

(19)



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(11)

EP 0 713 608 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:
27.10.1999 Bulletin 1999/43

(51) Int Cl.⁶: **H01J 61/92, H01J 61/04,
H01J 61/10**

(21) Application number: **94923017.1**

(86) International application number:
PCT/GB94/01733

(22) Date of filing: **08.08.1994**

(87) International publication number:
WO 95/05001 (16.02.1995 Gazette 1995/08)

(54) **A GAS DISCHARGE LAMP**
GASENTLADUNGSLAMPE
LAMPE A DECHARGE

(84) Designated Contracting States:
DE FR GB IT

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(30) Priority: **09.08.1993 GB 9316505**

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(43) Date of publication of application:
29.05.1996 Bulletin 1996/22

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EP-A- 0 037 589 **US-A- 4 598 229**

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Description

[0001] The present invention relates to a gas discharge lamp and more particularly to a gas discharge lamp capable of being operated over a range of brightnesses.

[0002] Conventionally, a gas discharge lamp comprises a sealed elongate glass tube formed at opposite ends with electrodes which comprise a cathode and an anode. The glass tube is filled with an inert gas such as neon at low pressure, typically at $1/100$ th of atmospheric pressure. In operation a discharge is established between the anode and the cathode by creating a potential difference between the anode and cathode thus ionising the neon gas therebetween.

[0003] There are two basic known methods of varying the brightness of such a conventional gas discharge lamp. The first method is to vary the operating current of the gas discharge lamp such that by increasing the current a greater brightness is obtained and by decreasing the current a lower brightness is obtained. The second method is to pulse width modulate the power supply to the gas discharge lamp thus turning the lamp on and off very rapidly. This varies the ratio of on-time to off-time thereby causing the lamp to appear bright for a high ratio of on-time to off-time and dim for a low ratio of on-time to off-time.

[0004] with the first method discussed above, the brightness or efficacy (lumens per watt) of a lamp under certain conditions can be increased by using a thin or narrow tube. In a thin tube, the current density between the electrodes is increased, as compared with a wider tube of the same length. A similar effect may also be achieved under certain conditions by lowering the gas pressure within the tube. Accordingly, it is desirable to use a thin tube to provide a bright light source.

[0005] Referring to Figure 1, the negative resistance characteristics of a thin gas discharge lamp are labelled K/A and the power supply unit requirements to operate at a low brightness and at a high brightness are labelled PSU_L and PSU_H respectively. A thin lamp operates satisfactorily at a high current I_H , low voltage V_H to produce high brightnesses. However, to reduce the brightness of the thin tube, the operating current of the lamp must be decreased. It can be seen from Figure 1 that the Voltage-Current (vI) characteristics of a thin tube are such that the negative resistance of the gas discharge lamp increases dramatically at low current levels (I_L). Accordingly, when a thin tube is operated at the lower current I_L which is necessary to dim the lamp to a suitable level, the voltage requirement V_L of such a lamp becomes very high. For stable operation of such a thin tube at low currents it is necessary to load the power supply unit with a matched or higher resistance and this therefore requires a power supply unit which must be capable of operating under very high open circuit voltage conditions. Thus, the power supply unit required to operate a thin gas discharge tube over a wide range of brightness-

es must be capable of providing both a high voltage, low current condition (V_L, I_L) and a low voltage, high current condition (V_H, I_H). The cost of such a high performance power supply unit is higher than that of a standard power supply unit and the size of such a unit is large.

[0006] When varying the brightness of the gas discharge lamp by the second method, ie. by pulse width modulating the power supply to the gas discharge lamp, considerable radio frequency interference can result from the high peaks associated with the periodic re-ignition of the tube, particularly at high frequencies.

[0007] The lifetime of a gas discharge lamp is proportional to the volume of the gas within the tube and, because of the reduced amount of volume present in a thin gas discharge tube, the lifetime of a thin gas discharge lamp is reduced. Further, thin gas discharge lamps become very hot in use due to the relatively small surface area of thin lamps.

[0008] Moreover, in some applications it is necessary to provide an optical lens as close as possible to the outer surface of the discharge tube in order to focus or diffuse light emanating from the tube. Difficulties arise in mounting plastic optical lenses on conventional thin gas discharge lamps or in forming the lenses integrally with the lamps because of the high surface temperature associated with such lamps.

