

Description

This invention relates to fluorescent lighting devices which are operable from a standard 110 volt or 117 volt outlet line and which do not necessitate the use of a starter and a choke, or ballast type mechanism.

Lighting systems known in the art comprise two general types: incandescent and fluorescent. In prior art incandescent filament lighting systems, an electric current is directed through a conducting filament. Molecules of the filament become excited and upon heating up, the filament is caused to glow in the visible bandwidth of the electromagnetic radiation spectrum. The visible energy is radiated external to the structure of the prior art light bulb. However, the prior art type light bulb of this type is extremely inefficient and a vast amount of energy is necessitated to provide light within the visible region of the electromagnetic spectrum. This results in higher costs for use and is an unnecessary usage of energy resources.

Fluorescent tubes or lighting systems generally include a mixture of noble gas such as neon or argon and a secondary gas such as mercury. Within the fluorescent tube, there is generally provided a pair of filament type electrodes coated with a material which readily emits electrons when heated. When the electrical current is introduced to the filaments, the filaments heat up and emit electrons wherein one acts as an anode and one acts as a cathode at some particular time interval. One such structure is disclosed in GB-A-827487. In such prior fluorescent tubes, an extremely high voltage between the electrodes is necessitated in order to initiate the noble gas discharge. Thus, there is provided with such fluorescent tube, a starter and a choke or ballast type system. The starter is used for automatically breaking the circuit when the filaments have heated up which then causes the choke, generally an induction coil, to produce a pulse of high voltage electricity. This pulse of high voltage electricity initiates the noble gas discharge and subsequently, the mercury or other metal discharge. The latter is self-sustaining with a continuous flow of electrons being formed between the electrodes. The vapor of the mercury or other gas metal is ionized and radiation is produced in the ultraviolet region of the electromagnetic spectrum. The radiation then impinges a fluorescent material which is coated on the internal surfaces of the tube and such glows by absorbing the invisible ultraviolet and re-radiating it as a visible light. Fluorescent lighting has been found to operate at lower temperatures than incandescent filament light bulbs and additionally, more of the electrical energy goes into the emission of visible light and less into heat than that found in the incandescent filament type light bulbs. Such fluorescent tubes have been found to be relatively efficient and may be up to five times as efficient as filament light bulbs. However, such fluorescent lighting systems do

necessitate a high initial input of electrical energy and further necessitate the use of starters and ballasts for initiation of the self-sustaining discharge. This complicates and increases the cost of such systems.

In contrast, the present invention is directed to fluorescent lighting devices which involve the production of energy within the ultraviolet bandwidth of the electromagnetic spectrum responsive to the ionization of metal atoms, but without requiring the use of a choke or ballast system, and which can be operated over standard domestic or commercial electrical line inputs.

In one aspect, this invention provides a fluorescent lighting device comprising an outer translucent envelope internally coated with a material which fluoresces upon exposure to ultraviolet light and containing a gaseous composition comprising atoms capable of ionization and emission of ultraviolet radiation upon bombardment by electrons emitted by a cathode, and sealed within said envelope a cathode for the emission of said electrons and an anode, capable when energised, of heating said cathode to cause said emission, wherein said cathode is in the form of a tube closed at one end and sealed at the other to a base member, the cathode thus forming a hermetically sealed cathode chamber in which is mounted an auxiliary anode and which contains a substantially inert cathode gas at a pressure defined by the formula:

$$2.0 < \frac{p \times d}{1.33} < 3.0$$

where p is the pressure of the gas in millibars and d is the internal diameter of the tube in cms. (Alternatively

$$2.0 < p^* \times d < 3.0$$

where p* is the pressure of the gas in mmHg). Mounted externally of the cathode tube is a further anode which serves to accelerate the electrons which are emitted from the external surface of the cathode which is heated by means of a discharge between the cathode and the auxiliary anode.

A somewhat similar arrangement of a sealed cathode housing an anode and comprising a second anode mounted externally of the cathode, the whole being mounted in an external bulb is shown in US-A-2,845,567. In that case, however, the device is a thermionic amplifier tube, not a fluorescent lighting device. Thus there is no gas discharge between the cathode and the external anode, only between the cathode and the internal anode. As a result of this discharge thermionic emission takes place from the external surface of the cathode. The design of the cathode and the design of the external anode is specifically intended to achieve unidirectional thermionic emission from the cathode and to maximise the electron capture by the principal

(external) anode. This is in complete contrast to the arrangement of the present invention where the objective is to minimise electron capture by the outer anode, and to maximise the multi-directional emission of electrons from the cathode into the surrounding gas, thereby to maximise the collisions therein and maximise the emission of ultraviolet radiation, which in turn causes fluorescence and emission of light from the fluorescent coating. Such a coating is, of course, completely absent from the device shown in US-A-2,845,567.

In a second aspect, the invention provides a fluorescent lighting device comprising an outer translucent envelope internally coated with a material which fluoresces upon exposure to ultraviolet light and containing a substantially inert gas capable of undergoing ionization upon bombardment by electrons emitted from a cathode, a cathode and an anode sealed within the outer envelope, the cathode having an external surface defining a plurality of apertures or recesses defined on opposite sides by two opposed surfaces comprising or coated with a metal or metal containing composition which provides said surfaces with a work function of less than 3 electron volts and which contains atoms of a metal capable of emitting radiation in the ultraviolet region of the spectrum upon ionization of the metal atoms in the gaseous phase and following the extraction of such atoms into the gaseous phase by impingement of ions from the gaseous phase onto the said coating, and wherein the pressure of the inert gas in the envelope falls within the limits

$$2.0 < \frac{p \times d}{1.33} < 3.0$$

where p = pressure of the gas in millibars and d is the distance in centimetres between said opposing surfaces, (or $2.0 < p^* \times d < 3.0$ where p^* is the pressure of the gas in mmHg).

