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

(11) Publication number: 0 394 743 A1

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: 90106846.0

(51) Int. Cl.5: H01J 61/16, H01J 61/30

(22) Date of filing: 10.04.90

(30) Priority: 28.04.89 JP 110083/89
09.06.89 JP 148025/89

(43) Date of publication of application:
31.10.90 Bulletin 90/44

(84) Designated Contracting States:
DE GB

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

Applicant: HARISON ELECTRIC CO., LTD.
5-2-1, Asahi-machi
Imabari-shi, Ehime-ken(JP)

(72) Inventor: Asakura, Masahiko
7-10-18, Hirasaku
Yokosuka-shi, Kanagawa-ken(JP)
Inventor: Noguchi, Hidehiko
2-1-5, Minamihiyoshi-cho
Imabari-shi, Ehime-ken(JP)
Inventor: Tsunekawa, Shinichi
6-2-6, Fujisawa
Fujisawa-shi, Kanagawa-ken(JP)

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

(54) Low pressure gas discharge lamp.

(57) A low pressure gas discharge lamp is made up of a light-emitting tubular bulb (2) whose elongated discharge space (3) contains a discharge gas including at least a xenon gas, an internal electrode (4) sealed within the bulb and located at one end of the bulb, a band-like external electrode (7) formed on the outer surface of the bulb and extending up to the other end of the bulb in the axial direction of the bulb, and a fluorescent material (6) coated on the inner surface of the bulb. The xenon gas contained in the discharge space has a partial pressure within the range of 5 to 40 Torr.

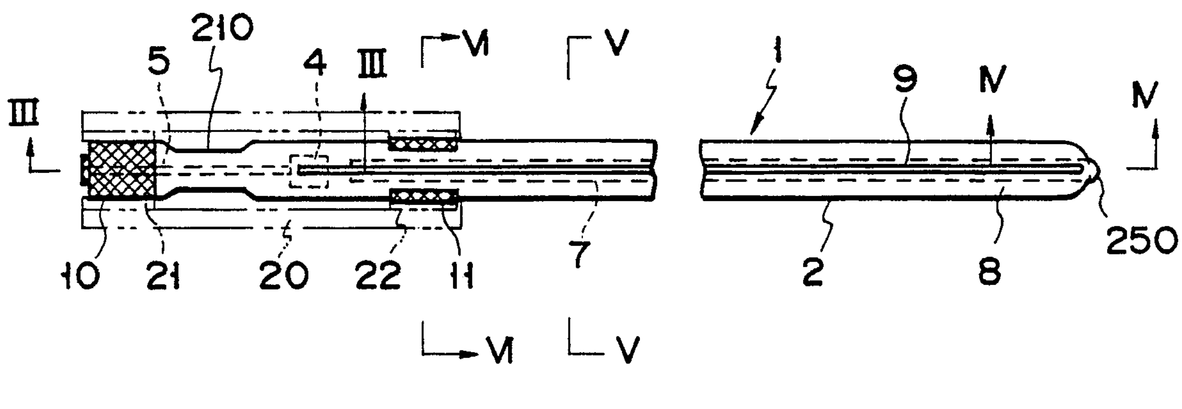

FIG. 2

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The present invention relates to a low pressure gas discharge lamp wherein a rare gas including xenon gas is sealed in an elongated discharge space, and is most suitable for application to a xenon glow discharge lamp.

In recent years, measurement instruments or electric devices have been developed wherein a xenon glow discharge lamp is employed as a measurement indicator.

The xenon glow discharge lamp employed in the measuring instruments or electric devices comprises a very thin glass tube having an inner diameter of approximately 2 mm to 3 mm. The discharge lamp is coupled at one end to the rotating shaft of a meter, and is thus rotatable together with the rotating shaft. With this construction, the discharge lamp functions as the indicating needle of the meter. Since the discharge lamp emits light when turned on, no special illuminator is needed to illuminate the measurement scale of the meter.

The xenon glow discharge lamp used as the indicating needle of the meter comprises: an arc tube bulb which defines a long discharge space therein; an internal electrode arranged at one end of the bulb; an external electrode axially extending from one end to the other end along the outer surface of the bulb; and a phosphor layer coated on the inner surface of the bulb. A cold cathode is employed as the internal electrode since it withstands long use. The discharge space is filled with a rare gas; more specifically, it is filled with either a xenon gas, or a mixture gas of a xenon gas and at least one of neon (Ne), krypton (Kr) and argon (Ar) gases. When high-frequency power is applied between the internal and external electrodes, the rare gas produces glow discharge in the discharge space.

A light-shielding layer made of a synthetic resin or the like is formed on the outer surface of the bulb. The light-shielding layer is formed, except for a predetermined long and narrow region on the outer surface, to thereby provide a light-transmission slit extending in the axial direction of the bulb. Through this light-transmission slit, light is emitted from the discharge lamp. That is, the discharge lamp is an aperture type, wherein the light-emerging zone serving as an indicating needle is very long and narrow.

In the xenon glow discharge lamp mentioned above, ultraviolet rays of the spectrum peculiar to the xenon gas are produced due to the glow discharge occurring between the electrodes. The short-wavelength rays excite the fluorescent material coated on the inner surface of the bulb, whereby visible light is emitted from the fluorescent material.

How the visible light is produced from the xenon gas will be described in more detail.

In general, when discharge occurs between the electrodes, the atoms of the gas sealed in the discharge space are bombarded with the drifting electrons or ions caused by the discharge. As a result, the extranuclear electrons of the atoms receive energy from the electrons or ions caused by the discharge. Thus, the energy level of the atoms becomes high; in other words, the atoms are excited. Since this excited state is very unstable, the atoms tend to return into the original state. While the atoms return into the original state (i.e., the condition wherein the atoms return into the original state being referred to as a transitional condition), they emit electromagnetic waves, such as visible rays, infrared rays, ultraviolet rays, etc. These electromagnetic waves excite the fluorescent material, whereby the fluorescent material produces visible light.

In the case where the sealed gas is xenon, thermal ionization is produced when the atoms of the xenon gas are bombarded with electrons or ions. Since, therefore, the xenon generates heat, it is a gas having a large heat loss property.

A xenon glow discharge lamp of a double internal electrode type, wherein an internal electrode is located at each end of the bulb, is well known and widely used. In this type of xenon glow discharge lamp, a xenon gas is sealed in such a manner as to have a partial pressure of 100 Torr or more, since the xenon gas has a large heat loss property, as mentioned above.

Since such a double internal electrode type xenon lamp is intended for use as an ordinary illuminating device, it is required to provide a given quantity of light. To satisfy this requirement, the xenon gas is sealed in the lamp to have a comparatively high pressure, and occurrence of heat loss is regarded as being inevitable.

However, if a xenon gas is sealed to have a partial pressure of more than 100 Torr, as above, it is likely that a positive column generated in the discharge space will concentrate in a particular region.

In the case of the double internal electrode type lamp, a thin and long positive column is generated between the electrodes.

