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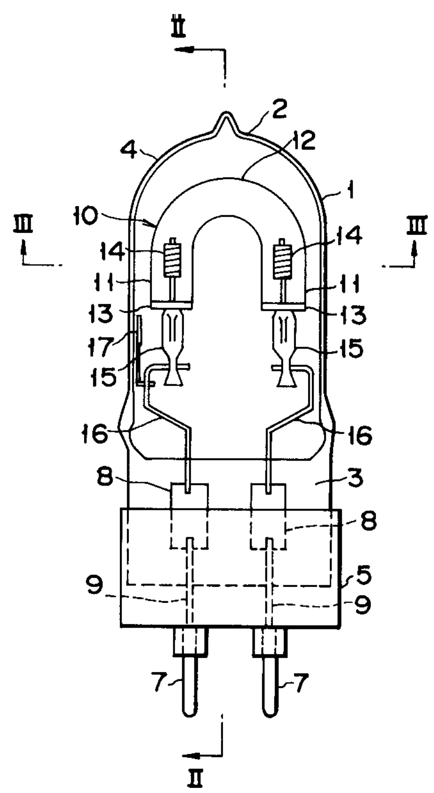
(71) Applicant: **TOSHIBA LIGHTING & TECHNOLOGY CORPORATION**
4-28, Mita 1-chome
Minato-ku Tokyo(JP)

(72) Inventor: **Okamura, Kazuyoshi**
2-14-10, Shinkoyasu, Kanagawa-ku
Yokohama-shi(JP)
Inventor: **Itoh, Akira**
80-6-107, Miharudai, Minami-ku
Yokohama-shi(JP)
Inventor: **Uchida, Kazuiki**
4-6-34, Honkugenuma
Fujisawa-shi, Kanagawa-ken(JP)

(74) Representative: **Henkel, Feiler, Hänzel & Partner**
Möhlstrasse 37
W-8000 München 80(DE)

(54) **Jacketed high pressure discharge lamp.**

(57) A jacketed high pressure discharge lamp comprising an outer envelope (1) and have an arc tube (10) contained in the outer envelope and defining a space relative to the outer envelope, the arc tube (10) being comprised of a U-shaped transparent ceramic tube, having straight portions (11) and (11) parallel to each other and a bent portion (12), wherein the outer envelope and arc tubes are so spaced as to satisfy a predetermined relation.



F I G. 1

EP 0 477 975 A2

The present invention relates to a jacketed high pressure discharge lamp having an outer envelope and an arc tube held in the outer envelope and, in particular, a lamp effective to be used for a ceramics discharge lamp whose arc tube is comprised of a U-shaped, transparent ceramic tube.

For example, a high-pressure sodium vapor discharge lamp is of such a jacketed that its outer envelope holds an arc tube therein serving as a discharge tube.

The arc tube is made of a light-transparent ceramics, such as transparent alumina tube, and has a pair of electrodes one at each end thereof which are hermetically sealed therein together with sodium as a light emitting material, mercury as a metal for a buffer gas and a rare gas for starting.

The light-transparent alumina tube is excellent in heat-resistance and in corrosion-resistance to the sodium and suitable to the use of a discharge bulb of this type of discharge lamp. However, the light-transparent alumina tube is high in melting point and hard to soften and manufacture. In the conventional case, a straight type tube which is formed by an extrusion-molding method is employed as an arc tube as such.

In recent times, high pressure discharge lamps have been employed as a light source for indoor illumination at the entrance halls and shops for instance. There is a growing demand for small-sized lamps.

In order to reduce the size of discharge lamps, it is important to reduce the size of their arc tubes. A practical method conceivable is to bend the portion of the arc tube in a U-shaped configuration. In the case of such a U-shaped arc tube, the length of the outer envelope can be substantially halved even if the electrode-to-electrode distance is maintained the same as that of the conventional lamp. It is thus possible to effectively reduce the size of the lamp as a whole.

Recently, a jacketed lamp has been developed by molding a U-shaped tube as an arc tube with the use of alumina and fitting the arc tube of transparent alumina ceramics in an outer envelope.

In the case of the U-shaped arc tube, there is a tendency that, during lighting, the inside wall becomes higher in temperature than the inside wall.