[0009] It is an object of the present invention to overcome or alleviate the above mentioned problems.

[0010] US-A-4598229 discloses various luminous tube colour generators. In each embodiment described there is an outer envelope of a relatively large diameter housing an inner tube of a relatively small diameter, the gas in the inner tube sharing a common atmosphere with the gas in the outer envelope. There are, in each embodiment, at least two electrodes between which a discharge path is defined. In each embodiment one electrode is located within the inner tube. In certain ones of the described embodiments there are also a further electrode which is located outside the inner tube. The inner tube bounds at least part of the discharge path between the two electrodes.

[0011] According to this invention there is provided a gas discharge lamp comprising an outer envelope housing an inner tube, the gas in the inner tube sharing a common atmosphere with the gas in the outer envelope, first and second electrodes between which a first discharge path is defined, the first electrode being located within the inner tube and the second electrode being located outside the inner tube, the inner tube bounding the majority of the first discharge path, wherein a third electrode is provided outside the inner tube, at the same end of the outer envelope as the first electrode such that a second discharge path is defined between the second electrode and the third electrode, the second discharge path being located between the inner tube and the outer envelope.

[0012] Conveniently, in use, the operating voltage of the discharge path between the first and second elec-

trodes is substantially equivalent to the operating voltage of the discharge path between the second and third electrodes.

[0013] Advantageously, in use, the current density in the discharge path between the first and second electrodes is greater than the current density in the discharge path between the second and third electrodes.

[0014] Preferably the discharge path between the first and second electrodes produces a light source between five and forty times brighter than the light source produced by the discharge path between the second and third electrodes.

[0015] Conveniently the outer envelope is provided with one or more optical elements to focus or diffuse light produced by the lamp, the or each optical element forming an integral part of the outer envelope.

[0016] Conveniently the outer envelope is of elongate, tubular form, the inner tube being concentrically mounted within the outer envelope.

[0017] Advantageously, the second electrode is mounted in the outer envelope at a position substantially opposite an open end of the inner tube.

[0018] The lamp as described above may be used as a centre high mounted stop light wherein the gas discharge length of each discharge path of the lamp being less than 381mm (15 inches).

[0019] In order that the present invention may be more readily understood, embodiments thereof will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic graph showing the voltage-current characteristics of a conventional thin gas discharge lamp and the current-voltage requirements of a power supply suitable for operating such a gas discharge lamp over a range of brightnesses;

Figure 2 is a schematic side elevation of a conventional gas discharge lamp;

Figure 3 is a cross-section through the gas discharge lamp of Figure 2 taken along the line III - III;

Figure 4 is a schematic side elevation of a gas discharge lamp embodying the present invention;

Figure 5 is a schematic graph of the voltage-current characteristics of the gas discharge lamp of Figure 4, and;

Figure 6 is a cross-section through a gas discharge lamp embodying the present invention and incorporating a reflective optical component.

[0020] Referring now to Figure 2, a gas discharge lamp 1 comprises an outer sealed elongate glass sleeve 2 provided at one end with a cold cathode K and at the other end with an anode A1. The cathode K is sealed in

the glass of the sleeve 2 and is provided with a portion 3 which projects into the sleeve 2. The anode A1 is centrally located in a cylindrical sealing plug 4 and projects into the sleeve 2. The plug 4 is also provided with an open ended thin glass tube 5 which surrounds the anode A1 and which extends within the glass sleeve 2 towards the cathode K at the other end of the gas discharge lamp. The glass tube 5 has an open end 6 adjacent the cathode K so that the gas in the tube 5 shares a common atmosphere with the gas in the sleeve 2. The sealing plug 4 is pinch sealed with the glass sleeve 2 at the end containing the anode A1. The glass sleeve 2 is filled with neon gas under low pressure (typically $1/100^{\text{th}}$ of atmospheric pressure). A cross-section through the gas discharge lamp 1 is shown in Figure 3.