However, if the cold cathode type xenon glow discharge lamp intended for use as the indicating needle of a meter is provided with two internal electrodes located at the respective ends of the tube, as above, then the lamp has a dark region (i.e., a region where no light is generated) on the back sides of the electrodes. When this lamp is used as the indicating needle, the indicating needle has a dark region at the distal end thereof. To use the lamp as a indicating needle, therefore, it is desirable that the light-generating region extend up to the distal end of the bulb. To satisfy this desire, the xenon glow discharge lamp is provided with an internal electrode located at the proximal end of the bulb, and an external electrode extending axially to the distal end along the outer surface of the bulb.

In the case of the xenon glow discharge bulb wherein the external electrode extends axially to the distal end of the bulb, the partial pressure of the xenon gas sealed inside the bulb should not be high. If the partial pressure is high, a positive column generated in the discharge space does not reach the distal end of the bulb. The positive column may be diffused in an intermediate region of the discharge space. In such a case, the positive column vibrates in the region where it is diffused.

If the positive column vibrates in the above-mentioned aperture type lamp, it is repeatedly shifted from the region of the slit in accordance with the vibration, thus causing a flickering problem.

Accordingly, an object of the present invention is to provide a low pressure gas discharge lamp which is free from vibration of a positive column and prevents the occurrence of a flickering phenomenon.

To achieve this object, the present invention provides a low pressure gas discharge lamp which comprises:
a light-emitting tubular bulb having an elongated discharge space located between two ends of the tubular bulb; an internal electrode sealed within the tubular bulb and located at one end of the bulb; an external electrode formed on the outer surface of the bulb and extending up to the other end of the bulb in the axial direction; a fluorescent material coated on the inner surface of the tubular bulb; and a discharge gas sealed in the discharge space and including at least xenon gas, the discharge gas being sealed to have a partial pressure which is in the range of 5 to 40 Torr.

In the lamp of the present invention, the partial pressure of the xenon gas sealed in the discharge space is comparatively low. Therefore, a positive column is not generated concentratedly but is uniformly diffused in the discharge space. Thus, the positive column does not produce a boundary, and does not vibrate. As a result, flickering is prevented or suppressed. Moreover, the lamp of the present invention can be reliably lit in a short time since the partial pressure of the xenon gas sealed in the lamp is comparatively low.

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 an exploded perspective view illustrating how a xenon glow discharge lamp according to the first embodiment of the present invention is used as the indicating needle of a measuring device;

Fig. 2 is a plan view of the xenon glow discharge lamp shown in Fig. 1;

Fig. 3 is a sectional view taken along line III - III in Fig. 2;

Fig. 4 is a sectional view taken along line IV - IV in Fig. 2;

Fig. 5 is a sectional view taken along line V - V in Fig. 2;

Fig. 6 is a sectional view taken along line VI - VI in Fig. 2;

Figs. 7 to 9 are views illustrating how a cold cathode is manufactured;

Figs. 10 to 14 are views illustrating how to provide a tip off end for the bulb;

Fig. 15 is a graph showing the relationships between a discharge start voltage and the sealing pressure of a xenon gas;

Fig. 16 is a graph showing the relationships between the flickering condition and the sealing pressure of a xenon gas;

Fig. 17 is a graph showing the relationships between a luminance maintenance factor and a lamp-lighting time;

Fig. 18 is a sectional view of the distal end of a lamp according to the second embodiment of the present invention; and

Fig. 19 is a sectional view of the distal end of a lamp according to the third embodiment of the present invention.

In the drawings, reference numeral 1 denotes a cold cathode xenon glow discharge lamp employed as the indicating needle of a measuring device. This discharge lamp 1 comprises an arc tube bulb 2, the interior of which defines an elongated discharge space 3. The bulb 2 is a glass tube and has, e.g., an outer diameter of 2.5 mn, an inner diameter of 1.5 mm, and an overall length of 60 mm. The entire bulb 2 looks like a needle.

One end of the bulb 2 has a pinch seal structure 210, as is shown in Fig. 3, while the other end thereof has a tip off structure 250, as is shown in Fig. 4.

A lead wire hermetically extends through the pinch seal portion 210 of the bulb 2. The lead wire 5 is a Dumet wire having a thickness of 0.3 mm or so. The extended end of the lead wire 5 is located within the bulb, and an internal electrode 4 is secured to the extended end of the lead wire 5. The internal electrode 4 serves as a cold cathode.

As is shown in Fig. 3, the cold cathode 4 is made up of a tubular electrode head 41, and an electron-emitting material (emitter) 42 which fills the hollow region of the electrode head 41. The electrode head 41 is formed of a low-melting point metal, such as nickel (Ni) or a zirconium-aluminium (Zr-Aℓ) alloy. In the case of this embodiment, the electrode head 41 is formed of nickel.

The electron-emitting material 42 emits electrons from the front opening of the electrode head 41 into the discharge space 3. A lanthanide-based rare earth element is used as the electron-emitting material 42. In the case of this embodiment, a powdered lanthanum boride (LaB_6) is used as the electron-emitting material 42 and fills the hollow region of the electrode head 42 at high density.

To manufacture the cold cathode 4, the process shown in Figs. 7 to 9 is used.

In Fig. 7, reference numeral 410 denotes a nickel tube to be employed as the electrode head. The nickel tube 410 has, e.g., an outer diameter of 5 mm, a thickness of 1 mm, and a length of 500 mm. The hollow region of this nickel tube 410 is filled, at high density, with a powdered electron-emitting material 42, i.e., with powdered lanthanum boride (LaB_6).

The nickel tube 410 is subjected to cold wire drawing processing, together with the electron-emitting material 42. In this processing, the nickel tube 410 is drawn in such as manner as to have an outer diameter of 0.6 mm or so by use of the drawing dies shown in Fig. 8. An elongation rolling machine or a swaging machine may be employed, in place of the drawing dies.

During the cold wire drawing processing, the electron-emitting material 42 inside the nickel tube 410 is compressed or condensed, so that the electron-emitting material 42 is packed at high density and firmly held inside the nickel tube 410.

The nickel tube 410, thus processed, is cut into pieces of predetermined length by use of a cutter 460, as is shown in Fig. 9. The length of the pieces cut from the nickel tube 410 is within the range of 2 to 3 mm, for example.

In the manner mentioned above, the cold cathode 4 shown in Fig. 3 is fabricated. The cold cathode 4, thus fabricated, is welded to the lead wire 5.

The cold cathode 4 uses a lanthanide-based rare earth element as the electron-emitting material 42. Therefore, the starting voltage can be low and the starting time can be short.

More specifically, the lanthanide-based earth element has a small work function, so that the electron-emitting material 42 constituted by the lanthanide-based earth element can easily emit electrons in the presence of weak radiations or cosmic rays coming from the earth crust. Since this emission of electrons causes discharge, the lamp can be easily started with a low starting voltage, and in a very short starting time. Thus, the starting characteristics of the lamp is improved, due to the use of the lanthanide-based earth element.

