of the cylindrical section 1111 of the discharge space 111 was 3.95 mm, a length L4 of the cone-shaped section 1112 of the discharge space 111 was 1.85 mm (accordingly, L4/L3 = 0.47), and the angle α of the cone-shaped section 1112 of the discharge space 111 was 18°.

[0037] The thickness of the seal section 12 was 2.8 mm, and the width thereof was 4.1 mm.

[0038] The composition of the metal halide 15 is described below.

[0039] ScI_3 : NaI : ZnI_2 : InBr = 47.5 : 47.5 : 4.75 : 0.25

[0040] The weight of the metal halide 15 was 0.2 mg.

[0041] The inert gas was xenon, and the gas pressure was 13 atm.

[0042] Mercury was 0 mg.

[0043] The metal foil 21 was made of molybdenum. The length of the metal foil 21 was 6.5 mm, the width thereof was 1.5 mm, and the thickness thereof was 0.02 mm.

[0044] The electrode 22 was made of thoriated tungsten. The diameter R of the electrode 22 was 0.30 mm, the actual gap G1 was 3.75 mm, and the exterior appearance gap G2 was 4.2 mm (accordingly, G2/G1 = 1.12).

[0045] The coil 23 was made of doped tungsten. The wire diameter of the coil 23 was 0.09 mm, the pitch thereof was 200%, and the coil winding length in the electrode axis was 3.5 mm.

[0046] The lead 24 was made of molybdenum. The diameter of the lead 24 was 0.4 mm.

[0047] The internal diameter of the outer tube 4 was 7.0 mm, and the thickness thereof was 1.0 mm.

[0048] The gas enclosed inside the outer tube 4 was nitrogen, and the enclosing pressure was 0.1 atm.

[0049] The metal halide lamp configured as described above (hereinafter, Examples) was turned on. A lamp voltage V_0 right after the initiation was 24 V, and the initiation power was 60 W. In addition, since the luminous flux after 4 seconds from the initiation exceeds 1000 lm, it was confirmed that luminous flux start-up is fast. Further, the lamp voltage V_0 right after the initiation is a voltage right after breakdown, that is, a voltage when the lamp voltage becomes lowest as illustrated in Fig. 5.

[0050] As in the metal halide lamp according to the example, in order to accelerate the luminous flux start-up of the metal halide lamp in initiation, it is important to supply high electric power so that the temperature of the light emitting section rises fast. However, the metal halide lamp of which the distance between the light emitting tube and the circuit is short is difficult to be designed in terms of temperature, and thus it is difficult for a high electric voltage to flow. If the electric current value is limited, the high electric voltage cannot be supplied at the time of initiation, and the luminous flux start-up is slow. In the metal halide lamp of which the electric current value is limited, in order to supply the high electric power, it is preferable to cause the lamp voltage at the point, especially, the lamp voltage V_0 right after the initiation to be high.

[0051] As a method of causing the lamp voltage to be high right after the initiation, there is a method of expanding the actual gap G1. For example, when the actual gap G1 is expanded by 0.5 mm, it is possible to increase the lamp voltage V_0 right after the initiation by about 0.5 V. However, since the upper limit of the exterior appearance gap G2 is restricted by the standard, the actual gap G1 has to be designed within the range. Therefore, a lamp having a different ratio (d2/d1) between the thickness d1 in the center of the light emitting section 11 and the thickness d2 in the end section is prepared so that the lens effect of the light emitting section 11 can be changed, and a test is performed. The result of the test is presented in Fig. 6.

[0052] First, in view of the ratio (d2/d1) between the thickness d1 in the center of the light emitting section 11 and the thickness d2 in the end section, when d2/d1 is equal to or lower than 0.65, the lamp voltage V_0 right after the initiation tends to decrease. This is because the effect of decreasing the lens effect is low, the actual gap G1 is not expanded, and thus the exterior appearance gap G2/the actual gap G1 is great. If the lamp voltage V_0 right after the initiation is low, it is required to supply high electric current in order to supply high electric power at the time of the initiation. When the electric current value exceeds the restriction of the electric current value that can be supplied to the metal halide lamp, the predetermined electric power may not be supplied. Therefore, the luminous flux start-up or the like may be influenced.