Lighting devices according to the present invention will be further described with reference to the accompanying drawings:—

Figure 1 is a sectional elevational view of a preferred embodiment of a lighting device according to the first aspect of the present invention, and showing the complete device;

Figure 2 is a perspective exploded view of the cathode and the auxiliary anode used in the embodiment of Figure 1;

Figure 3 is a section elevational cut-away view of the cathode and auxiliary anode as shown in Figure 2;

Figure 4 is a perspective view of a lighting device according to the second aspect of the invention;

Figure 5 is a section elevational view of the embodiment shown in Figure 4 showing both the anode and cathode mounted within the external envelope;

Figure 6 is an exploded view of the embodi-

ment shown in Figure 4 providing a perspective view of the cathode and the anode;

Figure 7 is a perspective exploded view of the anode used in the embodiment of Figures 4—6;

Figure 8 is a perspective exploded view of an alternative form of the cathode and anode to be used in the embodiment of Figure 4;

Figure 9 is a section taken along the section 9—9 of Figure 8; and,

Figure 10 is yet another alternative construction of an anode and cathode for use in the embodiment of Figure 4.

Referring now to Figures 1—3, lighting device 10 of the present invention is based upon the concept of initiating electron flow from an external surface of cathode 12 which is heated when a voltage is applied between an auxiliary anode 14 and the cathode 12. This causes a discharge between the auxiliary anode and the cathode and the release of electrons from the cathode. Such release of electrons further ionizes the internal gas in a cumulative fashion and results in the overall heating of cathode 12. Electrons driven from the external surface of cathode 12 due to the heating process are accelerated by a second anode 16 mounted externally of the cathode 12 and interact with metal atoms in the gaseous medium contained in the outer envelope 18 thereby causing the metal atoms to ionize and radiate energy in the ultraviolet bandwidth of the electromagnetic spectrum. The ultraviolet energy impinges on a coating of fluorescent material 20 coating the inner surface of the outer envelope 18 which then radiates within the visible bandwidth of the electromagnetic spectrum.

Referring in more detail to the basic structure of lighting device 10, this includes a cathode 12 utilized for emitting electrons from an external surface thereof. Cathode 12 includes a tube 22 which is generally cylindrical in contour with a closed end 26 and an open end 28. Cathode tube 22 may include a flange 30 extending around the periphery of the open end 28 for purposes to be described in following paragraphs. Cathode tube 22 is formed of any metal or alloy commonly used in the fabrication of indirectly heated oxide cathodes which are well-known and commercially available. Thus tube 22 may be formed of molybdenum, tantalum, zirconium, tungsten, nickel, or any of the alloys commonly used in such heated oxide cathode manufacturing. The cathode tube 22 and the associated flange 30 may be fabricated in one-piece formation and are preferably seamless.

As shown in Figure 3, the cathode tube 22 is sealed via the flange 30 to a cathode base member 24 and together they form a hermetically sealed cathode chamber 32. Hermetic sealing between cathode tube 22 and the base member 24 may be provided by a number of well-known techniques utilizing adhesive mechanisms such as glass frit sealing or some like fabrication not important to the inventive concept as is herein described.

(14)

Base member 24 may either be formed of a dielectric material such as a ceramic composition, or may be formed of the same or similar metal composition as the tube 22. In the event that cathode base member 24 is formed of a metal similar to that of cathode tube 22, then an insulation member must be placed around the surface of the auxiliary anode 14 between it and the cathode base member 24.

Subsequent to sealing of the tube 22 to the base member 24, a cathode gas composition is inserted into the internal chamber 32 of the cathode 12 at a predetermined pressure. Inert gases such as helium, neon, argon, krypton, xenon or hydrogen as well as combinations thereof, have been used successfully. In actual practice, a minimum suitable pressure between 4.0 and 6.0 mmHg (5.3 to 8 millibars) has been found useful where a 0.5 cm diameter tube is used. Upon application of a potential between the auxiliary anode 14 and the cathode 12, there is a predetermined voltage corresponding to the breakdown which is described in Paschen's Law. This Law states that the breakdown potential between two terminals in a gas is generally proportional to the pressure multiplied by the gap length. It has been found advantageous that the gas composition predetermined pressure within cathode internal chamber 32 be maintained in accordance with the formula:

$$2.0 < \frac{p \times d}{1.33} < 3.0$$

or

$$2.0 < p \times d < 3.0$$

wherein in the first formula p is the pressure of the gas in millibars, and d is the internal diameter of the tube in cms., or, in the second formula, p* is the gas pressure in mmHg.

As seen in Figure 3 the auxiliary anode 14 is mounted in the cathode base member 24 and passes therethrough into the chamber 32. In construction, the auxiliary anode 14 may be an electrical wire or may be an electrode of electrically conducting composition. Auxiliary anode 14 is electrically coupled to a lead wire 36 which is directed to a standard domestic or commercial outlet line. As can be seen cathode 12 is also coupled to a standard outlet line through cathode lead wire 38. In order to maximize efficiency of the overall system, a resistor may be inserted in series with cathode 12 on lead 38. A resistor having a value of approximately 250 ohms has been successfully used in this manner. When a voltage is applied between the auxiliary anode 14 and cathode 12, cathode 12 is essentially made negative. A discharge is instantaneously established and depending on the current allowed to flow in the discharge by the magnitude of the source's internal heat impedance, will quickly heat the metal walls of the cathode 12.

The external surface 34 of the cathode 12 is coated with an oxide film 40, e.g. an oxide of barium, strontium, calcium, or some like metallic oxide coating, which emits a high density stream of electrons upon being heated.