In the cold cathode 4, the electron-emitting material 42 fills the hollow region of the tubular electrode head 41, so that it is held or supported with a simple structure.

According to the manufacturing process shown in Figs. 7 to 9, the electrode head 41 is subjected to cold wire drawing processing, whereby the electron-emitting material 42 inside the electrode head 41 is compressed or condensed. Thus, the electron-emitting material 42 can be strongly held or supported in the electron head 41. In addition, since the electron-emitting material 42 is not subjected to heat treatment, it is not adversely affected by heat. Moreover, the operation for causing the electron-emitting material 42 to be supported by the electrode head 41 is easy to perform.

The tip off portion 250 of the bulb 2 has such a shape as is shown in Fig. 4. As is shown, the outer face 251 and inner face 252 of the tip off portion 250 are projected in the opposite directions. Due to this structure, a thick portion 255, which is thicker than the other portions of the bulb 2, is defined between the outer and inner faces 251 and 252, as is indicated by ℓ in Fig. 4.

Due to the formation of the thick portion 255, the tip off portion 250 of the bulb 2 is mechanically stronger than the other portions. Even if the tip off portion 250 is touched by something, it is not easily broken.

Since the bulb 2 has a tip off end, as mentioned above, air can be discharged from the discharge space 3 through the tip off end, during the manufacture of the bulb 2. Therefore, an exhaust tube need not be connected to an intermediate portion of the bulb 2. Thus, the bulb 2 is permitted to have a uniform cross sectional shape throughout the overall length thereof, and the cross section of the discharge space 3 defined by the bulb 2 is substantially the same from one end to the tip end of the inner face 252. This means that the positive column generated in the discharge space at the time of the glow discharge has substantially uniform thickness from the proximal end to the distal end. Accordingly, the lamp provides a uniform luminance intensity throughout the axial direction.

Moreover, a fluorescent material 6 can be coated even on the portion which is closer to the distal end of the bulb 2 than the tip end of the inner face 252. Thus, even the distal end of the bulb 2 emits sufficient light. Since such a lamp has a long light-emitting region, it is advantageous for use as the indicating needle of a meter.

The process in which the thick portion 255 is provided for the tip off portion 250 will be described, with reference to Figs. 10 to 14.

Fig. 10 shows the bulb 2 which is formed by a glass tube and the inner surface of which is coated with a fluorescent material. This bulb 2 is connected to an air discharge machine (not shown). By use of this air exhaust machine, air is exhausted from the bulb 2 and a discharge gas, such as a xenon gas, is sealed in the bulb 2 such that the discharge gas has a predetermined pressure lower than the atmospheric pressure.

With the discharge gas sealed as above, that portion of the bulb 2 at which a tip off structure is to be provided is heated by a heater 310, such as a gas burner. When the portion becomes soft, the bulb 2 is slowly pulled in the opposite directions, as is shown in Fig. 11.

As the bulb 2 is pulled more, the softened portion of the bulb 2 becomes thinner, and the glass walls at the softened portion are brought into contact with one another. In this state, the bulb 2 is closed at the softened portion. When the bulb 2 is pulled further, the bulb 2 is separated into two pieces, as is shown in Fig. 12. When the bulb 2 is separated, a projection 260 is left at the end of the bulb 2.

Next, the projection 260 of the bulb 2 is heated by a heater 320, such as a gas burner, as is shown in Fig. 13. By this heating process, the projection 260 is softened. Since, as noted above, the pressure of the discharge gas sealed in the bulb 2 is lower than the atmospheric pressure, the softened projection 260 is sucked or drawn inside. At this time, the projection 260 becomes spherical, due to the action of the surface tension of the glass. As a result, the outer face 251 and inner face 252 are projected in the opposite directions, thereby defining the thick portion 255 therebetween, as is shown in Figs. 4 and 14.

In the above fashion, the thick portion 255 can be easily formed.

With respect to the bulb 2 thus obtained, a fluorescent material 6 is coated on the inner surface, and a xenon gas is sealed in the discharge space 3. The xenon gas sealed such that its pressure is within the range of 5 to 40 Torr, preferably within the range of 20 to 40 Torr. In the case of this embodiment, the sealing pressure of the xenon gas is 30 Torr or thereabouts.

On the outer surface of the bulb 2, a band-like external electrode 7 is formed in such a manner as to extend in the axial direction of the bulb 2.

To form the external electrode 7, carbon • phenol paste, silver • epoxy resin paste, or the like is first coated on the outer surface of the bulb 2 in the axial direction, and is then baked.

The external electrode 7 extends such that its one end corresponds in location to the internal electrode 4 and the other end corresponds in location to the tip end face of the tip off portion 250. The width of the external electrode 7 is more than one third of the circumferential length of the bulb 2; in other words, the width of the external electrode 7 is more than 120° of the circumferential angle of the bulb 2.

At that end of the bulb 2 where the cold cathode 4 is sealed, a first power-receiving terminal 10 is formed on the outer surface of the bulb 2. The first power-receiving terminal 10 is formed like a layer, and is obtained by coating conductive paste (such as silver • epoxy resin paste) in such a way as to have a predetermined width and baking it. It is electrically connected to the lead wire 5, i.e., to the cold cathode 4.

A second power-receiving terminal 11 is formed on the outer surface of the bulb 2, such that it is isolated from the first power-receiving terminal 10 in the axial direction of the bulb 2. The second power-receiving terminal 11 is obtained in a similar way to that of the first power-receiving terminal 10, and is electrically connected to the external electrode 7 mentioned above. It should be noted that the second electrode 11 is not formed in a slit region 9, which will be mentioned below.

A Light-shielding layer 8 is formed on the outer surface of the bulb 2. The light-shielding layer 8 is formed of a material including carbon, epoxy resin, land an adhesive, and this material is coated on the outer surface of the bulb 2 such that it covers the external electrode 7, and the resultant coating is baked.

The light-shielding layer 8 is not formed on the outer surface portions which oppose the external electrode, so that a light-transmitting slit 9 extending in the axial direction is left on the outer surface of the bulb 2. That is, the light-transmitting slit 9 is a portion on which the light-shielding layer 8 is not formed.

Fig. 5 illustrates cross sections of the external electrode 7, the light-shielding layer 8, and the light-transmitting slit 9. As is illustrated, the external electrode 7 is located on one side of the outer surface of the bulb 2 and is covered with the light-shielding layer 8. The light-transmitting slit 9 is located on that side of the outer surface which is 180° opposite to the external electrode 7. The light-transmitting slit 9 is narrower than the external electrode 7.

The light produced by the bulb 2 is emitted to the outside through only the light-transmitting slit 9. In other words, the discharge lamp 1 is of an aperture type.

As is shown in Fig. 6, the second power-receiving terminal 11 is not covered with the light-shielding layer 8; it is exposed to the outside.