[0053] Meanwhile, when d2/d1 is equal to or greater than 1.05, the luminous flux start-up tends to be slow. This is because the total thickness of the light emitting section 11 increases, and thus the increase of the temperature of the light emitting section 11 at the time of initiation becomes slow. Further, when the thickness d1 is equal to or greater than 1.9 mm, the luminous flux start-up is slow regardless of d2/d1. In addition, in view of the thickness d1 of the light emitting section 11, the thickness d1 is equal to or smaller than 1.5 mm, and the life span tends to decrease. This is because the portion having the thickness is the portion of which the temperature is highest during the lighting, and if the thickness d1 is equal to or less than 1.5 mm, the temperature rises too high.

[0054] From the above, when the thickness in the maximum outer diameter section of the light emitting section 11 is d1, and the thickness in the end section is d2, it is important to satisfy 1.6 mm $\leq$ d1 $\leq$ 1.8 mm, and 0.75 $\leq$ d2/d1 $\leq$ 0.95. By satisfying the relationships, it is possible to raise the lamp voltage V_0 right after the initiation, accelerate the luminous flux start-up, and lengthen the life span.

[0055] Further, the metal halide lamp according to the embodiment may be combined with the configuration below.

[0056] The angle α of the cone-shaped section 1112 preferably satisfies 16° $\leq \alpha \leq$ 35°, and more preferably

16° ≤ α ≤ 21°. This is because the angle α influences the lens effect, and the lens effect increases as the angle α decreases. Further, for the same reason, L4/L3 which is the length ratio between the cylindrical section 1111 and the cone-shaped section 1112 preferably satisfies 0.4 ≤ L4/L3 ≤ 0.6. In addition, the distal end section of the electrode 12 is preferably arranged in the same position with the boundary portion between the cylindrical section 1111 and the cone-shaped section 1112, specifically at a position of ±1.0 mm with respect to the boundary portion.

[0057] The thickness d2 of the light emitting section 11 preferably satisfies 1.0 mm ≤ d2 ≤ 1.4 mm. In addition, it is preferable that the internal diameter r1 of the discharge space 111 be 1.9 mm to 2.3 mm, the volume thereof be 16 mm^3 to 21 mm^3, the pressure of xenon which is the inert gas be 12 atm to 20 atm, and a length L1 of the light emitting section 11 in the boundary between the light emitting section 11 and a pair of seal sections 12 be 7.5 mm to 8.2 mm. This is because this configuration also influences the luminous flux start-up and the life span in the same manner as the thickness d1 of the light emitting section 11.

[0058] In the embodiment, the discharge space 111 includes the cylindrical section 1111, the pair of cone-shaped sections 1112 which are formed on both end sections of the cylindrical section 1111, and of which diameters decrease in the direction from the cylindrical section 1111 to the seal sections 12. Then, when the thickness of the maximum outer diameter section of the light emitting section 11 is d1, and the thickness of the light emitting section 11 between the point P2 on the cone-shaped section 1112 when a perpendicular line is drawn from the boundary point P1 between the light emitting section 11 and the seal section 12 to the cone-shaped section 1112, and the boundary point P1 is d2, 1.6 mm ≤ d1 ≤ 1.8 mm, and 0.75 ≤ d2/d1 ≤ 0.95 are satisfied. Therefore, it is possible to provide the metal halide lamp of which the luminous flux start-up is fast, of which the lamp voltage V_0 right after the lighting is high, and of which the life span is long. At this point, it is preferable that the angle α of the cone-shaped section 1112 satisfies 16° ≤ α ≤ 35°, and the thickness d2 of the light emitting section 11 satisfies 1.0 mm ≤ d2 ≤ 1.4 mm.

[0059] The invention is not limited to the embodiment described above, and various kinds of modifications are possible. For example, the metal halide lamp may be a metal halide lamp which is a type that only includes an igniter, or may be a metal halide lamp which is a type that does not include a lighting circuit as illustrated in Fig. 7. In addition, the flange FL may be substantially made of metal only, or may be substantially made of a resin only.

[0060] The cone-shaped section 1112 does not have to be a complete cone shape, and may be an arc shape, a shape in which they are gradually bent a plurality of times, or a shape that is somewhat irregular. The point is that the cone-shaped section 1112 may have any shape as long as the diameter thereof decreases so that a perpendicular line can be drawn from the boundary point P1.

