

FLUORESCENT LIGHTING SYSTEM

This invention relates to fluorescent lighting systems 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 a ballast type mechanism in the lighting circuit.

5 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
10 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.

15 Fluorescent tubes or lighting systems generally include a mixture of a 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
20 filaments heat up and emit electrons wherein one acts as an anode and one acts as a cathode at some particular time interval. 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
25 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
30 electrons being formed between the electrodes. The vapour of the mercury or other gas metal is ionised 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 costs of such systems.

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

The fluorescent lighting system or device of this invention comprises a hermetically sealed translucent outer bulb containing an ionisable gaseous medium at a predetermined pressure and coated internally with a layer of material which fluoresces upon exposure to ultra-violet radiation, and, sealed within the bulb, a cathode structure capable when energised of emitting electrons into said medium, thereby to cause ionisation thereof, and an anode capable of energising the cathode to cause said emission, said cathode further comprising a plurality of apertures or recesses defined on opposite sides by a pair of side walls constructed of or coated with a metal or metal-containing composition which, upon energisation of the cathode, itself undergoes ionisation of metal atoms therein with concomitant emission of radiation within the ultraviolet bandwidth of the electromagnetic spectrum and fluorescence of said coating consequent upon the impingement thereon of said radiation, said metal or metallic composition being such as to provide said cathode with a metallic side wall work function which is less than about 3 electron volts.

Embodiments according to the present invention will be further described with reference to the accompanying drawings in which:

Figure 1 is a perspective view of an embodiment of a lighting device according to this invention;

Figure 2 is a section elevational view of the embodiment shown in Figure 1 showing both the embodiment anode and cathode mounted within the outer bulb;

Figure 3 is an exploded view of the embodiment shown in Figure 1 providing a perspective view of the cathode and anode elements;

Figure 4 is a perspective exploded view of the anode structure of the embodiment of Figure 1;

Figure 5 is a perspective exploded view of an alternative structure for use in accordance with this invention;

Figure 6 is a section view of the anode and cathode structure of Figure 5 taken along the section line 9-9, and

Figure 7 is yet another structure for use in accordance with this invention.

Referring now to Figures 1-4, there is shown lighting system 10' comprising a cathode 60 which is adapted to produce energy in the ultraviolet bandwidth of the electromagnetic spectrum responsive to the ionisation of metal atoms. Cathode 60 includes a plurality of cathode openings 62 as is seen in Figure 3. 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 disc members 64 and 66 include a plurality of lug members 70 formed on a peripheral surface of disc members 64 and 66 with the lug members 70 extending radially therefrom as is seen in Figures 3 and 4.

In the construction of cathode 60 of lighting system 10', metallic ribbon 72 is positionally located in undulating fashion around disc lug members 70 for defining a longitudinally directed sidewall internal surface 74 facing an adjacent sidewall surface 74. Metallic ribbon 72 may be formed of a number of metal compositions, such as nickel, aluminum, tungsten, zirconium, or some like metal composition. As can be seen, the undulating metallic ribbon 72 defines cathode openings 62.

Sidewall internal surfaces 74 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 a final mixture composition formed on metallic sidewall internal surfaces 74 and may include a final composition mixture of calcium oxide 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 being electrically coupled external to bulb member 80 and is electrically connected to a standard outlet in the normal fashion of light bulb systems.

Bulb member 80 which encompasses cathode 60 includes internal chamber 82 which contains a predetermined gas composition having a predetermined pressure. The gas composition within internal chamber 82 of bulb member 80 may be a number of different types of gases and combinations thereof generally being classified as inert gas compositions. The gaseous medium contained within internal chamber 82 may be formed from the group consisting of argon, neon, krypton, xenon, hydrogen or helium.

The pressure within internal chamber 82 of bulb member 80 and the displacement distance between sidewall internal surfaces 74 of adjacent portions of metallic ribbon 72 are provided in a predetermined relation in accordance with the general formula:

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

where: p = predetermined gas composition pressure within internal chamber 82 in mm Hg.

d = predetermined sidewall displacement distance between adjacent internal surfaces 74 in cm.