[0021] The described configuration of a gas discharge lamp provides an ionisation path from the anode A1 to the cold cathode K via the neon gas located in the thin glass tube 5. The thin glass tube 5 serves to define or limit the gas ionisation or discharge path such that in use only the gas contained within the tube 5 and between the end 6 of the tube and the cathode K is ionised. The remainder of the gas held in the glass sleeve 2 is not ionised during discharge. Because of the high current density in the thin central glass tubes, the brightness or efficacy (lumens per watt) of the gas discharge lamp 1 is greater for given operating conditions than that of a gas discharge lamp having the same cross-sectional area as the glass sleeve 2.

[0022] The power dissipated during discharge is a function of two primary factors: the current carried by the discharge and the voltage drop across the discharge. Thus, the narrower the tube is the higher the voltage per unit length will be and, therefore, the more power will be dissipated. The general result is more light per unit length.

[0023] As mentioned, the lifetime of a gas discharge lamp is proportional to the volume of ionising gas present in the lamp and so the lifetime of the gas discharge lamp 1 is increased because the total volume of gas within the glass sleeve 2 is large compared to that contained within a thin gas discharge lamp of the same length, where the thin lamp would normally have a cross-sectional area of the same order of magnitude as the tube 5. The ionisation path from the anode A1 to the cathode K is thermally insulated by the volume of gas held in the glass sleeve 2 surrounding the tube 5. Thus, the temperature of the outer surface of the glass sleeve 2 lags behind that of the thin tube 5. The resultant steady state temperature of the sleeve 2 will be dependent upon the ratio of the surface areas of the thin tube 5 and the sleeve 2.

[0024] Whilst it is desirable to use thin gas discharge tubes because of the high brightness or efficacy which can be achieved and the precise line source of light provided, there are drawbacks associated with the use of thin tubes especially when the thin gas discharge tube must provide a wide range of brightnesses.

[0025] If greater brightness was sought in a tube of given length merely by increasing the current therein, then undesirable effects would ensue such as an increase in electrode power loss and a decrease in lifespan due to electrode sputtering.

[0026] Referring to Figure 4, in an embodiment of the present invention, the gas discharge lamp 1 is provided with a second anode A2 at the same end of the glass sleeve 2 as the first anode A1 but outside the central thin glass tube 5. The second anode A2 is held in the sealing plug 4 and is located in the volume of gas outside the thin tube 5 but within the sleeve 2.

[0027] The second anode A2 provides the gas discharge lamp 1 with a second discharge path in the glass sleeve 2 from the anode A2 to the cathode K but not within the central glass tube 5 which remains the discharge path for anode A1. Figure 5 shows the negative resistance characteristics of the discharge path between the anode A1 and the cathode K (the curve labelled K/A1) and of the discharge path between the anode A2 and the cathode K (the curve labelled K/A2). As can be seen the two discharge paths have different characteristics, the "broader" discharge path K/A2 having a lower characteristic voltage drop and a less pronounced negative resistance and the thin discharge path K/A1 being similar to that shown in Figure 1 for a conventional thin gas discharge lamp having a dramatically increasing negative resistance at low current levels.

[0028] In some applications it is desirable to be able to operate a gas discharge lamp at two different brightnesses with the greater brightness level being approximately twenty times brighter than the lesser brightness level. The lamp of Figure 4 can be operated to provide differing levels of brightness of this order of magnitude. Thus, the light source created by the gas discharge path between the anode A1 and the cathode K is some twenty times brighter than the light source created by the discharge path between the anode A2 and the cathode K. Hence by selecting the discharge path (ie. the appropriate anode A1 or A2) the desired level of brightness can be achieved. This may be effected by powering either anode A1 or anode A2 independently of the other or, for example, by powering anode A2 constantly and simultaneously powering anode A1 when greater brightness is required.

[0029] It is envisaged that the lamp of Figure 4 will be used in a motor vehicle as the light source in a combined side light and brake light unit where the brake light must be visibly brighter than the side light. The running side light of a car would be operated at the lower brightness level via the gas discharge path from the anode A2 to the cathode K whilst the braking light of a vehicle would be operated at the high brightness level created by the gas discharge path between anode A1 and cathode K. Accordingly, as seen in Figure 5, to obtain the bright light source anode A1 is operated at a high current level I_H but to obtain the lower brightness light source anode A2

is operated at a low current level I_L . Both anodes A1 and A2 are operated at substantially equal voltages V_H and V_L respectively or at least at a voltage well within the capabilities of a conventional and economic power supply unit.