[0061] The configuration of the metal halide 15 is not limited to the examples, and may include tin halide, cesium halide, or the like, or may remove zinc halide. In addition, halogen to be combined with the metal halide 15 is not limited to iodine or bromine, and may be combined with chlorine or the like. In addition, the inert gas is not limited to xenon, neon, argon, krypton, or the like may be used, and the combination thereof may also be used.

[0062] 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.

Claims

1. A mercury-free metal halide lamp for a vehicle, comprising:

a light emitting section that has a discharge space inside;
a light emitting tube that includes a pair of seal sections formed on both sides of the light emitting section;
metal halide and an inert gas enclosed in the discharge space; and
a pair of electrodes that is provided so that one end sides thereof are sealed in the seal sections and the other end sides thereof face each other in the discharge space,
wherein electric power of 23 W to 27 W is supplied between the pair of electrodes during stable lighting,
wherein the discharge space includes a cylindrical section, and a pair of cone-shaped sections which are formed on both end sections of the cylindrical section and of which diameters decrease in a direction from the cylindrical section to the seal portions,
wherein when a thickness of a maximum outer diameter section of the light emitting section is d1, a thickness of the light emitting section between a point on the cone-shaped section when a perpendicular line is drawn from a boundary point between the light emitting section and the seal section to the cone-shaped section, and the boundary point is d2, 1.6 mm ≤ d1 ≤ 1.8 mm,

and $0.75 \leq d2/d1 \leq 0.95$ are satisfied.

2. The metal halide lamp according to Claim 1, wherein when an angle of the cone-shaped section to the electrode axis is α, $16° \leq \alpha \leq 35°$ is satisfied.

3. The metal halide lamp according to Claim 1, wherein when a thickness of the light emitting section is d2, $1.0 \text{ mm} \leq d2 \leq 1.4 \text{ mm}$ is satisfied.

4. The metal halide lamp according to Claim 1, wherein an internal diameter r1 of the discharge space is 1.9 mm to 2.3 mm, a volume is 16 mm^3 to 21 mm^3, a pressure of the inert gas is 12 atm to 20 atm, and a length L1 of the light emitting section in a boundary between the light emitting section and the pair of seal sections is 7.5 mm to 8.2 mm.