The xenon discharge lamp 1 having the above construction is fitted in a lamp holder 20. The lamp holder 20 is formed of an electrically insulating material, such as a synthetic resin, and has a U-shaped cross section. It has first and second power supply terminals 21 and 22 isolated from each other in the longitudinal direction. Each of the power supply terminals 21 and 22 is a plate spring formed of a conductive material, such as phosphor bronze, and is bent to have a U-shaped cross section. As is shown in Fig. 6, each power supply terminal is adapted to clamp the bulb 2 with the opposing clamping portions 222 thereof.

The lamp holder 20 is fixed to the rotating shaft 25 of a measuring device, and is thus rotatable together with the rotating shaft 25. Although not shown, this rotating shaft 25 is hollow, and two cords are inserted through the hollow section of the rotating shaft 25. The cords are connected, at one end, to the first and second power supply terminals, respectively, and are commonly connected, at the other end, to a high-frequency power source (not shown).

The pinch seal end of the discharge lamp 1 is fitted in the lamp holder 20, such that the internal electrode 4 of the lamp 1 is located inside the lamp holder 20. More specifically, the first and second power-receiving terminals 10 and 11 of the bulb 2 correspond in location to the first and second power supply terminals 21 and 22 of the lamp holder 20. When the lamp is pushed into the lamp holder 20, the first power supply terminal 21 clamps the first power-receiving terminal 10 with its clamping portions 222; likewise, the second power supply terminal 22 clamps the second power-receiving terminal 11 with its clamping portions 222. In this manner, the discharge lamp 1 is held by the lamp holder 20.

When the discharge lamp 1 held by the lamp holder 20, the first and second power supply terminals 21 and 22 are electrically connected to the first and second power-receiving terminals 10 and 11, respectively. As a result, the internal electrode 4 and the external electrode 7 are electrically connected to the high-frequency power source.

A description will now be given of the operation of the discharge lamp having the above construction.

When high-frequency power is applied between the internal electrode 4 and the external electrode 7, glow discharge is generated between those electrodes.

The glow discharge actuates the xenon gas sealed in the discharge space 3, thus producing ultraviolet rays of the spectrum peculiar to the xenon gas. The short-wavelength rays excite the fluorescent material 6, whereby visible light is emitted from the fluorescent material 6.

The light emitted from the fluorescent material 6 is directed to the outside of the lamp through the narrow slit 9. Since the light generated by the long, narrow bulb 2 is further restricted by the narrow slit 9, the light output from the lamp looks like a needle. Since the discharge lamp 1 has a measurement scale thereon and this measurement scale radiates light, no special illuminator is needed to illuminate the measurement scale.

The lamp holder 20 is fixed to the rotating shaft 25, and is rotatable together with the rotating shaft 25. Thus, the discharge lamp 1 fitted in the lamp holder 20 is also rotatable together with the rotating shaft 25.

The discharge lamp 1 contains a xenon gas in the discharge space 3 thereof. The internal pressure of the xenon gas is within the range of 5 to 40 Torr. In the case of this embodiment, the internal pressure is approximately 30 Torr, which is lower than the corresponding internal pressure of a conventional lamp. Due to this low internal pressure, a positive column is not generated concentratedly but is diffused uniformly in the discharge space. Therefore, the positive column does not have a clear boundary between a concentration region and a diffusion region, as in the conventional lamp, and vibration of such a boundary does not occur in the lamp of the present invention. In other words, the glow discharge occurs in the discharge space 3 in a distributed fashion, so that flickering hardly occurs in the lamp of the present invention. Thus, the light output from the slit 9 hardly flickers, and is easy to look at.

If the pressure at which the xenon gas is sealed in the bulb 2 is too low, the lamp requires a very high starting voltage. This is because electrons cannot be easily emitted from a small amount of xenon and thus the fluorescent material cannot be easily excited.

The xenon gas has the characteristic that its ions may enter into the bulb wall, being drawn by the external electrode 7. In the worst case, the xenon gas may be completely lost from the discharge space 3. If the discharge space 3 contains only a small amount of xenon gas, the starting characteristics of the lamp is degraded. In addition, neither the excitation nor the transition of the xenon gas easily occurs, so that electromagnetic waves, such as visible rays, infrared rays, ultraviolet rays, etc. are not much produced. Thus, the brightness or luminance of the lamp is greatly degraded.

To prevent the above-mentioned problem, a certain amount of xenon gas must be sealed within the bulb. In consideration of this, the pressure at which the xenon gas is sealed inside the bulb is determined to be within the range of 5 to 40 Torr, preferably within the range of 20 to 40 Torr.

The advantages arising from the sealing pressure within this range are actually confirmed in the experiments conducted by the inventors of the present invention. The results of the experiments will be mentioned below.

Fig. 15 is a graph showing the relationships between the sealing pressure of the xenon gas and the starting voltage of the lamp. As can be understood from the graph, if the sealing pressure of the xenon gas is lower than 5 Torr, the starting voltage is as high as 800 V or more. Thus, the sealing pressure of the xenon gas should be at least 5 Torr, so as to improve the starting characteristics of the lamp.

Fig. 16 is a graph showing the relationships between the sealing pressure of the xenon gas and the occurrence of flickering.

The zones indicated in the graph shown in Fig. 16 are explained as follows:

A zone: a zone wherein the positive column of the glow discharge did not flicker at all;

B zone: a zone wherein flickering could be observed in the positive column if looked at carefully;

C zone: a zone wherein flickering occurred markedly in the positive column;

a zone: a zone wherein flickering could be observed in about half of the lamps used in the experiments, if looked at carefully; and

b zone: a zone wherein flickering occurred markedly in the positive column in about half of the lamps used in the experiment.

As can be understood from the graph shown in Fig. 16, flickering occurs more or less if the sealing pressure of the xenon exceeds the a zone. In other words, the flickering does not occur at all in the regions other than the B and C zones. Thus, the sealing pressure of the xenon should be 40 Torr or less.

In light of the results shown in Figs. 15 and 16, it is understood that the lower and upper limits of the sealing pressure of the xenon gas should be 5 Torr and 40 Torr, respectively, so as both to eliminate flickering and to attain satisfactory starting characteristics.

Fig. 17 is a graph showing the relationships among a luminance maintenance factor, the sealing pressure of a xenon gas, and a lighting hour. From this graph, it can be understood that the higher the sealing pressure is, the more satisfactory the luminance maintenance factor will be. Even if ions of the xenon gas enter the interior of the bulb wall, the amount of such ions are considered to be negligible, as compared with the total amount of xenon gas ions.

In the graph shown in Fig. 17, a lamp wherein the sealing pressure of xenon gas is 40 Torr is indicated by curve D, a lamp wherein the sealing pressure is 30 Torr is indicated by curve E, and a lamp wherein the sealing pressure is 20 Torr is indicated by curve F. A xenon gas was added to these lamps when their luminance intensities became insufficient, i.e., when the luminance intensities became d1, e1 and f1, respectively. As a result, the luminance intensities could be improved to d2, e2 and f2, respectively, as indicated in the graph.

As can be understood from this, the sealing pressure of the xenon gas is related to the brightness of the lamps.