[0030] The power supply unit requirement of the gas discharge lamp 1 shown in Figure 4 is therefore less demanding than for a conventional thin gas discharge lamp operating over the same range of brightnesses.

[0031] Referring to Figure 5 which shows the two respective operating conditions of the gas discharge lamp 1 of Figure 4, typical values of the low current I_L and the high current I_H would be 3mA and 60mA respectively with voltages V_L and V_H both being approximately 1000V.

[0032] Hence, the discharge path from anode A1 to cathode K through the thin central glass tube 5 provides a high current density ionisation or discharge path which thereby provides a high brightness light source when the lamp is discharged at high current levels I_H .

[0033] The light source from the thin central glass tube 5 is a line source which can be efficiently focused thereby reducing the power requirement of the gas discharge lamp. As shown in Figure 6 the glass sleeve 2 can incorporate a focusing means such as a reflective coating 10 to focus the line light source in a particular direction. Such a reflective coating may be made of plastics material. Additionally, the cross-section of the gas discharge lamp may be of a "rounded" triangular form having a substantially parabolic reflecting surface as shown in Figure 6 rather than the circular cross-section shown in Figure 3.

[0034] The gas discharge lamp of Figure 4 can be operated by either a DC or an AC supply. When using a DC supply, the anodes A1 and A2 can be made very small because they will not be bombarded by ions. Because of the small size of the anodes, the anodes A1 can be readily inserted within the thin central glass tube 5 and the size of the anode A1 does not limit the thinness of the thin central tube 5.

[0035] Under AC operation, the size of the electrodes A1, A2 must be increased because the electrodes A1, A2 must act both as cathodes and anodes and will be bombarded by ions. Accordingly, the size of the thin central tube 5 is constrained by the size of the electrode A1.

[0036] Under DC operation of the gas discharge lamp of Figure 5 there is no discharge current leakage from the discharge path from the anode A1 to the cathode K into the discharge path from the anode A2 to the cathode K. Accordingly, a uniform light source is produced.

[0037] Under AC operation it may be necessary to arrange optical reflector 10 shown in the embodiment of Figure 6, in such a way as to minimise any discharge current leakage from the gas discharge lamp 1.

[0038] In one embodiment of the present invention the thin tube 5 has an internal diameter of 3mm (0.12 inches) and the internal diameter of the sleeve is 13mm (0.51 inches).

[0039] In a preferred embodiment of the present invention the gas discharge lamp is configured as a centre high mounted stop light (CHMSL) for use on a compact or sub-compact vehicle. A CHMSL requires high efficacy as well as a short discharge length, i.e. less than 381mm (15 inches). Such a CHMSL would typically have an illuminated area of 3871mm² (6 square inches, 25.4mm (1 inch) by 152mm (6 inches) in length. The minimum light output of the CHMSL is not less than 32 Candelas and the lifespan is greater than 2000 hours and preferably greater than 7500 hours.

[0040] A gas discharge lamp having such a high efficacy with such a short tube 152mm (6 inches) is possible because of the provision of the narrow tube within the outer envelope. Such a narrow tube having an internal diameter of the order of 3mm (0.12 inches) produces a much higher voltage per unit length and, as such, operates at a higher power than a conventional single envelope gas discharge lamp. The general result is more light per unit length allowing CHMSLs to be manufactured having a length of 152mm (6 inches). Tubes having a diameter of 2½mm (0.1 inches), 2mm (0.08 inches) and 1mm (0.04 inches) are possible and provide suitable increases in light per unit length.

[0041] It is envisaged that, owing to the large increases possible in the lifetime of the lamps according to the present invention, it will be possible to decrease further the pressure in the sleeve to improve the brightness or efficacy of the gas discharge lamp or to provide a reduction in input power.