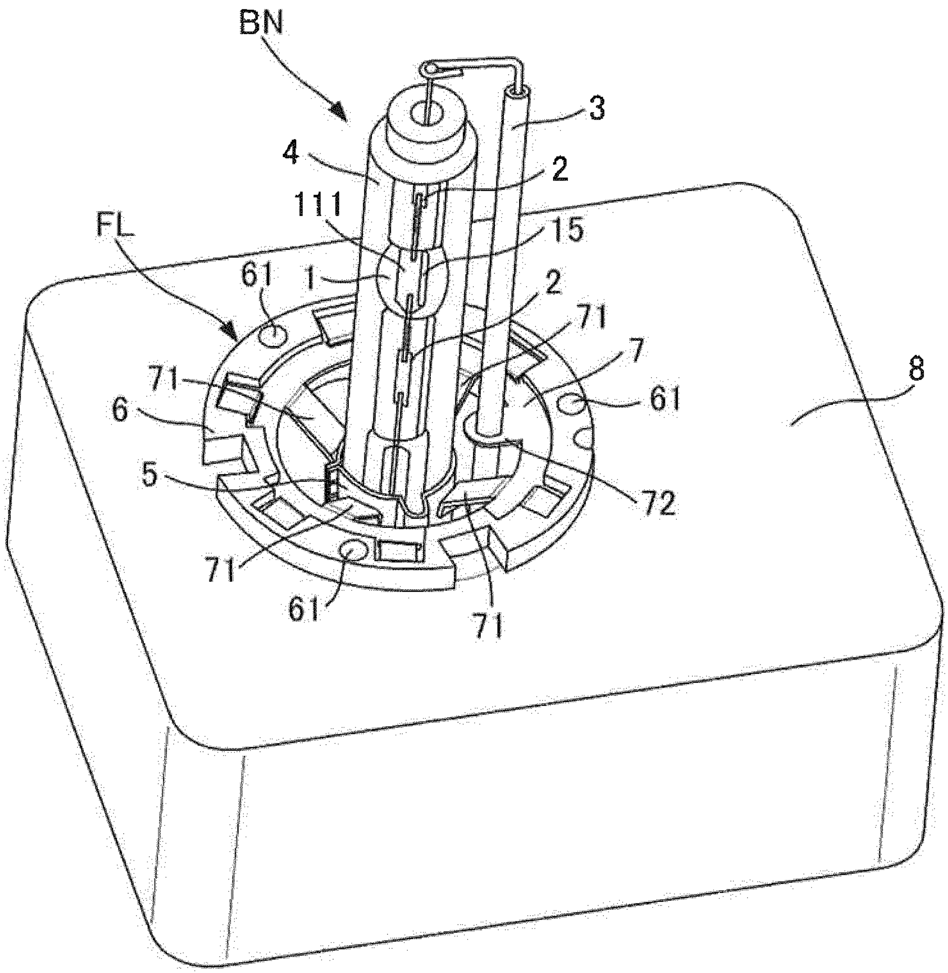

FIG. 1

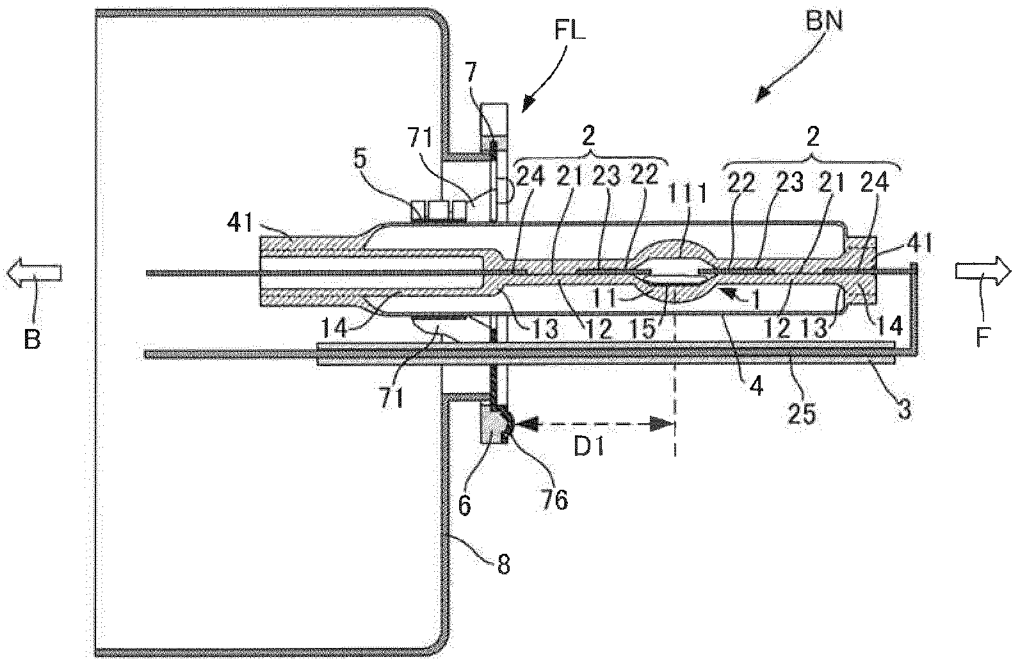
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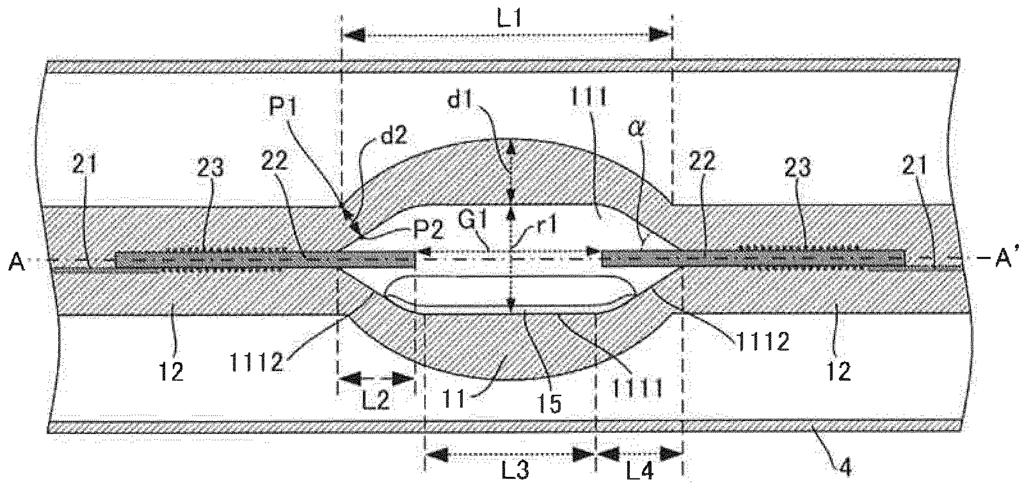
FIG. 2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L4