The xenon glow discharge lamp mentioned above is used not only as the indicating needle of a measuring device but also as the power source of an office automation (OA) device, such as the back light of a liquid crystal display. When used as the power source of an OA device, the xenon glow discharge lamp is required to have a luminance maintenance factor of 60% or more, even after it is lit for 1,000 hours.

To satisfy this requirement, it is desirable that the sealing pressure of the xenon gas be higher than 20 Torr, as can be understood from the graph shown in Fig. 17.

In summary, the sealing pressure of the xenon gas should be 5 Torr or more, so as to attain satisfactory starting characteristics, and should preferably be 20 Torr or more, so as to provide a satisfactory luminance maintenance factor.

In the lamp of the above embodiment, the internal electrode 4 is constituted by a cold cathode. Since such an internal electrode produces only a small amount of heat, it withstands long use. In addition, the cold cathode enables the use of a small-diameter bulb 2, e.g. a bulb 2 whose diameter is as small as 3 mm or less. As a result of this, a needle-like lamp can be obtained.

If the diameter of the bulb 2 is small, the volume of the discharge space 3 is also small, so that the amount of discharge gas which can be sealed in the discharge space is inevitably small. Thus, the pressure of the xenon gas in the discharge space may become lower than 5 Torr, even if a very small amount of xenon gas is lost from the discharge space. In the present invention, however, the xenon gas is initially sealed in the bulb at a pressure of 20 Torr or more, so that it is unlikely that the pressure of the xenon gas will become lower than 5 Torr during the use of the lamp.

As mentioned above, the external electrode 7 attracts ions of the xenon sealed in the discharge space 3. Since, in the embodiment of the present invention, the width of the external electrode 7 is more than one third of the circumferential length of the bulb 2 (more than 120° of the circumferential angle of the bulb 2), a certain amount of xenon ions may be lost from the discharge space, being attracted by the external electrode. However, the initial sealing pressure of the xenon gas is 20 Torr or more, so that it is unlikely that the pressure of the xenon gas will become lower than 5 Torr during use of the lamp, .

Fig. 18 shows the second embodiment of the present invention. This alternative embodiment differs from the foregoing embodiment, in the structure of the tip off portion 250. In the first embodiment, the outer face 251 and inner face 252 of the thick portion 255 are projected in the opposite directions. In the second embodiment, however, only the outer face 251 of the thick portion 555 is projected; the inner face 252 is not projected, as in the first embodiment.

Fig. 19 shows the third embodiment. In this embodiment, only the inner face 252 of the thick portion 655 is projected; the outer face 251 is not projected, as in the first and second embodiments.

The present invention is not limited to the embodiments mentioned above, and may be modified in various manners without departing from the spirit and scope of the invention.

For example, the discharge gas to be sealed inside the bulb is not limited to xenon. A mixture gas of xenon and at least one of neon, krypton and argon may be used, if so desired. In the case where mixture gas is made up of xenon and neon, the scaling pressure of the mixture gas may exceed 40 Torr, but the partial pressure of the xenon gas should be lower than 40 Torr. In other words, the above-mentioned range of the sealing pressure is limited to the xenon gas even when the mixture gas is used. Thus, the mixture gas should be introduced into the bulb such that the partial pressure of the xenon gas is within the range of 5 to 40 Torr, preferably within the range of 20 to 40 Torr.

The foregoing embodiments were described, referring to the case where the discharge lamp was used as the indicating needle of a measuring device. However, the present invention is applicable to the back light of a liquid crystal display.

Moreover, the bulb used in the embodiments need not be straight; it may be curved in accordance with the need.

Claims

1. A low pressure gas discharge lamp comprising: a light-emitting tubular bulb (2) defining an elongated discharge space (3) which is located between two ends of the bulb and which contains a discharge gas including at least a xenon gas;
an internal electrode (4) sealed within the tubular bulb and located at one of the two ends of the bulb;
a band-like external electrode (7) formed on an outer surface of the bulb and extending up to the other end of the bulb in an axial direction of the bulb; and
a fluorescent material (6) coated on an inner surface of the bulb,
characterized in that said xenon gas contained in the discharge space has a partial pressure within the range of 5 to 40 Torr.

2. A low pressure gas discharge lamp according to claim 1, characterized in that said bulb has a light-transmitting slit extending in the axial direction of the bulb.

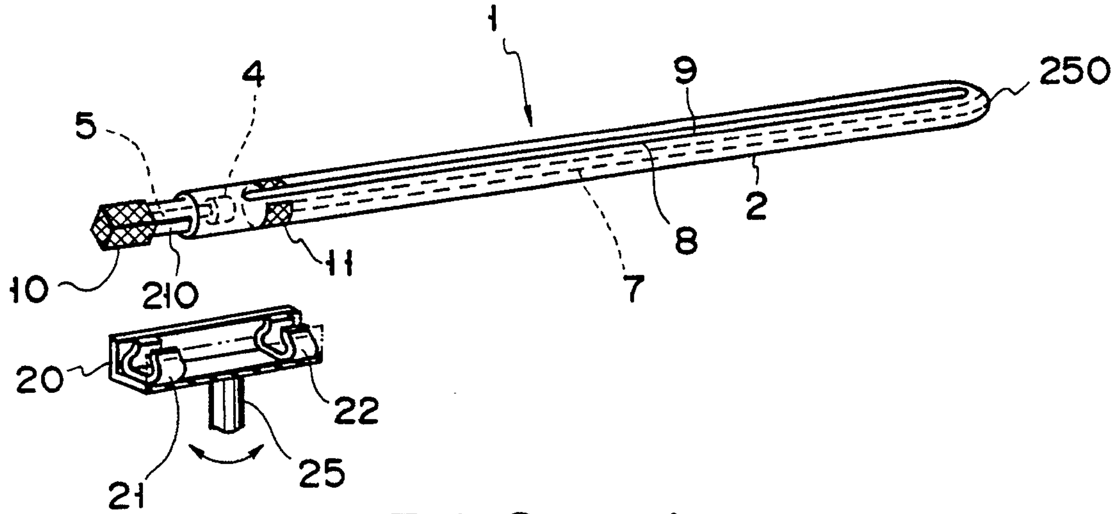
3. A low pressure gas discharge lamp according to claim 1, characterized in that said discharge gas contained in the discharge space includes at least one of neon, krypton and argon gases, in addition to the xenon gas whose partial pressure is within the range of 5 to 40 Torr.

4. A low pressure gas discharge lamp according to claim 1, characterized in that said internal electrode includes a cold cathode.

5. A low pressure gas discharge lamp according to claim 1, characterized in that said xenon gas contained in the discharge space has a partial pressure within the range of 20 to 40 Torr.