That is, at the inside wall, radiant heat is transmitted from each straight portion to the other straight portion of the arc tube to allow each of the straight portions to heat the other straight portion of the U-shaped arc tube. This is the reason why the temperature of the inside wall becomes higher than that of the outside wall.

The discharge lamp, in general, has a nature such that an arc generated between the electrodes passes across the shortest electrode-to-electrode distance. The arc tube, if being U-shaped, has a tendency that the arc moves nearer the inner bent wall. The deflection of the arc overheats the inner bent wall of the U-shaped arc tube.

In the U-shaped arc tube, a temperature difference is generated between the inner bent wall and the outer bent wall, causing heat strain in the arc tube and hence being liable to destroy the arc tube.

It is accordingly the object of the present invention to provide a jacketed high-pressure discharge lamp having a U-shaped arc tube, which can alleviate a heat difference across the arc tube and hence prevent generation of a heat strain and a breakage to the arc tube.

According to the present invention, there is provided a jacketed high pressure discharge lamp comprising an outer envelope having a closed end as one end and a pinch-sealed section at the other end; an arc tube contained in the outer envelope and defining a space relative to the outer envelope, the arc tube being comprised of a U-shaped transparent ceramic tube, having straight portions parallel to each other and a bent portion connected to each one end of the straight portions, being held in the outer envelope with the bent portion located on the closed end of the outer envelope and the other end of the straight portion directed toward the pinch-sealed section of the outer envelope, and having light emitting metal and rare gas filled therein; and a pair of electrodes sealingly provided in the arc tube, each, at the other end of the straight portion, wherein the outer envelope and arc tube are so spaced as to satisfy the following condition:

$$S_1 < S_2$$

where

S_1: a distance between the outer surface of the straight portion of the arc tube and the inner surface of the outer envelope as viewed in a direction of a line passing through each axis of the straight portions of the arc tube; and

S_2: a distance between the outer surface of the straight portions of the arc tube and the inner surface of the outer envelope as viewed both in a direction perpendicular to a line passing through each axis of the straight portion of the arc tube and in a direction passing through the axis of the arc tube.

According to the aforementioned arrangement, since $S_1 < S_2$, the outside wall of the straight portion of the arc tube is located nearer the outer envelope and a temperature rise occurs at the outside wall of the straight portion due to the presence of radiant heat. As a result, a temperature difference between the inside wall and the outside wall of the straight portion becomes smaller and heat distortion is less produced along the periphery of the straight portion. It is, therefore, possible to prevent a damage to the arc tube.

This invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a front view showing a jacketed high pressure sodium vapor discharge lamp according to an embodiment of the present invention;

Fig. 2 is a cross-sectional view as taken along line II-II in Fig. 1;

Fig. 3 is a cross-sectional view as taken along line III-III in Fig. 1;

Fig. 4 is a cross-sectional view showing an arc tube in the discharge lamp in Fig. 1;

Fig. 5 is a graph showing a relation of the distance between the straight portions of an arc tube to the percentage of occurrence of cracks when that arc tube is 3 mm in diameter;

Fig. 6 is a graph showing a relation of the distance between the straight portions of an arc tube to the percentage of occurrence of cracks when that arc tube is 4 mm in diameter; and

Fig. 7 is a graph showing a relation of the distance between the straight portions of an arc tube to the percentage of occurrence of cracks when that arc tube is 5 mm in diameter.

Fig. 1 shows a high-pressure sodium vapor discharge lamp whose rated input power is 70 W. Reference numeral 1 shows an outer envelope made of quartz.

The outer enbelope 1 is closed at one end 2 and sealed, as a pinch-sealed section, at the other end 3. A cylindrical section 4 circular in cross-section is formed between these ends 2 and 3. The outer envelope 1 is evacuated and maintained at a predetermined vacuum level. A base cap 5 made of, for example, ceramics, is fitted over the pinch-sealed section 3. The base cap 5 is cemented to the pinch-sealed section 3 by an insulation cement 6 and a pair of base pins 7, 7 are projected at the base cap 5.

An arc tube 10 is enclosed in the outer envelope 1 with a space left therebetween. The arc tube 10 is comprised of a discharge tube of a generally U-shaped configuration made of a light-transmissive alumina.

The U-shaped arc tube 10 comprises, as shown in Fig. 4, straight portions 11, 11 substantially parallel to each other and a bent portion 12 connecting these straight portions 11, 11 at one end of the straight section. The other end (open end) of each straight portion 11 is closed by a corresponding ceramics disk 13.