FIG. 3

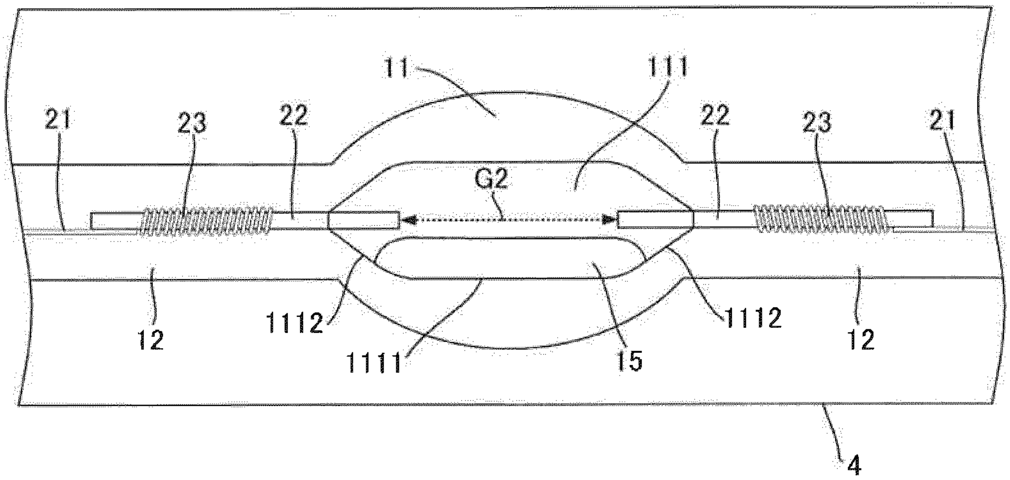
11
111
21
23
22
G2
22
23
21
12
1112
1111
15
1112
12
4

FIG. 4

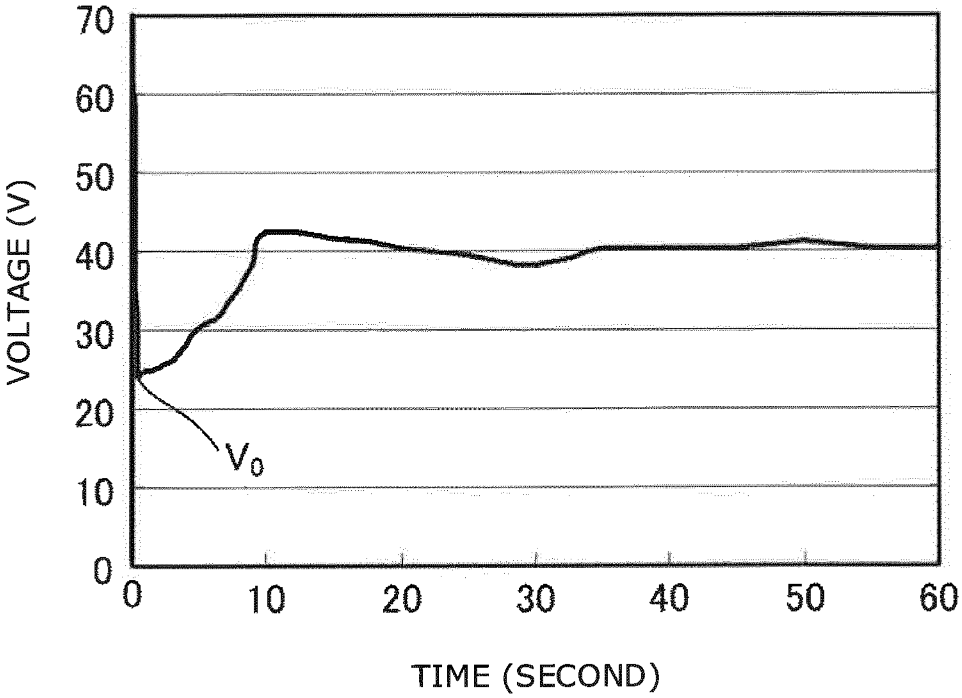
70
60
50
40
30
20
10
0
VOLTAGE (V)
V_0
0
10
20
30
40
50
60
TIME (SECOND)