As will be clearly seen in Figures 2 and 3 a barrier element 42 is provided surrounding anode 14 throughout a substantial part of its length anode within the cathode chamber 32. Barrier element 42 is formed of a dielectric material composition such as glass. As is seen, barrier element 42 is spaced from the auxiliary anode 14 and is mounted on cathode base member 24 in fixed relation thereto to provide a screening effect for metallic atoms which may be displaced from the internal surface 44 of the cathode tube 22.

When a potential is initiated between the auxiliary anode 14 and the cathode 12, gas is ionized within chamber 32. Impingement of gaseous ions on the internal surface 44 of the cathode causes atoms of metal to be displaced from the cathode 12. These metal atoms will deposit on a random basis inside the cathode chamber and may, if not prevented from doing so, deposit in such a manner that there is an electrical path between the auxiliary anode 14 and the base member 24, or the cathode tube 22, thereby short circuiting the device. Thus, in order to minimize the possibility of a short circuit the barrier element 42 is placed around the auxiliary anode 14 with such a structure that metal deposits would have to pass inside the barrier element 42 through the annular openings 46 and coat the internal surface of the barrier element 42 before reaching the base member 24 to create a short circuit. This has the effect of lengthening the life of lighting system 10 and provides a shorting screen for the entire system.

Also mounted inside the envelope 18, but external to the cathode 12 is a further anode 16 which is used for accelerating electrons emitted from the external surface 34 of the cathode when a potential is applied to a second anode lead 48. Anode 16 is actuated through a standard outlet as is the case in cathode lead 38 and lead 36 to the auxiliary anode. Anode 16 may be mounted to flange 30 through dielectric struts 50 or some like technique not important to the inventive concept as is herein described, with the exception that the anode 16 must of course be electrically insulated from cathode 12.

Anode 16 is shown as an annulus type structure. However, it is to be understood that anode 16 may be a lead wire or some other type of contour which only has as its criteria, the fact of being displaced from cathode 12. The object of anode 16 is to accelerate electrons passing from coating 40. When a voltage is applied to the anode 16, which makes it positive with respect to cathode 12, then a discharge occurs between the cathode 12 and the anode 16. Due to the fact that the pressure of gas maintained within the outer envelope 18 (as will be described in following paragraphs) is less than that inside the cathode

chamber 32, the mean free path of the emitted electrons is much larger.

As is the usual case in lighting devices, the cathode 12 and the two anodes 14 and 16 may be mounted on stem member 52 positionally located and maintained in fixed securement to the internal surfaces of the outer envelope 18. Stem member 52 may be formed of a glass or some like composition not important to the inventive concept as is herein described. Stem member 52 is merely used as a mounting base for the elements of lighting device 10.

The outer envelope 18 which encompasses the cathode 12 and the two anodes is clearly seen in Figure 1. A hermetic seal is formed to provide a hermetically sealed internal chamber 54 which contains therein a predetermined gas composition such as mercury vapour at a predetermined pressure. Envelope 18 may be formed of a glass composition, as is standard in commercial lighting systems. Additionally, the internal surface 56 of the envelope is coated with fluorescent material 58 as is shown. Fluorescent material 58 may be a standard phosphor composition. Minute quantities of metallic compositions are introduced into chamber 54 and as an example, when mercury is introduced, a pressure approximating 10^{-3} mmHg (0.0013 millibar) is provided for internal chamber 54. In overall concept, gas composition atoms of mercury or like metal are ionized and radiate in the ultraviolet bandwidth of the electromagnetic spectrum. Fluorescent material 58 intercepts the ultraviolet energy responsive to the ionization of gas composition atoms and re-radiates in the visible light region.

Thus, when the device is energised there is high current density source of electrons passing from coating 40 on external surface 34 of the cathode 12. The voltage difference between cathode 12 and anode 16 causes a discharge and since the pressure within enclosure or chamber 54 is substantially less than the chamber 32, the mean free path of the electrons is greater. In such an instance, the entire volume of internal chamber 54 is filled with radiation from electrons travelling a longer distance to produce collisions with atoms of mercury or other suitable metal contained in the gaseous medium which fills chamber 54. Collision of the electrons with the metal atoms in the gaseous composition with chamber 54 causes ionization thereof and the emission of ultraviolet radiation which impinges on the fluorescent material 58 to cause fluorescence and the emission of visible light from the device.

Referring now to Figures 4—7, there is shown an alternative lighting device 10' according to a second embodiment of this invention.

Lighting system 10' includes a cathode 60 which is adapted to produce energy in the ultraviolet bandwidth of the electromagnetic spectrum responsive to the sputtering of metal atoms therefrom into the surrounding gaseous medium and the ionization of those atoms in the

gaseous phase to provide the ultraviolet radiation which causes the desired fluorescence and illumination of the device. Cathode 60 includes a plurality of cathode openings 62 as is seen in Figure 6. Cathode openings 62 are defined by the overall structure of cathode 60 as will be defined in following paragraphs.

Cathode 60 includes a pair of dielectric disc members 64 and 66 which are displaced each from the other in longitudinal direction 68. Each of the disc members 64 and 66 includes a plurality of lug members 70 formed on a peripheral surface and extending radially therefrom as is seen in Figures 6 and 7.

In the construction of the cathode 60 of lighting system 10', a metallic ribbon 72 is wound in undulating fashion around the lug members 70 and defines a plurality of longitudinally directed sidewall internal surfaces 74 opposed one to the other. The metallic ribbon 72 may be formed of a number of metals, such as nickel, aluminium, tungsten, zirconium, or the like. As can be seen, the undulating metallic ribbon 72 defines cathode openings 62.