A pair of electrodes 14, 14 are each mounted on the corresponding disks 13, 13 in a manner to be located in the straight portions 11, 11 and comprised of an electrode rod and a coil wound around the electrode rod. An emitter of at least one kind selected from the group consisting of yttrium oxide, thorium oxide and rare earth metal oxide is deposited on the electrode coil.

Electrical lead through 15 and 15 comprised of a niobium tube extend through the ceramics disks 13 and 13 and are connected to the electrodes 14 and 14. The conductive tubes 15 and 15 provide the coolest area at their outer side.

The electrical lead through 15 and 15 are connected to lead wires/support wires 16 and 16. The lead wires/support wires 16 and 16 are connected to metal foil conductors 8 and 8 made of, for example, molybdenum and sealed to the pinch-sealed section 3 of the outer envelope 1. The metal foil conductors 8 and 8 are connected to outer lead wires 9 and 9. The outer lead wires 9 and 9 are connected to the base pins 7 and 7.

Both the ends of the arc tube are directed towards the pinch-sealed section 3 side of the outer envelope 1 and the bent portion 12 is directed toward the closed end 2 of the outer envelope 1. In this way, the arc tube is held within the outer envelope.

In the case where the pinch-sealed section 3 is to be formed at the outer envelope, the corresponding portion of the outer envelope is pinched in a direction perpendicular to that in which the straight portions 11 and 11 of the arc tube are aligned to each other.

The outer envelope 1 and arc tube 10 are so spaced that, as shown in Fig. 3.

$$S_1 < S_2$$

where S_1 shows a distance between the outer surface of the straight portion of the arc tube and the inner surface of the outer envelope as viewed in a direction of a line passing through each axis of the straight portions of the arc tube, and

S_2 shows a distance between the outer surface of the straight portions of the arc tube and the inner surface of the outer envelope as viewed both in a direction perpendicular to a line passing through each axis of the straight portion of arc tube and in a direction passing through the axis of the arc tube.

In the case of a lamp whose rated input power is 35 to 200 W, the distance S_1 is set to be 1 to 3 mm.

A distance n between a midpoint on an imaginary curvature of the inner surface of the outer envelope at the closed end 2 and the outer surface of the bent portion of the arc tube as shown in Fig. 2 is set to be 5 to 15 mm.

The arc tube 10 has a relation as set out below:

$3 \text{ mm} \leqq d \leqq 5 \text{ mm}$ (1)

and

$1.6 \leqq \ell/d \leqq 6$ (2)

where

ℓ(mm): a distance between the straight portions 11, 11 of the arc tube; and

d(mm): the inner diameter of the arc tube.

In the case of a 70 W lamp, the arc tube 10 is so dimensioned that d = 4.0 mm; the distance between those electrodes passing through the axis of the arc tube is 15 mm; ℓ 10 mm; and the inner diameter of the bent portion of the arc tube 12 is 4.0 mm. In this instance, $\ell/d = 2.5$.

The U-shaped bent portion 12 connecting the straight portions 11 and 11 of the arc tube 10 provides a light emitting area and hence light substantially coming from the bent portion 12 of the arc tube is externally emitted through the outer envelope 1.

10 milligrams of amalgam consisting of 25 weight percent sodium and 75 weight percent mercury, and a xenon gas of 20 torrs, is filled in the arc tube 10.

A getter 17 of a powdered mass, such as Zr-Aℓ, is attached to the support wire 16.

The high pressure sodium lamp is started with a maximum current of 2 amperes and provides a light output of about 3500 ℓm at an input power of 70 W during a steady lighting time.

Since the arc tube 10 is U-bent in the lamp, the length of the outer envelope 1 becomes about half as small as that of the conventional counterpart. It is thus possible to largely reduce the size of the lamp and to attach it to a small-sized lighting fixture.

In the conventional lamp using a U-shaped arc tube 10, during lighting, temperature becomes higher on the inner bent wall than on the outer bent wall of the U-shaped arc tube and heat originates from the straight portions 11 and 11 of the arc tube such that it is transmitted from each straight portion to the other straight portion of the U-shaped arc tube whereby mutual heating is done there. In the straight portions of the arc tube, however, there is a tendency that a higher temperature is involved on the inside wall 11a than on the outside wall 11b.