FIG. 5

THICKNESS d1 (mm)	d2/d1	G2/G1	Vo(V)	LUMINOUS FLUX START-UP	LIFE SPAN	DETERMINATION
1.5	0.65	1.1	×	△	×	×
1.5	0.75	1.05	○	○	×	×
1.5	0.95	1.02	○	○	×	×
1.5	1.05	0.98	○	×	×	×
1.6	0.65	1.1	×	△	○	×
1.6	0.75	1.05	○	○	○	○
1.6	0.95	1.02	○	○	○	○
1.6	1.05	0.98	○	×	○	×
1.7	0.65	1.1	×	△	○	×
1.7	0.75	1.05	○	○	○	○
1.7	0.95	1.02	○	○	○	○
1.7	1.05	0.98	○	×	○	×
1.8	0.65	1.1	×	△	○	×
1.8	0.75	1.05	○	○	○	○
1.8	0.95	1.02	○	○	○	○
1.8	1.05	0.98	○	×	○	×
1.9	0.65	1.1	×	×	○	×
1.9	0.75	1.05	○	×	○	×
1.9	0.95	1.02	○	×	○	×
1.9	1.05	0.98	○	×	○	×

FIG. 6

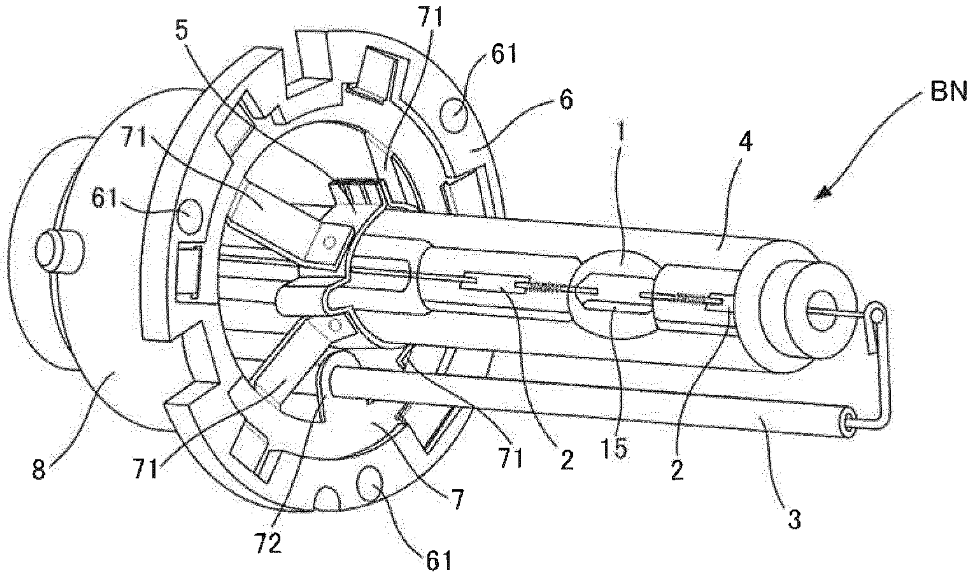

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2013/071927

A. CLASSIFICATION OF SUBJECT MATTER
H01J61/88(2006.01)i, *H01J61/86*(2006.01)i

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)
H01J61/88, H01J61/86

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

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Kokai Jitsuyo Shinan Koho	1971-2013	Toroku Jitsuyo Shinan Koho	1994-2013

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 2010-521771 A (Koninklijke Philips Electronics N.V.), 24 June 2010 (24.06.2010), paragraphs [0040] to [0042]; fig. 3 & US 2010/0141138 A1 & EP 2122662 A & WO 2008/110967 A1 & CN 101636816 A	1-4
A	JP 2011-23149 A (Panasonic Corp.), 03 February 2011 (03.02.2011), entire text; all drawings & US 2011/0193466 A1 & WO 2011/007495 A1 & CN 102150232 A	1-4

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

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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
28 August, 2013 (28.08.13)	10 September, 2013 (10.09.13)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2010521771 T **[0004]**