Claims

1. A gas discharge lamp(1) comprising an outer envelope(2) housing an inner tube(5), the gas in the inner tube sharing a common atmosphere with the gas in the outer envelope, first(A1) and second(K) electrodes between which a first discharge path is defined, the first electrode(A1) being located within the inner tube(5) and the second electrode(K) being located outside the inner tube, the inner tube bounding the majority of the first discharge path, characterised in that a third electrode(A2) is provided outside the inner tube, at the same end of the outer envelope(2) as the first electrode(A1) such that a second discharge path is defined between the second electrode(K) and the third electrode(A2), the second discharge path being located between the inner tube(5) and the outer envelope(2).
2. A gas discharge lamp(1) according to Claim 1 wherein, in use, the operating voltage of the discharge path between the first(A1) and second(K) electrodes is substantially equivalent to the operating voltage of the discharge path between the second(K) and third(A2) electrodes.

3. A gas discharge lamp(1) according to any one of the preceding Claims wherein, in use, the current density in the discharge path between the first(A1) and second(K) electrodes is greater than the current density in the discharge path between the second(K) and third(A2) electrodes.
4. A gas discharge lamp(1) according to any one of the preceding Claims wherein the discharge path between the first(A1) and second(K) electrodes produces a light source between five and forty times brighter than the light source produced by the discharge path between the second(K) and third(A3) electrodes.
5. A gas discharge lamp(1) according to any preceding Claim, wherein the outer envelope(2) is provided with one or more optical elements(10) to focus or diffuse light produced by the lamp, the or each optical element forming an integral part of the outer envelope.
6. A gas discharge lamp(1) according to any one of the preceding Claims wherein the outer envelope (2) is of elongate, tubular form, the inner tube(5) being concentrically mounted within the outer envelope.
7. A gas discharge lamp(1) according to any one of the preceding Claims wherein the second electrode (K) is mounted in the outer envelope at a position substantially opposite an open end of the inner tube (5).

8. A centre high mounted stop light comprising a gas discharge lamp(1) according to any preceding claim, the gas discharge length of each discharge path of the lamp being less than 381mm (15 inches).

Patentansprüche

1. Eine Gasentladungslampe (1), mit einem äußeren Kolben (2), der eine innere Röhre (5) aufnimmt, wobei das Gas in der inneren Röhre an einem gemeinsamen Luftdruck mit dem Gas in dem äußeren Kolben teilhat, ersten (A1) und zweiten (K) Elektroden, zwischen denen ein erster Entladungsweg gebildet wird, wobei die erste Elektrode (A1) sich innerhalb der inneren Röhre (5) befindet und die zweite Elektrode (K) sich außerhalb der inneren Röhre befindet, ferner die innere Röhre die Mehrheit des ersten Entladungsweges begrenzt, dadurch gekennzeichnet, daß eine dritte Elektrode (A2) außerhalb der inneren Röhre an demselben Ende des äußeren Kolbens (2) wie die erste Elektrode (A1) vorgesehen ist, so daß ein zweiter Entladungsweg zwi-

schen der zweiten Elektrode (K) und der dritten Elektrode (A2) gebildet wird, wobei der zweite Entladungsweg sich zwischen der inneren Röhre (5) und dem äußeren Kolben (2) befindet.

2. Eine Gasentladungslampe (1) nach Anspruch 1, worin die Betriebsspannung des Entladungsweges zwischen den ersten (A1) und zweiten (K) Elektroden im Gebrauch im wesentlichen der Betriebsspannung des Entladungsweges zwischen den zweiten (K) und dritten (A2) Elektroden gleicht.

3. Eine Gasentladungslampe (1) nach irgendeinem der vorangehenden Ansprüche, worin die Stromdichte in dem Entladungsweg zwischen den ersten (A1) und zweiten (K) Elektroden im Gebrauch größer als die Stromdichte in dem Entladungsweg zwischen den zweiten (K) und dritten (A2) Elektroden ist.

4. Eine Gasentladungslampe (1) nach irgendeinem der vorangehenden Ansprüche, worin der Entladungsweg zwischen den ersten (A1) und zweiten (K) Elektroden eine Lichtquelle erzeugt, die zwischen 5- und 40-fach heller als die Lichtquelle ist, die von dem Entladungsweg zwischen den zweiten (K) und dritten (A3) Elektroden erzeugt wird.

5. Eine Gasentladungslampe (1) nach irgendeinem vorangehenden Anspruch, worin der äußere Kolben (2) mit einem oder mehreren optischen Element(en) (10) zum Fokussieren oder Zerstören des von der Lampe erzeugten Lichts versehen ist, wobei das oder jedes optische Element einen integralen Bestandteil des äußeren Kolbens bildet.