The opposed surfaces 74 on opposite sides of the openings 62 are coated with a predetermined metallic composition for providing a metallic sidewall work function less than approximately 3.0 electron volts. In general, the metallic sidewall composition may be formed of a mixture composition substantially composed of calcium carbonate and strontium carbonate. The mixture composition is generally fired in a substantial vacuum in order to form an oxide deposit on the surfaces 74 for reducing the overall work function of the metallic sidewalls. It is to be noted that the metallic sidewalls defined by the metallic ribbon 72 may be further formed of lanthanum hexaboride.

Cathode 60 of lighting system 10' further includes a pair of leads 76 and 78 electrically coupled external to the outer envelope 80 and connectable to a standard outlet in the normal fashion of lighting devices.

Outer envelope 80 which encompasses cathode 60 defines an internal chamber 82 which contains a predetermined gas composition having a predetermined pressure. The gas composition within internal chamber 82 may be a number of different types of gases and combinations thereof generally being classified as inert gas compositions and selected from the group consisting of argon, neon, krypton, xenon, hydrogen and helium.

The gas pressure within the outer envelope and the distance between the sidewall internal surfaces 74 of adjacent portions of metallic ribbon 72 are provided in a predetermined relation in accordance with the general formula:

$$2.0 < \frac{p \times d}{1.33} < 3.0$$

where

p is the gas pressure within internal chamber 82 in millibars, and

d is the distance between adjacent internal surfaces 74 in cms.

Lighting system 10' further includes an anode 86 formed of an electrically conducting metal such as aluminium, nickel, or some like composition. Anode 86 may include upper tabs 84 and lower tabs 88 extending from the substantially cylindrical contour of anode 86 in longitudinal direction 68. Upper tabs 84 are insertable through upper disc apertures 90 shown in Figure 7 and lower tabs 88 are insertable through lower disc apertures 92 in order to form a substantially rigid structure between anode 86 and the cathode, and the cathode dielectric disc members 64 and 66. As can be seen in Figure 5, lower tabs 88 may be bent around a lower surface of dielectric disc member 64 and the entire structure mounted on stem 94 contained within the outer envelope 80. Stem 94 may be formed of glass or some like material which is standard in the commercial light bulb industry. Lower tabs 88 include a lead 96 which is coupled to a standard outlet as was hereinbefore described for leads 76 and 78 of cathode 60.

The mounting of anode 86 and cathode 60 on stem 94 within the envelope 80 may be accomplished through glass frit type sealing or some like technique not important to the inventive concept as is herein described. Additionally, leads 76 and 78 may be inserted internal to stem member 94 in the usual commercial fashion of the manufacture of incandescent light bulbs.

Thus, anode 86 may include a metallic tube-like member which is fixedly secured to opposing disc members 64 and 66 on opposing longitudinal ends thereof. As can be seen in Figures 6 and 7, the opposing disc members 64 and 66 are axially aligned with each other in the longitudinal direction 68. Tab or anchor tab members 84 and 88 are thus further insertable through upper disc apertures 90 and lower disc apertures 92 formed through upper disc member 64 and lower disc member 66, respectively. Where anode 86 is formed of a metallic tube member, an internal surface is at least partially coated with an electrically resistive composition. The electrically resistive composition which may be formed of a carbon coating layer is coupled to anode electrical lead 96.

In the alternative, anode 86 may be formed of a dielectric material which may include a glass composition tube member fixedly secured to disc members 64 and 66 on opposing longitudinal ends thereof. In this case, the upper tab members 84 and lower tab members 88 would not be present and the overall formation of the anode 86 would be in the form of a cylindrical tube or cylinder. In such a case, the dielectric tube member would have an electrically conductive coating layer formed on an external surface thereof directly facing the cathode 60. Where anode 86 is formed of a glass type composition tube member, there would be an internal surface at least partially coated with an electrically resistive

coating and such would be electrically coupled to the electrically conductive coating on the external surface of anode 86.

Outer envelope 80 thus encompasses cathode 60, and anode 86 in a substantially hermetic seal. The hermetic type seal provided for the envelope 80 would be substantially the same as that standardly used for sealing incandescent light bulbs. The internal surface 96 of the envelope 80 is coated with a fluorescent material 98 for intercepting ultraviolet energy responsive to ionization of metal ions resulting from the energisation of anode 86 and cathode 60. Fluorescent material 98 may be a phosphor composition commonly used in fluorescent type light bulbs.

The ultraviolet radiation being directed to fluorescent material 98 is generated by a gaseous plasma which originates in the negative glow captured in cathode openings 62 between sidewall internal surfaces 74. The energy produced comes from ionized atoms of metal which are sputtered from cathode surfaces 74 and generally consist of the ionized metal's largest spectral lines which are generally found in the ultraviolet bandwidth of the electromagnetic radiation spectrum.

In this embodiment anode 86 is located internal and in fixed displacement with respect to cathode 60 for actuating ionization of the metal atoms of cathode 60 responsive to electrical actuation of a standard outlet line between 110—117 A.C. volts operating at 60 cycles per second or in the alternative 110—117 D.C. volts. In operation of the device the gaseous medium within bulb member 80 is ionized by an electrical field applied to anode 86 and cathode 60. Gaseous ions impinging on the metallic sidewall composition of metallic ribbon 72 ionizes the metal atoms and produces the ultraviolet energy which impinges the fluorescent material 98 to re-radiate in the visible bandwidth of the electromagnetic spectrum.

If desired an ultraviolet transparent protective coating layer composition may be formed on an internal surface of the fluorescent material 98 for protecting the fluorescent material 98 from ion impingement. A number of commercially available ultraviolet transparent protective coating layers are usable, one of which being tantalum pentoxide.