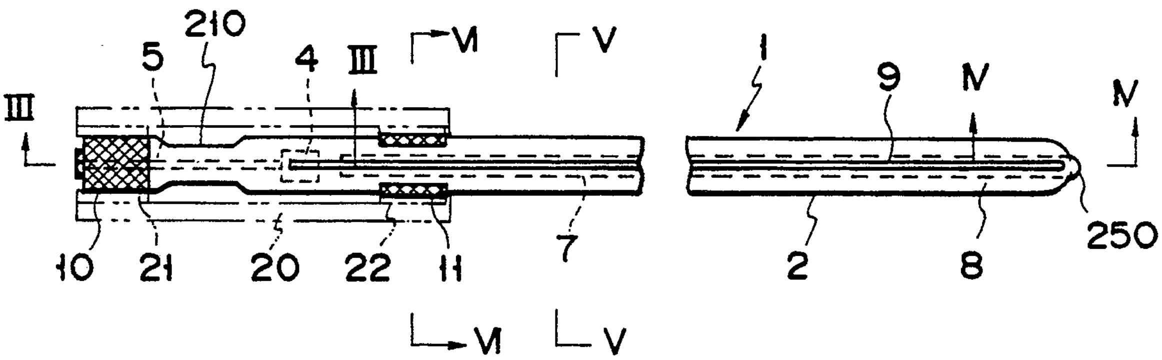
6. A low pressure gas discharge lamp according to claim 5, characterized in that said internal electrode includes a cold cathode, and said bulb has an inner diameter of 3 mm or less.

7. A low pressure gas discharge lamp according to claim 5, characterized in that said internal electrode includes a cold cathode, and said external electrode has a width larger than 1/3 of a circumferential length of the bulb.



1
4
9
250
5
2
8
10
210
11
7
20
22
21
25

F I G. 1



210
5
4
III
VI
V
1
9
IV
IV
III
10
21
20
22
11
7
2
8
250
VI
V

F I G. 2

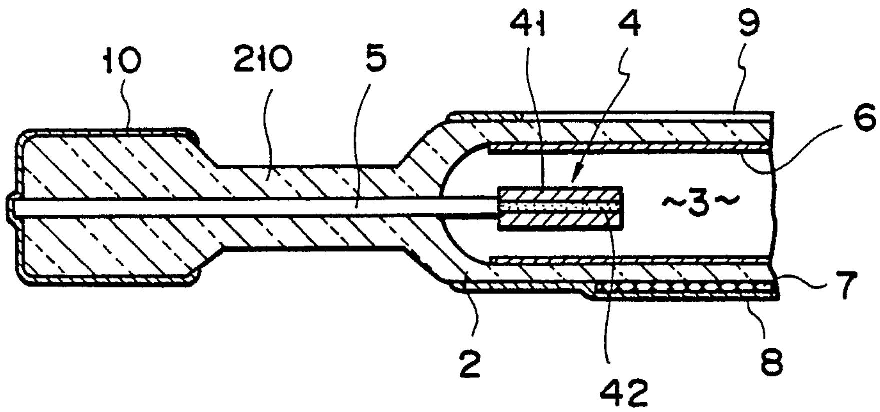


FIG. 3

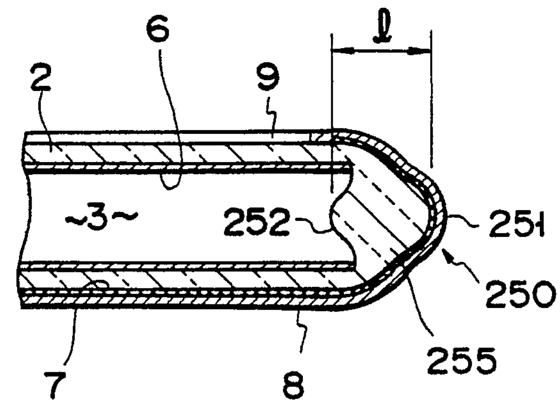


FIG. 4

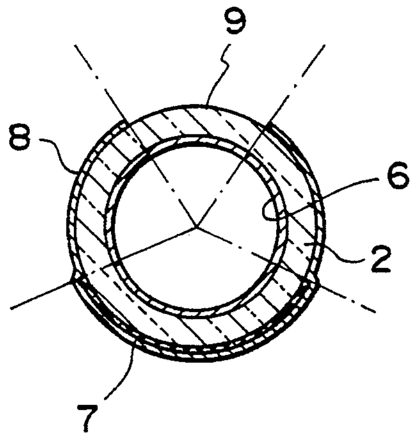


FIG. 5

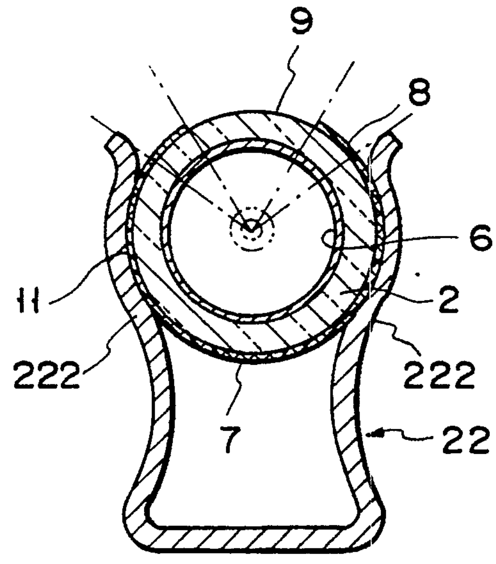
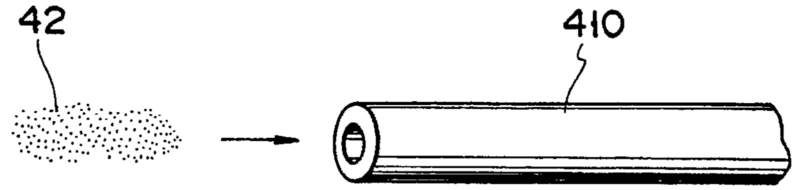
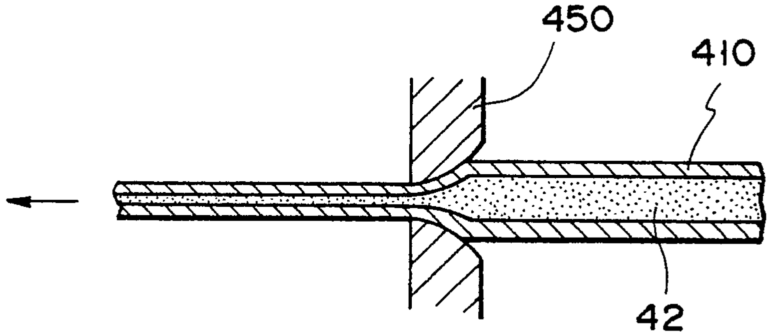