6. Eine Gasentladungslampe (1) nach irgendeinem der vorangehenden Ansprüche, worin der äußere Kolben (2) eine längliche, rohrförmige Gestalt aufweist, wobei die innere Röhre (5) in dem äußeren Kolben konzentrisch angebracht ist.

7. Eine Gasentladungslampe (1) nach irgendeinem der vorangehenden Ansprüche, worin die zweite Elektrode (K) in dem äußeren Kolben an einer Position angebracht ist, die sich im wesentlichen gegenüber einem offenen Ende der inneren Röhre (5) befindet.

8. Ein zentrales, hoch angebrachtes Bremslicht, mit einer Gasentladungslampe (1) nach irgendeinem vorangehenden Anspruch, wobei die Gasentladungslänge des Entladungsweges der Lampe weniger als 381 mm (15 Zoll) beträgt.

Revendications

1. Lampe à décharge de gaz (1) comprenant une enveloppe extérieure (2) logeant un tube intérieur (5), le gaz se trouvant dans le tube intérieur partageant une atmosphère commune avec le gaz se trouvant dans l'enveloppe extérieure, des première (A1) et deuxième (K) électrodes entre lesquelles un premier chemin de décharge est défini, la première électrode (A1) étant placée à l'intérieur du tube intérieur (5) et la deuxième électrode (K) étant placée à l'extérieur du tube intérieur, le tube intérieur servant de limite à la majeure partie du premier chemin de décharge de gaz, caractérisée en ce qu'une troisième électrode (A2) est prévue à l'extérieur du tube intérieur, à la même extrémité de l'enveloppe extérieure (2) que la première électrode (A1) de manière qu'un deuxième chemin de décharge soit défini entre la deuxième électrode (K) et la troisième électrode (A2), le deuxième chemin de décharge étant placé entre le tube intérieur (5) et l'enveloppe extérieure (2).

2. Lampe à décharge de gaz (1) selon la revendication 1, dans laquelle, en utilisation, la tension de fonctionnement du chemin de décharge entre les première (A1) et deuxième (K) électrodes est sensiblement équivalente à la tension de fonctionnement du chemin de décharge entre les deuxième (K) et troisième (A2) électrodes.

3. Lampe à décharge de gaz (1) selon l'une quelconque des revendications précédentes, dans laquelle, en utilisation, la densité de courant dans le chemin de décharge entre les première (A1) et deuxième (K) électrodes est supérieure à la densité de courant dans le chemin de décharge entre les deuxième (K) et troisième (A2) électrodes.

4. Lampe à décharge de gaz (1) selon l'une quelconque des revendications précédentes, dans laquelle le chemin de décharge entre les première (A1) et deuxième (K) électrodes produit une source lumineuse qui est entre cinq et quarante fois plus brillante que la source lumineuse produite par le chemin de décharge se trouvant entre les deuxième (K) et troisième (A3) électrodes.

5. Lampe à décharge de gaz (1) selon l'une quelconque des revendications précédentes, dans laquelle l'enveloppe extérieure (2) est dotée d'un ou plusieurs éléments optiques (10) destinés à focaliser ou à diffuser la lumière produite par la lampe, le ou chaque élément optique formant partie intégrante de l'enveloppe extérieure.

6. Lampe à décharge de gaz (1) selon l'une quelconque des revendications précédentes, dans laquelle

l'enveloppe extérieure (2) est de forme allongée tubulaire, le tube intérieur (5) étant monté concentriquement à l'intérieur de l'enveloppe extérieure.

7. Lampe à décharge de gaz (1) selon l'une quelconque des revendications précédentes, dans laquelle la deuxième électrode (K) est montée dans l'enveloppe extérieure en une position sensiblement opposée à une extrémité ouverte du tube intérieur (5). 5
- 10
8. Feu de stop monté en position élevée centrale, comprenant une lampe à décharge à gaz (1) selon l'une quelconque des revendications précédentes, la longueur de décharge de gaz de chaque chemin de décharge de la lampe étant inférieure à 381 mm 15
(15 pouces).