According to the present invention, however, since $S_1 < S_2$, the outside wall 11b of the straight portion of the arc tube 10 is located nearer the outer envelope 1. For example, the distance S_1 is set to be about 1.2 to 2.0 mm at a 70 W lamp. For this reason, heat emitted from the straight portions 11 of the arc tube 10 is transmitted as radiant heat to the outer envelope 1 and a temperature rise occurs in the outer envelope 1 at those areas nearer the straight portions of the arc tube 10. The heat reflected on the outer envelope 1 is transmitted as radiant heat to the straight portions 11 of the arc tube 10. That is, as the straight portions 11 of the arc tube are located nearer the outer envelope 1, the outside wall 11b of the straight portions 11 receives the radiant heat from the outer envelope 1, causing a temperature rise there.

In the straight portions 11 of the arc tube, a difference in temperature between the inside wall 11a and the outside wall 11b becomes smaller.

As a result, a temperature difference becomes smaller in the peripheral direction of the straight portions 11 and heat strain is hard to produce, preventing a damage to the arc tube 10.

In a lamp whose rated input power is 35 to 200 W, it has been confirmed that, if the aforementioned distance S_1 is set to be 1 to 3 mm, it is possible to reduce the temperature difference in the peripheral direction of the straight portion 11 of the arc tube.

It will be seen from Fig. 3 that, since the outer envelope 1 has a circular cross-section, the distance S_2 as defined above is naturally greater than 1 to 3 mm.

Since an arc is generally of such a nature that passes across a shortest electrode-to-electrode distance, there is a tendency that, in the case of a U-shaped arc tube 10, the arc goes nearer toward the inner bent wall of the arc tube at an area of the bent portion 12. The deflection of the arc locally overheats the bent portion 12, causing cracks to the bent portion 12.

Examination has been made on how cracks occur on the bent portion of the arc tube and it has been found that, when a start-up current is applied at the time of starting a lamp, an arc nearer the inner bent wall of the bent portion 12 moves into contact with the inner bent wall surface of the bent portion 12, a greater temperature difference is produced at a site between an arc contact area and the other area and a failure is caused to the bent portion due to a heat strain involved.

In this case, the smaller the curvature radius of the inner bent wall of the bent portion 12, the smaller the angle of the inner bent wall of the bent portion 12. It has been found that, since a resultant acute angle area locally contacts with an arc, heat is concentrated at a particular point and, hence, there is a greater risk of cracks being produced at that area.

In order to prevent the crack it may be possible to increase the curvature radius of the bent portion 12, broaden the area with which an internally bent arc makes contact and prevent any local point or site from being heated. It may, therefore, be possible to broaden a heated area and eliminate any abrupt temperature difference.

It may be possible that the curvature radius of the bent portion 12 of the arc tube can be regarded as corresponding to one half the distance ℓ between the straight portions 11 and 11 of the arc tube 10. It is, therefore, better to increase the distance ℓ between the straight portions 11 and 11 of the arc tube.

If a heated area inside the bent portion 12 is spaced apart from the outer bent wall of the bent portion 12, a temperature difference between the inner and outer bent walls of the bent portion 12 becomes greater, producing heat distortion. If, therefore, the inner diameter d of the bent portion 12 is decreased, it is possible to decrease a temperature difference across the width of the bent portion.

The inventors of the present invention have examined the relation between the distance ℓ and the inner diameter d set out above.

Figs. 5 to 7 show the percentage of occurrence of cracks upon testing under the condition that the relation of the distance ℓ and inner diameter d set out above varies at a high pressure sodium vapor discharge lamp of about 70 W.

At each testing, each lamp was turned ON and OFF 1000 times at a 30% overload state and the percentage of occurrence of cracks was measured.

Fig. 5 shows the percentage of occurrence of cracks under a varying ratio of ℓ/d at d = 3 mm.

Fig. 6 shows the percentage of occurrence of cracks under a varying ratio of ℓ/d at d = 4 mm.

Fig. 7 shows the percentage of occurrence of cracks under a varying ratio of ℓ/d at d = 5 mm.

From the characteristic curves it has been found that, if the ratio ℓ/d is set to be above 1.6 in the case of d = 3 to 5 mm, the occurrence of cracks can be reduced to a minimum.