Lighting system 10' further includes anode 86 formed of an electrically conducting metal such as aluminum, 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 4 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 cathode dielectric disc members 64 and 66. As can be seen in Figure 2, 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 bulb member 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 lead 96 which is coupled to a standard outlet as was hereinbefore described for leads 76 and 78 of cathode 60.

Mounting of anode 86 and cathode 60 on stem 94 within bulb member 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 3 and 4, opposing disc members 64 and 66 are axially aligned each from the other in 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, upper tab members 84 and lower tab members 88 would not be present and the overall formation of 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 for interfacing directly with 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.

Bulb member 80 thus encompasses cathode 60, and anode 86 in a substantially hermetic seal. The hermetic type seal provided for bulb member 80 would be substantially the same as that standardly used for incandescent light bulb hermetic sealing. Bulb member 80 includes internal surface 96 which is coated with a fluorescent material 98 for intercepting ultraviolet energy responsive to ionisation of metal ions resulting from the energization 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 ionised atoms of metal which are sputtered from cathode surfaces 74 and generally consist of the ionised metal's largest spectral lines which are generally found in the ultraviolet bandwidth of the electromagnetic radiation spectrum.

In summary, lighting system 10' shown in Figures 1-4 thus includes cathode 60 which is adapted to produce energy in the ultraviolet bandwidth of the electromagnetic spectrum responsive to the ionisation of metal atoms. As has been shown, cathode 60 includes a plurality of cathode openings 62 formed by the undulating metallic ribbon 72. Each of the cathode openings 62 define a pair of metallic sidewalls having sidewall internal surfaces 74 which are displaced each from the other by a predetermined distance. The sidewall internal surfaces 74 have a predetermined composition formed thereon for providing a metallic sidewall work function less than approximately 3.0 electron volts.

In this embodiment of lighting system 10', anode 86 is located internal and in fixed displacement with respect to cathode 60 for actuating ionisation 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 and as has been described, the gaseous medium within bulb member 80 is ionised by an electrical field applied to anode 86 and cathode 60. Gaseous ions impinging on the metallic sidewall composition of metallic ribbon 72 ionises 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.

5 In general, the gaseous medium contained within bulb member 80 is formed of a substantially inert gas composition and may be formed from the group consisting of argon, neon, krypton, xenon, hydrogen, helium, or some combination thereof. The metallic sidewall composition coated on metallic ribbon 72 may be formed of a mixture composition substantially composed of calcium carbonate and strontium carbonate. In the overall manufacture of the final mixture composition formed on the metallic sidewalls, the
10 mixture composition of calcium carbonate and strontium carbonate may be fired in a substantial vacuum to form the final mixture composition including calcium oxide for reducing the work function of the metallic sidewalls. Additionally, lanthanum hexaboride has been successfully used as a metallic sidewall composition for coating metallic ribbon 72.

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

20 Thus, there has been shown a method of radiating energy in the visible bandwidth of the electromagnetic radiation spectrum which includes the initial step of providing at least one cathode 60 having openings 62 formed therethrough defining at least a pair of metallic sidewalls having internal surfaces 74 displaced each from the other by a predetermined
25 distance. The metallic sidewall internal surfaces 74 are coated with a predetermined composition for reducing the metallic sidewall work function to less than approximately 3.0 electron volts. An anode 86 is established in fixed displacement with respect to cathode 60.

Anode 86 and cathode 60 are hermetically sealed within bulb member
30 80 having a predetermined gaseous medium contained therein which is maintained at a predetermined pressure. Bulb member 80 has internal surface 96 coated with fluorescent material 98. The method of radiating further includes applying a potential between anode 86 and cathode 60 for (1) ionising the gaseous medium and (2) ionising a metal atom from the
35 metallic sidewall with the ionised metal atom radiating in the ultraviolet bandwidth of the electromagnetic spectrum. Finally, the ultraviolet

radiation is applied to fluorescent material 98 for re-radiation into the visible bandwidth of the electromagnetic spectrum.