Referring to Figure 8 and 9, there is shown an alternative structure for the cathode 60 and anode 86 of lighting system 10'. In this embodiment, cathode 60' surrounds anode 86' as is shown. Cathode 60' is formed of a dielectric tubular member extending in longitudinal in longitudinal direction 68 and defines lateral sidewall section 100. Sidewall 100 includes a plurality of slots 102 formed through lateral sidewall 100. As can be seen, slots 102 define slot internal sidewalls 104. Sidewalls 104 are coated with an electrically conductive coating defining metallic sidewalls. As has been the previous case, the metallic sidewall composition may be formed of a mixture composition substantially composed of calcium carbonate and strontium carbonate. Additionally,

12

the composition as formed may be formed of lanthanum hexaboride or some like composition.

A pair of dielectric disc members 106 and 108 are fixedly secured to opposing longitudinal ends of anode 86' as is shown in Figure 8. Anode 86' extends in longitudinal direction 68 substantially coincident with an axis line of cathode 60'. Anode 86' may be formed of metallic tubular member 110 extending between opposing discs 106 and 108, as is shown. Where anode 86' is formed of a metallic tubular member 110, such includes internal through passage 112 defining anode internal surface 114. Anode internal surface 114 includes an electrically resistive coating layer such as a carbon composition type formation applied to internal surface 114 and being coupled to an anode electrical lead (not shown) exiting from the anode/cathode structure in the identical fashion that was provided for previous embodiments shown in Figures 4-7.

Figure 10 is directed to yet another cathode and anode structure for use in the device of Figure 4. In this embodiment, the cathode 60'' is mounted within and encompassed by the anode 86''. In this structural configuration, cathode 60'' is fixedly mounted on opposing longitudinal ends to opposing ceramic disc members 106' and 108'. Fixed securement may be through a glass seal type adhesive bonding, or some like technique not important to the inventive concept as is herein described. Cathode 60'' may be formed of metallic tubular contoured member, as is shown in cut-away section. Cathode 60'' may be formed of aluminium, nickel, or some like metal composition not important to the inventive concept as is herein described. Further, cathode 60'' may include a plurality of annular disc sections 116 displaced each from the other in predetermined relation as defined by previously described equations associated with Paschen's Law. Additionally, annular disc sections 116 define annular section internal walls 118 which are coated with a metallic coating composition as has previously been shown and described in previous paragraphs.

Anode member 86'' is formed of an undulating wire passing in longitudinal direction 68 around the periphery of disc members 106' and 108'. Wire members 120 may be mounted within notches formed in disc members 106' or 108', or in the alternative, may be secured to opposing disc members in any standard manner.

The embodiments described with reference to Figures 8, 9 and 10 operate in precisely the same manner as the embodiment described in Figures 4-7.

Claims

1. A fluorescent lighting device comprising a translucent outer envelope (18) internally coated with a material which fluoresces upon exposure to ultraviolet light and containing a gaseous composition comprising atoms capable of ionization and emission of ultraviolet radiation

upon bombardment by electrons, and sealed within said outer envelope (18).

i) a cathode (12) in the form of a tube (22) closed at one end (26) and sealed at the other to a base member (24) thereby forming a hermetically sealed cathode chamber (32) in which there is sealed a substantially inert cathode gas, the pressure of which, related to the internal diameter of the tube, falls within the following limits:

$$2.0 < \frac{p \times d}{1.33} < 3.0$$

where p=the pressure of the gas in millibars and d is the internal diameter of the tube in cms., (or

$$2.0 < p^* \times d < 3.0,$$

if p* is the pressure of the gas in mmHg),

ii) an auxiliary anode (14) inside said cathode chamber (32), and

iii) a further anode (16) externally of said cathode (12), the cathode being heated by a discharge between the auxiliary anode (14) and the cathode (12) and electrons emitted from the external surface of the cathode (12) being accelerated into the gaseous composition contained in the envelope (18) by the anode (16).

2. A lighting device according to claim 1 characterised in that auxiliary anode (14) extends through and is fixedly secured to said cathode base member (24).

3. A lighting device according to claim 1 or 2, where said cathode base member (24) is formed of a dielectric material.

4. A lighting device according to claim 1, 2 or 3, characterised in that said cathode sleeve (22) is formed of electrically conductive material, and said auxiliary anode (14) is electrically insulated from said base member.

5. A lighting device according to any one of claims 1-4, characterised in that the cathode gas is argon, neon, krypton, xenon, hydrogen or helium.

6. A lighting device according to any one of claims 1-5, characterised in that the anode (16) is in the form of an annulus concentrically mounted about the tube (22) of the cathode (12).

7. A fluorescent lighting device comprising an outer translucent envelope (80) internally coated with a material (98) which fluoresces upon exposure to ultraviolet light and containing a substantially inert gas capable of undergoing ionization upon bombardment by electrons emitted from a cathode, a cathode (60, 60', 60'') and an anode (86) sealed within the outer envelope, the cathode (6, 60', 60'') having a plurality of apertures (62, 102) or recesses (118) which are defined on opposite sides of each aperture or recess by two surfaces (74, 104) comprising or coated with a metal or metal containing composition which provides said surfaces with a work function of less than 3 electron volts and which contains atoms of a

the composition as formed may be formed of lanthanum hexaboride or some like composition.

A pair of dielectric disc members 106 and 108 are fixedly secured to opposing longitudinal ends of anode 86' as is shown in Figure 8. Anode 86' extends in longitudinal direction 68 substantially coincident with an axis line of cathode 60'. Anode 86' may be formed of metallic tubular member 110 extending between opposing discs 106 and 108, as is shown. Where anode 86' is formed of a metallic tubular member 110, such includes internal through passage 112 defining anode internal surface 114. Anode internal surface 114 includes an electrically resistive coating layer such as a carbon composition type formation applied to internal surface 114 and being coupled to an anode electrical lead (not shown) exiting from the anode/cathode structure in the identical fashion that was provided for previous embodiments shown in Figures 4-7.