The tests were conducted within a restricted range of d = 3 to 5 mm, the results of which are as follows:

In order for a compact, small output power type high pressure sodium vapor discharge lamp to further reduce its size, the common practice was to bend its arc tube in U-shaped configuration. Such a target lamp belongs in the order of 50 to 150 W.

In the case of a U-shaped arc tube of the order of 50 to 150 W to which the present invention is directed, an arc is bent along the bent portion of the arc tube and hence moved along the inner side of the bent portion of the arc tube in an offset relation to cause the optical length to increase. As a result, a lamp of 35 to 150 W (rated input power) lamp reveals high color rendering at a tube diameter of 3 to 5 mm. This might cause a lowering in the color rendering but this state can be avoided if the condition d = 3 to 5 mm is satisfied. In view of this, the inner diameter d of the arc tube is set within the restricted range of 3 to 5 mm.

Stated conversely, if no cracks occur within the range of d = 3 to 5 mm, the inner diameter d of the arc tube is satisfactory for the high color rendering type high pressure sodium vapor discharge lamp belonging in the order of 50 to 150 W.

If the aforementioned distance ℓ becomes too great at an area between the straight portions 11 and 11, the coolest area at the end of one straight section 11 or at the forward end of the electrical lead through 15 receives no radiant heat from the other straight portion 11 and electrode 14 of said other straight portion of the arc tube. As a result, the coolest temperature area is not raised in temperature and the vapor pressure of sodium in the arc tube is not raised to a predetermined level, thus causing a lowering in color characteristic.

Upon examination it has been found that the ratio ℓ/d has to be restricted to below 6.0.

As will be appreciated from the above experiment, if the conditions

$$3 \text{ mm} \leqq d \leqq 5 \text{ mm} \qquad (1)$$

and

$$1.6 \leqq \ell/d \leqq 6 \qquad (2)$$

are satisfied, then it is possible to prevent occurrence of cracks.

Since the aforementioned distance n is set to be 5 to 15 mm, a greater spacing is left between the outer envelope 1 and the arc tube 10, thus imparting the radiant heat from the outer envelope 1 to the bent portion 12 of the are tube. It is, therefore, possible to control a temperature rise at the bent portion 12 serving as a major light emitting area.

Since the pinch-sealed section 3 of the outer envelope 1 is formed in the direction perpendicular to the plane in which the straight portions 11 and 11 are aligned to each other, a smaller spacing can be provided at a zone near the pinch-sealed section of the outer envelope 1. That is, if at the end portion of the outer envelope 1 a pinch-sealed section is formed in the same direction as that in which the straight portions 11 and 11 are aligned with each other, the pinching section has to be formed in a lower position due to the presence of the straight portions 11 and 11. If, on the other hand, the pinching section is formed in the direction perpendicular to that in which the straight portions 11 and 11 are aligned to each other, the pinching section can be formed in a relatively high position, reducing the spacing size on the pinch-sealed section 3 side.

It is, therefore, possible to reduce the distance y between the lower ends of the straight portions 11 and 11 and the outer envelope 1. Further, the coolest areas at the outer ends of the electrical lead throughs 15 and 15 is located nearer the wall of the outer envelope 1 and these areas receive heat from the wall of the outer envelope 1 and a temperature rise is liable to occur.

If the lamp is lit with the pinch-sealed section 3 down, there is a tendency that a temperature rise occurs in the outer envelope 1 at the closed end 2 side (an upper side in this case). If, however, the lower ends of the straight portions 11 and 11 and coolest areas at the electrical lead throughs 15 and 15 receive heat from the wall of the outer envelope 1 to cause a temperature rise there, a temperature difference becomes smaller in the outer envelope 1 and hence a temperature difference becomes smaller in the arc tube 10.

Since the temperature is raised in the coolest areas, it is possible to increase the vapor pressure of sodium and hence to improve the color rendering.

The present invention can be applied not only to the high pressure sodium vapor discharge lamp but also to other lamps, such as an HID lamp.

Although, in the aforementioned embodiment, the outer envelope 1 has been explained as being maintained in a vacuum state, the outer envelope may be maintain in a vacuum state for an arc tube of 70 W or below, but the rare gas, such as argon, xenon and kripton, is desirably filled in the outer envelope 1 in which case a lamp has an input power exceeding 70 W.