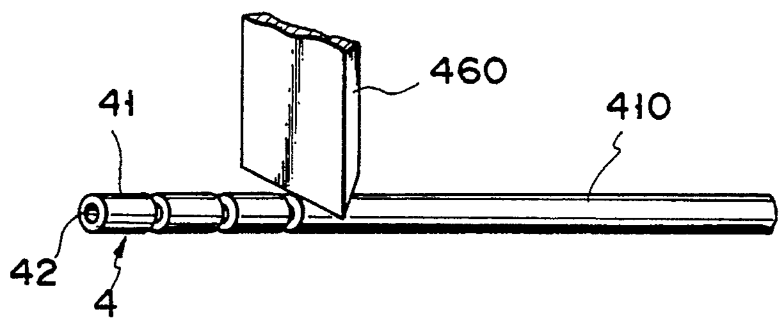
FIG. 6



F I G. 7



F I G. 8



F I G 9

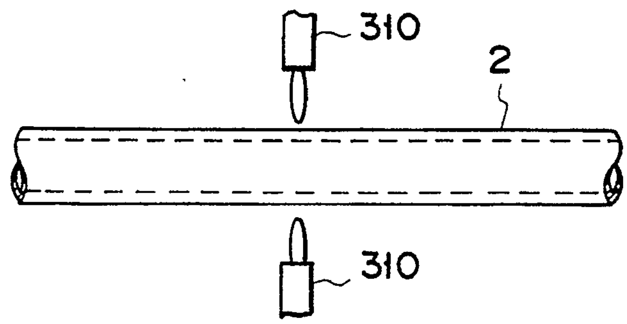


FIG. 10

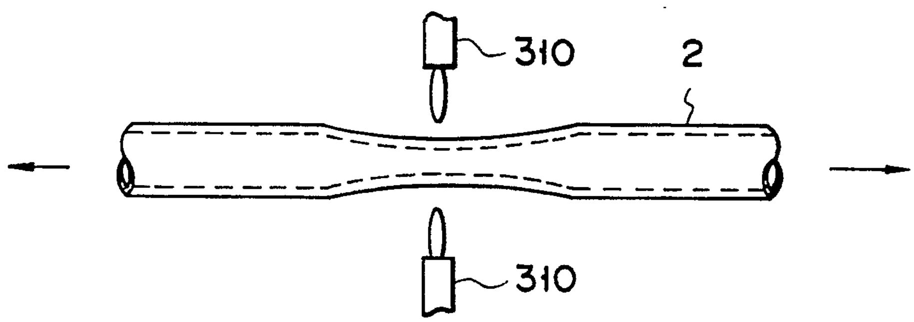


FIG. 11

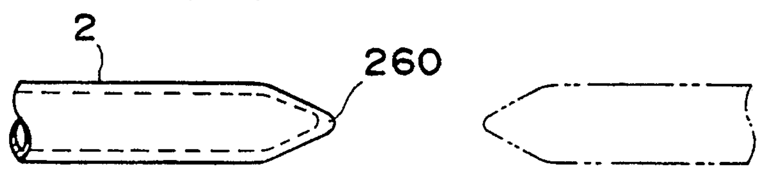


FIG. 12

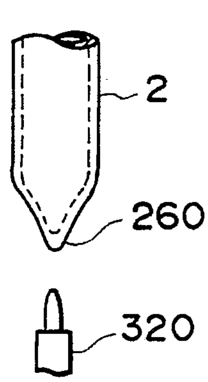


FIG. 13

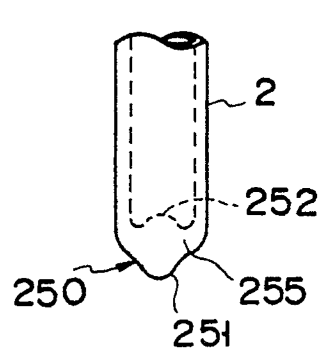


FIG. 14

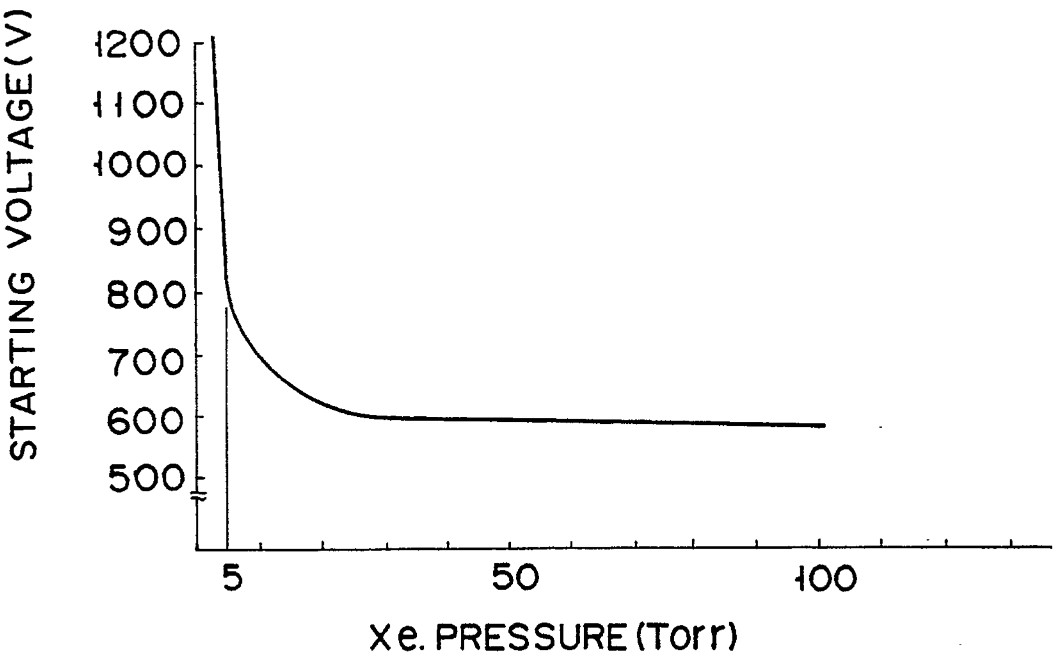

STARTING VOLTAGE (V)
1200
1100
1000
900
800
700
600
500
5
50
100
Xe. PRESSURE (Torr)