Figure 10 is directed to yet another cathode and anode structure for use in the device of Figure 4. In this embodiment, the cathode 60'' is mounted within and encompassed by the anode 86''. In this structural configuration, cathode 60'' is fixedly mounted on opposing longitudinal ends to opposing ceramic disc members 106' and 108'. Fixed securement may be through a glass seal type adhesive bonding, or some like technique not important to the inventive concept as is herein described. Cathode 60'' may be formed of metallic tubular contoured member, as is shown in cut-away section. Cathode 60'' may be formed of aluminium, nickel, or some like metal composition not important to the inventive concept as is herein described. Further, cathode 60'' may include a plurality of annular disc sections 116 displaced each from the other in predetermined relation as defined by previously described equations associated with Paschen's Law. Additionally, annular disc sections 116 define annular section internal walls 118 which are coated with a metallic coating composition as has previously been shown and described in previous paragraphs.

Anode member 86'' is formed of an undulating wire passing in longitudinal direction 68 around the periphery of disc members 106' and 108'. Wire members 120 may be mounted within notches formed in disc members 106' or 108', or in the alternative, may be secured to opposing disc members in any standard manner.

The embodiments described with reference to Figures 8, 9 and 10 operate in precisely the same manner as the embodiment described in Figures 4-7.

Claims

1. A fluorescent lighting device comprising a translucent outer envelope (18) internally coated with a material which fluoresces upon exposure to ultraviolet light and containing a gaseous composition comprising atoms capable of ionization and emission of ultraviolet radiation

upon bombardment by electrons, and sealed within said outer envelope (18).

i) a cathode (12) in the form of a tube (22) closed at one end (26) and sealed at the other to a base member (24) thereby forming a hermetically sealed cathode chamber (32) in which there is sealed a substantially inert cathode gas, the pressure of which, related to the internal diameter of the tube, falls within the following limits:

$$2.0 < \frac{p \times d}{1.33} < 3.0$$

where p = the pressure of the gas in millibars and d is the internal diameter of the tube in cms., (or

$$2.0 < p^* \times d < 3.0,$$

if p* is the pressure of the gas in mmHg),

ii) an auxiliary anode (14) inside said cathode chamber (32), and

iii) a further anode (16) externally of said cathode (12), the cathode being heated by a discharge between the auxiliary anode (14) and the cathode (12) and electrons emitted from the external surface of the cathode (12) being accelerated into the gaseous composition contained in the envelope (18) by the anode (16).

2. A lighting device according to claim 1 characterised in that auxiliary anode (14) extends through and is fixedly secured to said cathode base member (24).

3. A lighting device according to claim 1 or 2, where said cathode base member (24) is formed of a dielectric material.

4. A lighting device according to claim 1, 2 or 3, characterised in that said cathode sleeve (22) is formed of electrically conductive material, and said auxiliary anode (14) is electrically insulated from said base member.

5. A lighting device according to any one of claims 1-4, characterised in that the cathode gas is argon, neon, krypton, xenon, hydrogen or helium.

6. A lighting device according to any one of claims 1-5, characterised in that the anode (16) is in the form of an annulus concentrically mounted about the tube (22) of the cathode (12).

7. A fluorescent lighting device comprising an outer translucent envelope (80) internally coated with a material (98) which fluoresces upon exposure to ultraviolet light and containing a substantially inert gas capable of undergoing ionization upon bombardment by electrons emitted from a cathode, a cathode (60, 60', 60'') and an anode (86) sealed within the outer envelope, the cathode (6, 60', 60'') having a plurality of apertures (62, 102) or recesses (118) which are defined on opposite sides of each aperture or recess by two surfaces (74, 104) comprising or coated with a metal or metal containing composition which provides said surfaces with a work function of less than 3 electron volts and which contains atoms of a



metal capable of emitting radiation in the ultra-violet region of the spectrum upon ionization of the metal atoms in the gaseous phase and following the extraction of such atoms into the gaseous phase by impingement of ions from the gaseous phase onto the said coating, and wherein the pressure of the inert gas in the envelope falls within the limits

$$2.0 < \frac{p \times d}{1.33} < 3.0$$

where p=pressure of the gas in millibars and d is the distance in centimetres between said opposing surfaces (74, 104), (or

$$2.0 < p^* \times d < 3.0$$

where p* is the pressure of the gas in mmHg).

8. A device according to claim 7, wherein the cathode (60) is formed of a metallic ribbon (72) wound about insulating supports (70) at opposite ends to form a generally cylindrical cathode with longitudinally extending openings (62) between adjacent lengths of ribbon, and said anode (86) comprises a longitudinally extending member located internally of said cathode and coaxial therewith.

9. A device according to claim 7, wherein the cathode (60') is in the form of a cylinder (100) having a plurality of apertures (102) therein and said anode (110) comprises a longitudinally extending member located internally of said cathode and coaxial therewith.

10. A device according to claim 7, wherein the cathode (60'') is in the form of a cylinder having a plurality of annular recesses in the external surface thereof and the anode (120) comprises a wire wound about insulating supports at opposite ends to form a generally cylindrical open wire anode coaxially spaced around said cathode.

11. A device according to any one of claims 6-9, wherein the opposed surfaces (74, 104) defining the opposite sides of the apertures or recesses (62, 102) in the cathode (60, 60', 60'') are coated with carbonate strontium carbonate, calcium oxide or lanthanum hexaboride.