In the case where the rare gas is filled in the bulb 1 in the case of a lamp having a greater rated power input, heat is conducted by the heat transmission of the rare gas from the arc tube 10 to the outer envelope 1 and heat loss is, therefore, increased, preventing a temperature rise in the arc tube 10 and a local temperature rise in the arc tube 10.

Although, according to the present invention, the distance S_1 has been explained as being smaller than the distance S_2, the outside wall 11b side of the straight portion is located nearer the outer envelope and receives radiant heat from the outer envelope, causing a temperature rise there. For this reason, a temperature difference between the outside wall 11b and the inside wall 11a of the straight portion becomes smaller and hence the temperature gradient is alleviated along the periphery of the straight portions of the arc tube, causing less heat distortion. It is possible to prevent a damage to the arc tube.

Claims

1. A jacketed high pressure discharge lamp including an outer envelope (1) having a closed end (2) as one end and a pinch-sealed section (3) at the other end;

an arc tube (10) contained in the outer envelope and defining a space relative to the outer envelope, the arc tube (10) being comprised of a U-shaped transparent ceramic tube, having straight portions (11) and (11) parallel to each other and a bent portion (12) connected to each one end of the straight portions, being held in the outer envelope with the bent portion (12) located on the closed end of the outer envelope and the other end of the straight portion directed toward the pinch-sealed section of the outer envelope, and having light emitting metal and rare gas filled therein; and a pair of electrodes (14, 14) sealingly provided in the arc tube, each, at the other end of the straight portion, characterized in that:

the outer envelope and arc tubes are so spaced as to satisfy the following condition:

$S_1 < S_2$

where

S_1: a distance between the outer surface of the straight portion of the arc tube and the inner surface of the outer envelope as viewed in a direction of a line passing through each axis of the straight portions of the arc tube; and

S_2: a distance between the outer surface of the straight portions of the arc tube and the inner surface of the outer envelope as viewed both in a direction perpendicular to a line passing through each axis of the straight portion of the arc tube and in a direction passing through the axis of the arc tube.

2. The jacketed high pressure discharge lamp according to claim 1, characterized in that, in a lamp having a rated input power of 35 to 200 W, the distance (S_1) is set to be 1 to 3 mm.

3. The jacketed high pressure discharge lamp according to claim 1, characterized in that a distance n between the outer envelope at the closed end and the bent portion of the arc tube is set to be 5 to 15 mm.

4. The jacketed high pressure discharge lamp according to claim 1, characterized in that, for a lamp whose outer envelope has its pinch-sealed section located in a downwardly directed attitude, the pinch-sealed section of the outer envelope is formed in a direction perpendicular to that in which the straight portions of the arc tube are aligned with each other.

5. The jacketed high pressure discharge lamp according to claim 1, characterized in that the arc tube is so dimensioned as to have a relation:

$3\ mm \leqq d \leqq 5\ mm$

and

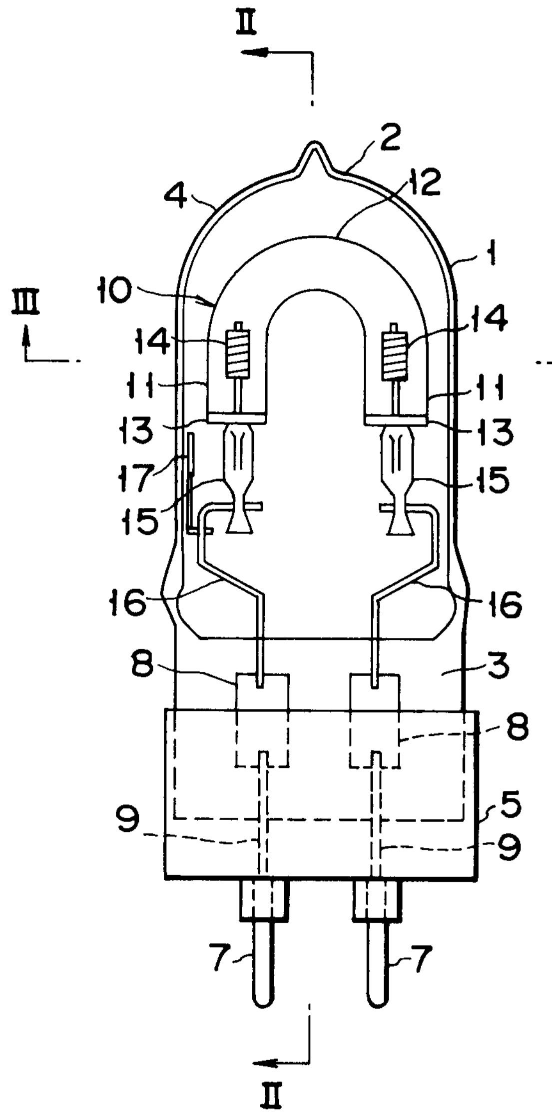
$1.6 \leqq \ell/d \leqq 6$

where

ℓ(mm): a distance between the straight portions of the arc tube; and

d(mm): the inner diameter of the arc tube.

6. The jacketed high pressure discharge lamp according to claim 1, characterized in that said lamp is of such a type that sodium is filled, as the light emitting metal, in the arc tube.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II

FIG. 1

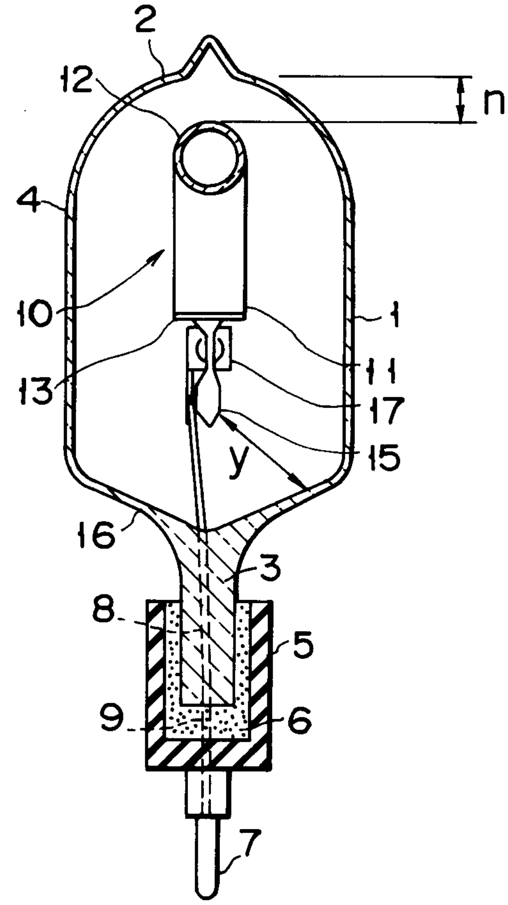
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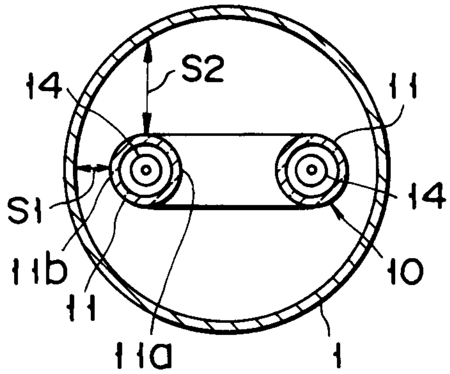
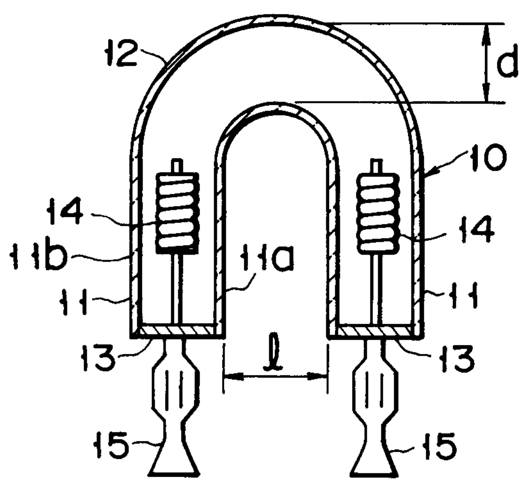
FIG. 2