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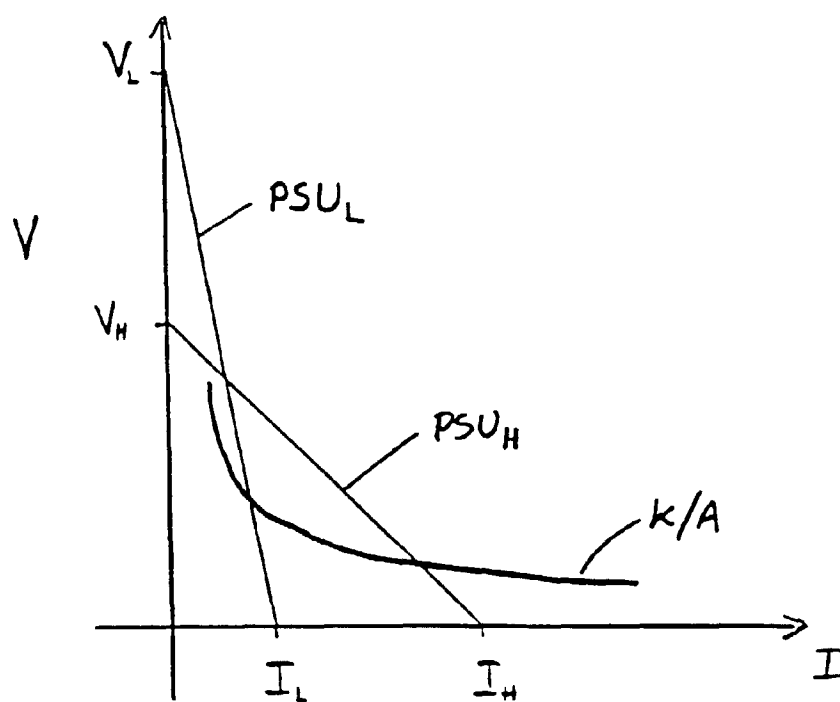