FIG. 15

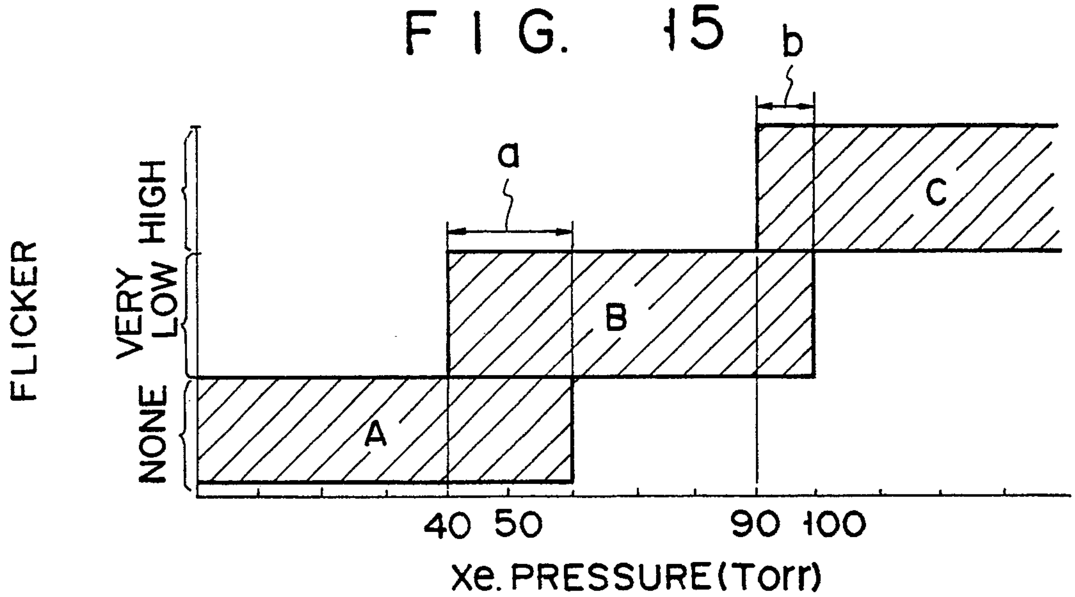

FLICKER
HIGH
VERY LOW
NONE
a
b
A
B
C
40 50
90 100
Xe. PRESSURE (Torr)

FIG. 16

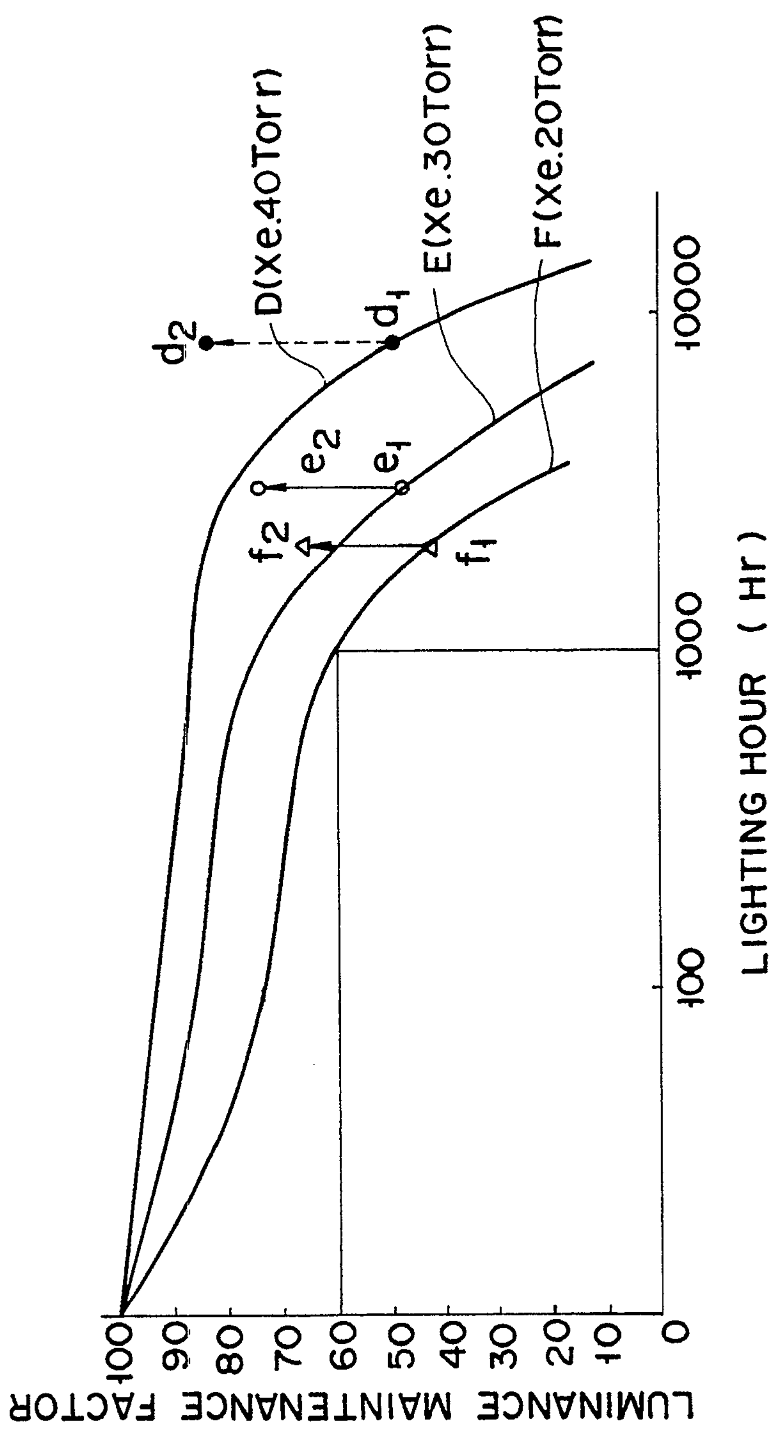
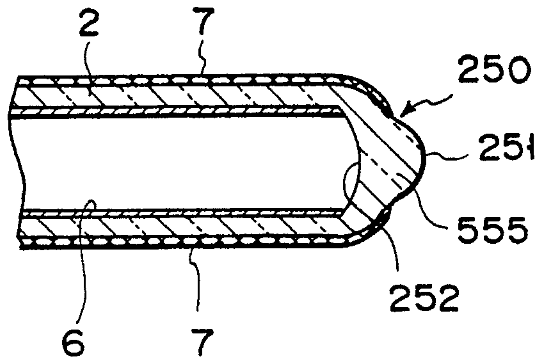
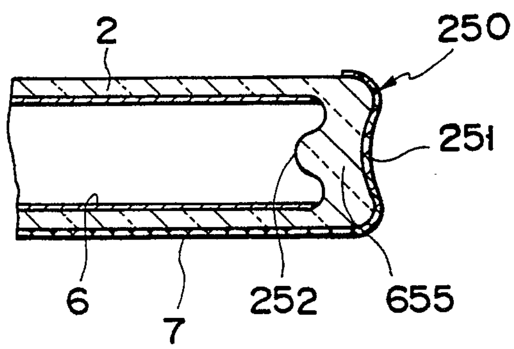

LUMINANCE MAINTENANCE FACTOR
100
90
80
70
60
50
40
30
20
10
0
100
1000
10000
LIGHTING HOUR (Hr)
D(Xe.40Torr)
E(Xe.30Torr)
F(Xe.20Torr)
d1
d2
e1
e2
f1
f2

FIG. 17



F I G. 18



F I G. 19

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 90106846.0

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int Cl.5)
X	US - A - 2 053 879 (SPANNER) * Fig.; totality *	1	H 01 J 61/16 H 01 J 61/30
A		3,7	
A	GB - A - 2 009 493 (BBC) * Claims 1,3 *	1,3,6	
A	US - A - 2 440 832 (PENNY BACKER) * Column 1, line 36 - column 2, line 36 *	4,6	
A	DE - A1 - 3 403 914 (WOLFF)		

TECHNICAL FIELDS SEARCHED (Int Cl.5)

H 01 J 61/00
H 01 J 7/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	12-07-1990	BRUNNER

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