Patentansprüche

1. Fluoreszierende Beleuchtungsvorrichtung, umfassend eine durchsichtige äußere Hülle (18), die innen mit einem Material beschichtet ist, das fluoresziert, wenn es ultravioletter Licht ausgesetzt wird, und die eine gasförmige Zusammensetzung enthält, welche Atome umfaßt, die bei Beschuß mit Elektronen zur Ionisation und zur Emission ultravioletter Strahlung fähig sind, und dicht eingeschlossen innerhalb der genannten äußeren Hülle (18)

i) eine Kathode (12) in der Form einer Röhre (22), die an einem Ende (26) geschlossen und am anderen Ende dicht an einen Basisteil (24) angeschlossen ist und dabei eine hermetisch

verschlossene Kathodenkammer (32) bildet, in der ein im wesentlichen inertes Kathodengas eingeschlossen ist, dessen Druck, im Zusammenhang mit dem inneren Durchmesser der Röhre, innerhalb der folgenden Grenzen fällt:

$$2.0 < \frac{p \times d}{1.33} < 3.0$$

worin p der Druck des Gases in Millibar ist und d der innere Durchmesser der Röhre in cm ist (oder

$$2.0 < p^* \times d < 3.0$$

wenn p* der Druck des Gases in mmHg ist),

ii) eine Hilfsanode (14) innerhalb der genannten Kathodenkammer (32), und

iii) eine weitere Anode (16) außerhalb der genannten Kathode (12), wobei die Kathode durch eine Entladung zwischen der Hilfsanode (14) und der Kathode (12) geheizt wird und wobei von der äußeren Oberfläche der Kathode (12) emittierte Elektronen durch die Anode (16) in die in der Hülle (18) enthaltene gasförmige Zusammensetzung beschleunigt werden.

2. Beleuchtungsvorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß sich die Hilfsanode (14) durch den genannten Kathodenbasisteil (24) hindurch erstreckt und an diesem fest befestigt ist.

3. Beleuchtungsvorrichtung nach Anspruch 1 oder 2, worin der genannte Kathodenbasisteil (24) aus einem dielektrischen Material gebildet ist.

4. Beleuchtungsvorrichtung nach Anspruch 1, 2 oder 3, dadurch gekennzeichnet, daß die genannte Kathodenhülle (22) aus elektrisch leitendem Material gebildet ist und die genannte Hilfsanode (14) elektrisch vom genannten Basisglied isoliert ist.

5. Beleuchtungsvorrichtung nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, daß das Kathodengas Argon, Neon, Krypton, Xenon, Wasserstoff oder Helium ist.

6. Beleuchtungsvorrichtung nach Anspruch 1 bis 5, dadurch gekennzeichnet, daß die Anode (16) in Form eines Ringes konzentrisch um die Röhre (22) der Kathode (12) befestigt ist.

7. Fluoreszierende Beleuchtungsvorrichtung, umfassend eine äußere durchsichtige Hülle (80), die innen mit einem Material (98) beschichtet ist, das, wenn es ultravioletter Licht ausgesetzt ist, fluoresziert, und die ein im wesentlichen inertes Gas enthält, das bei Beschuß mit von einer Kathode emittierten Elektronen eine Ionisierung erfahren kann, eine Kathode (60, 60', 60'') und eine Anode (86), die innerhalb der äußeren Hülle eingeschlossen sind, wobei die Kathode eine Mehrzahl von Öffnungen (62, 102) oder Vertiefungen (118) aufweist, die auf gegenüberliegenden Seiten jeder Öffnung oder Vertiefung durch zwei Oberflächen (74, 104) definiert sind, welche ein Metall oder eine Metall enthaltende Zusammensetzung enthalten oder damit beschichtet sind, die besagte Oberflächen mit



einer Austrittsarbeit von weniger als 3 Elektronvolt versieht und die Atome eines Metalls enthält, das bei Ionisierung der Metallatome in der gasförmigen Phase und nach der Extraktion solcher Atome in die gasförmige Phase durch Aufprall von Ionen aus der gasförmigen Phase auf die genannte Schicht fähig ist, Strahlung im ultravioletten Bereich des Spektrums zu emittieren, und worin der Druck des inerten Gases in der Hülle innerhalb der Grenzen liegt:

$$2,0 < \frac{p \times d}{1,33} < 3,0,$$

worin p der Druck des Gases in Millibar ist und d der Abstand in cm zwischen den genannten gegenüberliegenden Oberflächen (70, 104) ist (oder

$$2,0 < p^* \times d < 3,0,$$

worin p* der Druck des Gases in mmHg ist).

8. Vorrichtung nach Anspruch 7, worin die Kathode (60) von einem metallischen Band (72) gebildet ist, das um isolierende Halter (70) an gegenüberliegenden Enden gewunden ist, um eine im wesentlichen zylindrische Kathode mit sich longitudinal erstreckenden Öffnungen zwischen zwei benachbarten Bandlängen zu bilden, und die genannte Anode (86) einen sich longitudinal erstreckenden Teil umfaßt, der innerhalb der genannten Kathode und koaxial damit liegt.

9. Vorrichtung nach Anspruch 7, worin die Kathode (60') die Form eines Zylinders (100) hat, welcher eine Mehrzahl von Öffnungen (102) darin aufweist, und die genannte Anode (110) einen sich longitudinal erstreckenden Teil umfaßt, der innerhalb der genannten Kathode und koaxial damit liegt.

10. Vorrichtung nach Anspruch 7, worin die Kathode (60'') die Form eines Zylinders hat, welcher eine Mehrzahl ringförmiger Vertiefungen in der äußeren Oberfläche davon aufweist und die Anode (120) einen Draht umfaßt, der um isolierende Halter an gegenüberliegenden Enden gewunden ist, um eine im wesentlichen zylindrische, offene Drahtanode zu bilden, die koaxial um die genannte Kathode mit Zwischenraum angeordnet ist.

11. Vorrichtung nach einem der Ansprüche 6 bis 9, worin die gegenüberliegenden Oberflächen (74, 104) die die gegenüberliegenden Seiten der Öffnungen oder Vertiefungen (62, 102) in der Kathode (60, 60', 60'') definieren, mit Karbonat, Strontiumkarbonat, Kalziumoxid oder Lanthanhexaborid beschichtet sind.