Referring to Figures 6 and 7, there is shown a further embodiment of the particular structure of cathode 60 and anode 86 for use in a lighting system 10' in accordance with the present invention. In this embodiment, cathode 60' surrounds anode 86' as is shown. Cathode 60' is formed of a dielectric tubular member extending 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, 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 5. Anode 86' extends in longitudinal direction 68 substantially coincident with an axis line of anode 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 1-4.

Figure 7 is directed to still a further embodiment of a cathode/anode structure for use in a lighting system 10' according to the invention. In this embodiment, cathode 60" is mounted within and encompassed by 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 mechanism 60" may be formed of metallic tubular contoured member, as is shown in cut-away section. Cathode 60" may be formed of

aluminum, 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.

5 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.

10 As will be understood the alternative cathode/anode structures described with reference to Figures 5 and 6 on the one hand and Figure 7 on the other are designed to be mounted in a hermetically sealed bulb 80 coated internally with a coating which fluoresces upon impingement by ultraviolet light in exactly the same manner as the cathode/anode structure described and illustrated by the embodiment of Figures 2-4.

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CLAIMS

1 A fluorescent lighting device comprising a hermetically sealed translucent outer bulb containing an ionisable gaseous medium at a predetermined pressure and coated internally with a layer of material which fluoresces upon exposure to ultra-violet radiation, and, sealed within the bulb, a cathode structure capable when energised of emitting electrons into said medium, thereby to cause ionisation thereof, and an anode capable of energising the cathode to cause said emission, said cathode further comprising a plurality of apertures or recesses defined on opposite sides by a pair of side walls constructed of or coated with a metal or metal-containing composition which, upon energisation of the cathode, itself undergoes ionisation of metal atoms therein with concomitant emission of radiation within the ultraviolet bandwidth of the electromagnetic spectrum and fluorescence of said coating consequent upon the impingement thereon of said radiation, said metal or metallic composition being such as to provide said cathode with a metallic side wall work function which is less than about 3 electron volts, the said predetermined pressure being such that the relationship between the pressure and the distance between the opposite sidewalls of said recesses or apertures is within the formula:

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

where p is the pressure of the gas in mmHg and d is the distance between said side walls measured in cms.

2 A device according to claim 1 wherein the gaseous medium comprises one or more of argon, neon, krypton, xenon, hydrogen or helium.

3 A device according to claim 1 or 2 wherein the cathode is formed of a metallic ribbon wound about insulating supports at opposite ends to form a generally cylindrical cathode with longitudinally extending openings between adjacent lengths of ribbon, said ribbon being coated with a metal composition to provide said metal



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side wall work function of less than about 3 electron volts, and said anode comprising a longitudinally extending member located internally of said cathode and coaxial therewith.

4 A device according to claim 1 or 2 wherein the cathode is in
5 the form of an apertured cylinder coaxially mounted around a long-
itudinally extending anode, the apertures in said cylinder having
opposite side walls spaced a predetermined distance apart and
coated with a metallic composition such as to provide said metallic
side wall work function of less than about 3 electron volts, said
10 anode comprising a longitudinally extending member located
internally of said cathode and coaxial therewith.

5 A device according to claim 1 or 2 wherein the cathode is
in the form of a cylinder having a plurality of annular recesses
15 in th external surface thereof, said recesses being defined on
opposite sides by side walls spaced a predetermined distance apart
and coated with a metallic composition such as to provide said
metallic side wall work function of less than about 3 electron volts,
and wherein the anode comprises a wire wound about insulating supports
20 at opposite ends to form a generally cylindrical open wire anode
coaxially spaced around said cathode.

6 A device according to any one of claims 1 - 5 wherein said side
walls are of metal coated with a material selected from calcium
25 carbonate, strontium carbonate, calcium oxide or lanthanum hexaboride.

7 A device according to claim 1, substantially as hereinbefore
described with reference to Figures 1-4, 5 and 6, or 7 of the accompanying
drawings.