F I G. 3



F I G. 4

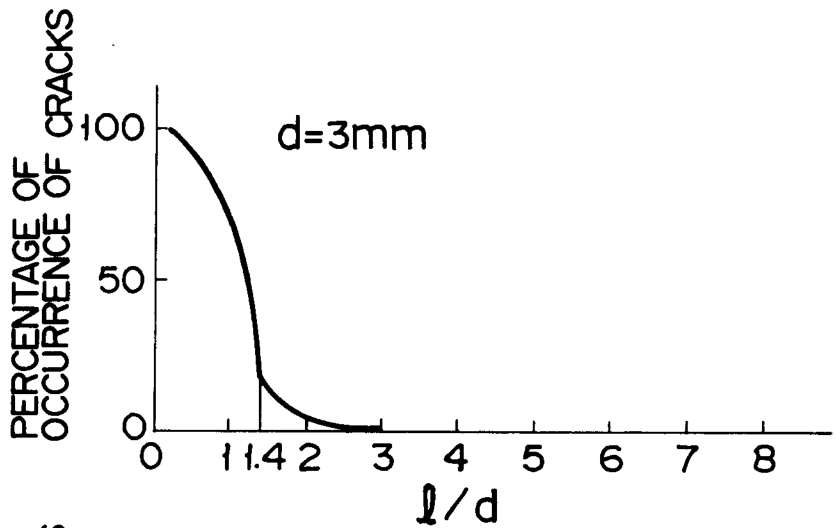


FIG. 5

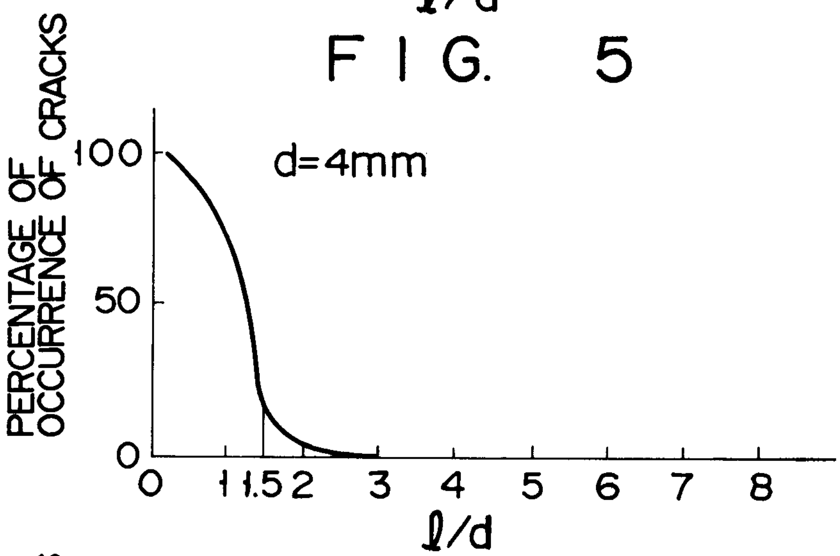


FIG. 6

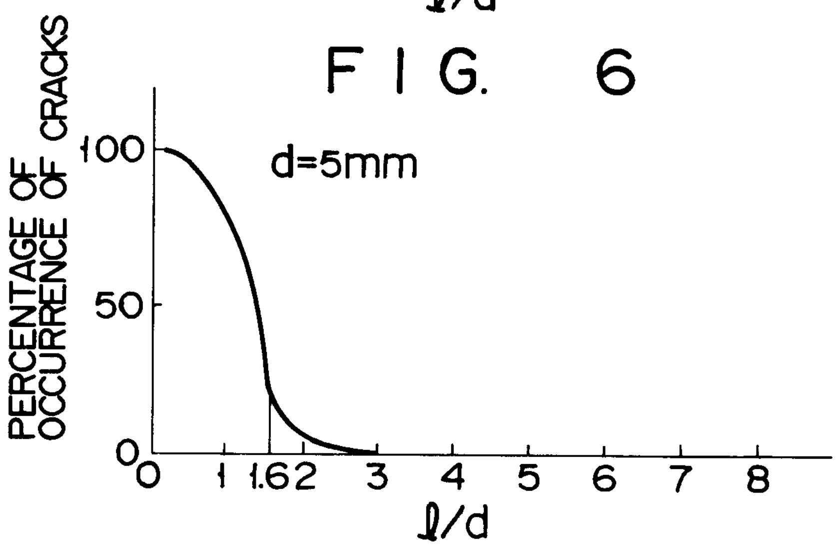


FIG. 7