Revendications

1. Un dispositif d'éclairage fluorescent comprenant une ampoule extérieure translucide (18) revêtue intérieurement d'une matière qui donne lieu à une émission de fluorescence sous l'effet de

l'exposition à de la lumière ultraviolette, et contenant une composition gazeuse comprenant des atomes capables d'être ionisés et d'émettre un rayonnement ultraviolet sous l'effet d'un bombardement par des électrons, et les éléments suivants, enfermés hermétiquement dans l'ampoule extérieure (18):

i) une cathode (12) se présentant sous la forme d'un tube (22) fermé à une extrémité (26) et accouplé hermétiquement à l'autre extrémité à une embase (24), de façon à former une chambre de cathode (32) fermée hermétiquement dans laquelle est enfermé hermétiquement un gaz de cathode pratiquement inerte, dont la pression, par rapport au diamètre intérieur du tube, est comprise dans les limites suivantes:

$$2,0 < \frac{d \times d}{1,33} < 3,0$$

en désignant par p la pression du gaz en millibars et par d le diamètre intérieur du tube en centimètres (ou

$$2,0 < p^* \times d < 3,0,$$

si p* est la pression du gaz en millimètres de mercure),

ii) une anode auxiliaire (14) à l'intérieur de la chambre de cathode (32), et

iii) une anode supplémentaire (16) à l'extérieur de la cathode (12), la cathode étant chauffée par une décharge entre l'anode auxiliaire (14) et la cathode (12), et des électrons émis par la surface extérieure de la cathode (12) étant accélérés par l'anode (16) dans la composition gazeuse contenue dans l'ampoule (18).

2. Un dispositif d'éclairage selon la revendication 1, caractérisé en ce que l'anode auxiliaire (14) traverse l'embase de cathode (24) et est fixée fermement à cette dernière.

3. Un dispositif d'éclairage selon la revendication 1 ou 2, dans lequel l'embase de cathode (24) est formée par une matière diélectrique.

4. Un dispositif d'éclairage selon la revendication 1, 2 ou 3, caractérisé en ce que le tube de cathode (2) est formé par une matière conductrice de l'électricité, et l'anode auxiliaire (14) isolée électriquement de l'embase.

5. Un dispositif d'éclairage selon l'une quelconque des revendications 1—4, caractérisé en ce que le gaz de cathode est de l'argon, du néon, du krypton, du xénon, de l'hydrogène ou de l'hélium.

6. Un dispositif d'éclairage selon l'une quelconque des revendications 1—5, caractérisé en ce que l'anode (16) se présente sous la forme d'un anneau monté en position concentrique autour du tube (22) de la cathode (12).

7. Un dispositif d'éclairage fluorescent comprenant une ampoule translucide extérieure (80) revêtue intérieurement par une matière (98) qui produit une émission de fluorescence sous l'effet de l'exposition à de la lumière ultraviolette, et qui contient un gaz pratiquement inerte capable de



subir une ionisation sous l'effet du bombardement par des électrons émis par une cathode, une cathode (60, 60', 60'') et une anode (86) enfermées hermétiquement dans l'ampoule extérieure, la cathode (60, 60', 60'') comportant un ensemble d'ouvertures (62, 102) ou de cavités (118) qui sont définies, au niveau de côtes opposés de chaque ouverture ou cavité, par deux surfaces (74, 104) formées ou revêtues par un métal ou une composition contenant un métal qui donne à ces surfaces une énergie d'extraction inférieure à 3 électrons-volts, et qui contient des atomes d'un métal capable d'émettre un rayonnement dans la région ultraviolette du spectre, sous l'effet de l'ionisation des atomes de métal dans la phase gazeuse, et à la suite de l'extraction de ces atomes les faisant passer dans la phase gazeuse, par le bombardement du revêtement par des ions provenant de la phase gazeuse, et dans lequel la pression du gaz inerte dans l'ampoule est comprise entre les limites:

$$2,0 < \frac{p \times d}{1,33} < 3,0$$

en désignant par p la pression du gaz en millibars et par d la distance en centimètres entre les surfaces opposées (74, 104), ou

$$2,0 < p^* \times d < 3,0$$

en désignant par p^* la pression du gaz en millimètres de mercure].

8. Un dispositif selon la revendication 7, dans

lequel la cathode (60) est formée par un ruban métallique (72) enroulé autour de supports isolants (70) à des extrémités opposées, pour former une cathode de forme générale cylindrique avec des ouvertures longitudinales (62) entre des longueurs adjacentes de ruban, et l'anode (86) consiste en un élément s'étendant en direction longitudinale qui est placé à l'intérieur de la cathode et en position coaxiale par rapport à cette dernière.

9. Un dispositif selon la revendication 7, dans lequel la cathode (60') se présente sous la forme d'un cylindre (110) comportant un ensemble d'ouvertures (102), et l'anode (110) consiste en un élément s'étendant en direction longitudinal qui est placé à l'intérieur de la cathode et en position coaxiale par rapport à cette dernière.

10. Un dispositif selon la revendication 7, dans lequel la cathode (60'') se présente sous la forme d'un cylindre comportant un ensemble de cavités annulaires dans sa surface extérieure, et l'anode (120) consiste en un fil enroulé autour de supports isolants à des extrémités opposées, pour former une anode en fil, de forme générale cylindrique et ouverte, disposée en position coaxiale autour de la cathode, à une certaine distance de cette dernière.

11. Un dispositif selon l'une quelconque des revendications 6—9, dans lequel les surfaces opposées (74, 104) définissant les côtés opposés des ouvertures ou des cavités (62, 102) dans la cathode (60, 60', 60'') sont revêtues de carbonate de calcium, de carbonate de strontium, d'oxyde de calcium ou d'hexaborure de lanthane.