Figure 1

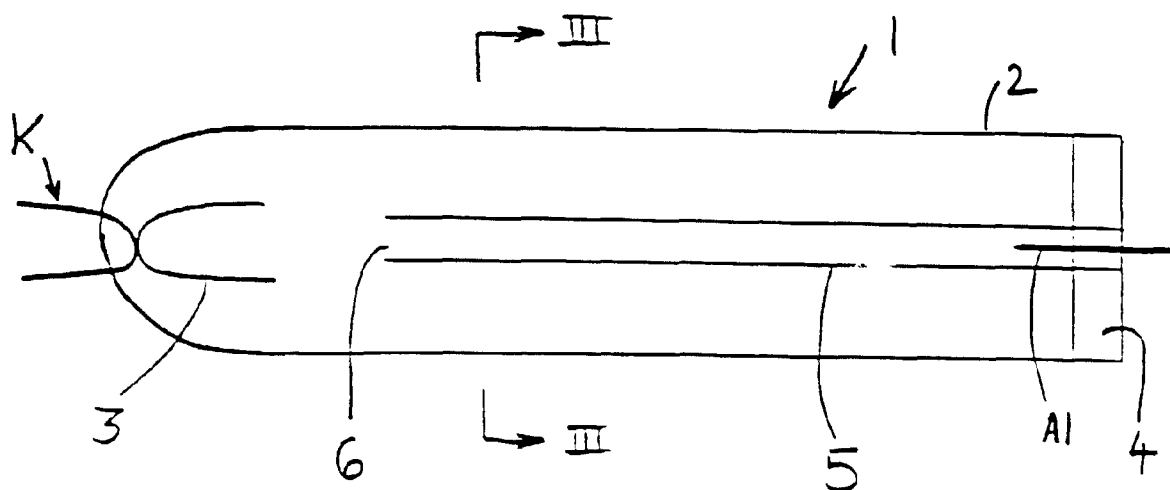


Figure 2

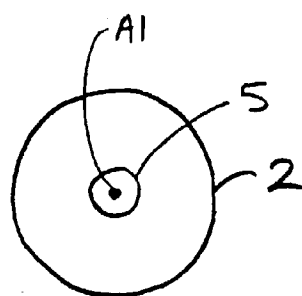


Figure 3

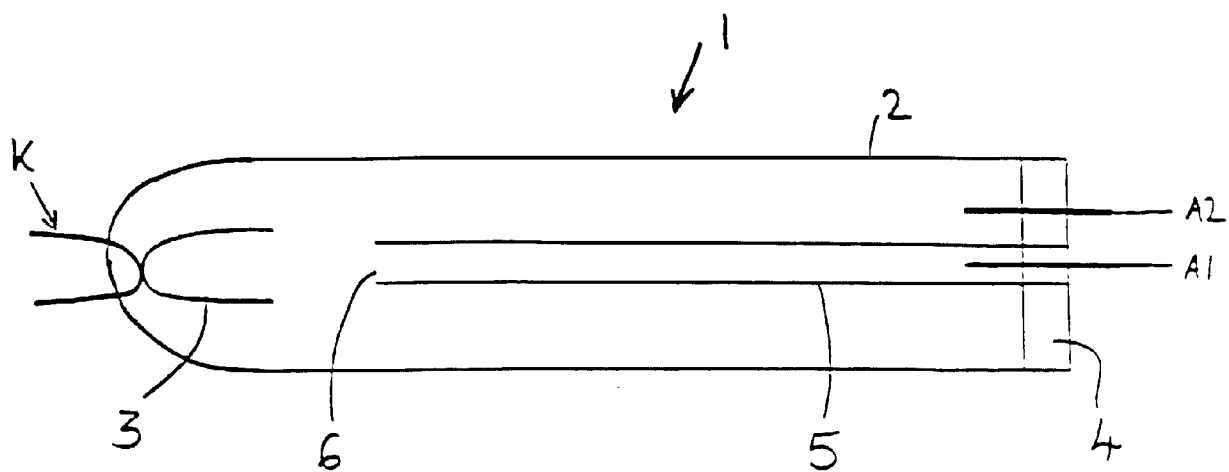


Figure 4

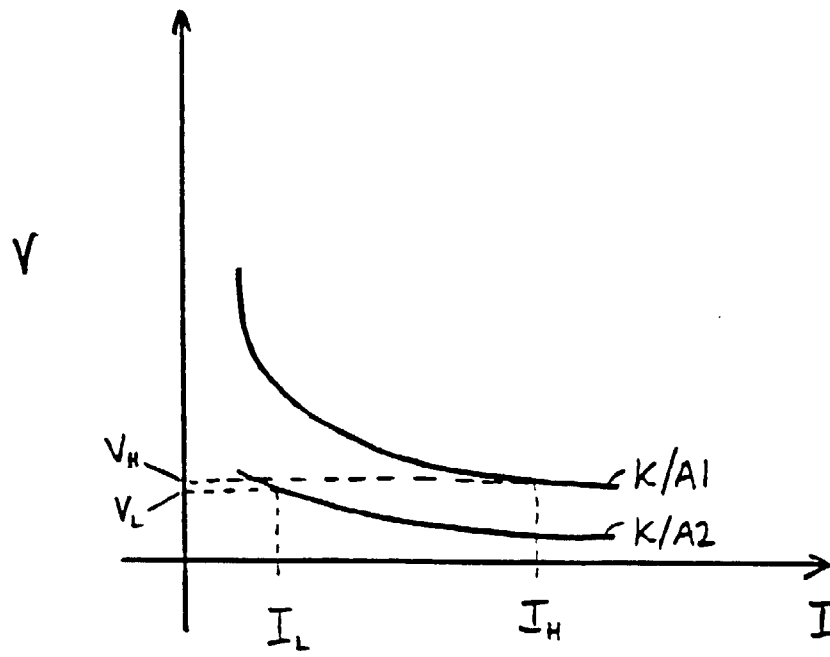


Figure 5

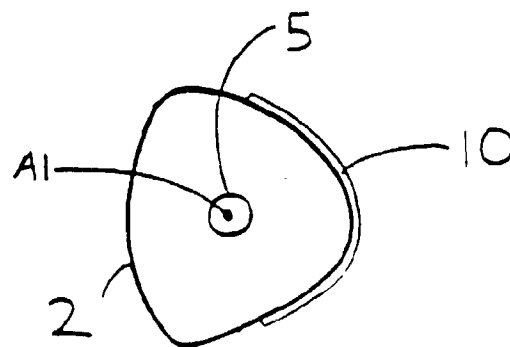


Figure 6