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SECONDARY EMISSION MEANS FOR GAS-FILLED GLOW DISCHARGE CHARACTER DISPLAY TUBES

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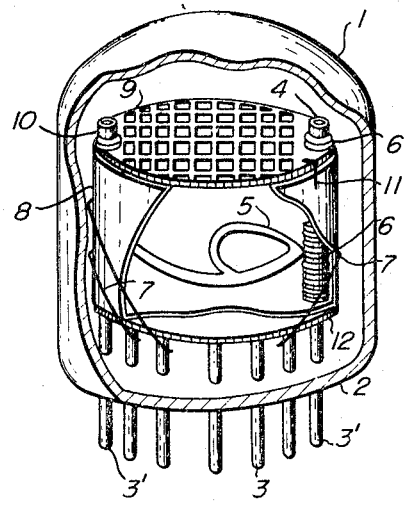

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SECONDARY EMISSION MEANS FOR GAS-FILLED GLOW DISCHARGE CHARACTER DISPLAY TUBES

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The present invention relates to the structure of a gas-filled glow discharge character display tube adapted for use with both alternating current and direct current.

Gas-filled glow discharge character display tubes (hereinafter referred to as C.D. tubes) of conventional design comprise a common anode, at least one metallic cathode, and a transparent vessel for containing a suitable body of gas for maintaining negative glow, wherein individual cathodes are shaped in the form of respective numerals (0–9), alphabetical characters or special symbols. The structure of these C.D. tubes is such that, when a suitable positive voltage is impressed on the anode and a negative voltage is applied to the selected cathode, glow is generated from this specific cathode to display a desired character. When, however, a negative voltage is impressed on the anode and a positive voltage on the cathode, glow appears on the anode and it is impossible to display the desired character. Therefore, the C.D. tubes of conventional design have not been adapted for use with the supply of an A.C. voltage.

The primary object of the invention is to provide a new and improved C.D. tube operable on both A.C. and D.C., which has a novel electrode structure of such a feature that anodes and cathodes disposed in a vessel are surrounded by a rare gas that can be ionized and a starting potential of glow discharge at the anodes when supplied with a negative voltage higher than the maximum value of A.C. voltage at which the C.D. tube is operated.

According to the invention, there is provided a C.D. tube comprising a closed vessel filled with a rare gas that can be ionized, said vessel containing therein anodes, an electrode associated with said anodes, and at least one cathode, said anodes and said electrode associated therewith being subjected to a surface treatment by means such as carbonization, oxidation or black chromium plating so that said anodes and said electrode associated therewith, which are at a negative potential when said cathode is at a positive potential, have a starting potential of glow discharge higher than the maximum value of A.C. voltage at which said C.D. tube is operated.

There are other objects and particularities of the invention which will become obvious from the following description with reference to the accompanying drawing, in which the sole figure is a perspective view of a preferred embodiment of a C.D. tube according to the present invention, with portions broken away to show the internal structure thereof.

Referring to the drawing, there is shown a transparent glass vessel **1** in which a body of gas such as neon or argon at a pressure in the order of several tens of mm. Hg is enclosed. A stem **2** is integrally joined to the vessel **1** by means of fusion, and a plurality of base pins **3** of metallic material penetrate the stem **2** for providing electrical connection with an external voltage supply source. Two pins **3'** are disposed diametrically opposite to each other and extend through the stem **2** into the vessel **1** to form supports **4** for supporting at least one cathode **5**. Although not shown, the supports **4** are coated with a suitable insulating material such as glass or the like. The cathode **5** is made of a suitable metal such as stainless steel, iron, aluminium, Nicrome, molybdenum or the like and is formed into a shape of desired numeral, alphabetical

character or other special symbol by means such as corrosion or punching. The cathode **5** has holes (not shown) bored diametrically opposite to each other, by which any required number of cathodes can be stacked in tiers on the supports **4** in suitably spaced relation, with an insulating spacer **6** of steatite, multifoam glass or like material interposed between the adjacent cathodes.

In order to provide electrical connection between each cathode **5** and the corresponding base pin **3**, a plurality of ribbons **7** of a suitable metal such as iron or nickel are secured to the cathodes **5** and the base pins **3** as by electric spot welding. Surrounding the cathodes **5**, there is provided an anode **8** of a cup-like shape. Above said cup-like anode **8**, there is also provided an anode **9** which is formed into a meshed screen shape to provide means of observing the glow. The mesh-like anode **9** is firmly secured on the supports **4** by means such as caulking by eyelet grummets **10** or electric spot welding, with the insulating spacers **6** interposed between the anodes **8** and **9** to provide a suitable space therebetween. The cup-like anode **8** and the mesh-like anode **9** are electrically connected with each other by a lead **11**.

According to the invention, the electrodes **8**, **9** and **11** forming the anodic elements of the C.D. tube are made of a metal such as nickel, iron or aluminium, and are subjected to surface treatment by means such as carbonization, oxidation or black chromium plating in order that a starting potential of glow discharge thereof is made higher than a starting potential of the cathodes **5** as well as a maximum value of A.C. voltage at which the C.D. tube is operated. Thus, the surfaces of the anodic electrodes so treated have extremely poor secondary electron emission than cleaned pure metal surfaces of the cathodes **5**. The cup-like electrode **8** is electrically connected to one of the base pins **3** by a lead (not shown). Electrical insulation between the cup-like anode **8** and the base pins **3** is provided by a plate **12** of an electrically insulating material such as mica.

Now, detailed explanation will be given hereinunder as to how the C.D. tube of the invention with the above arrangement operates when supplied with alternating current. Generally, when ions of the rare gas enclosed in the vessel **1** approach the electrode surface to an extent of 2 to 3 A. therefrom, conduction electrons in the electrode transit to the ground state of the ions which are thereby neutralized. Secondary electron emission will take place when electrons of another electrode are supplied with the energy emitted during the above transition and finally made to have higher energy than the potential barrier at the electrode surface. Voltage impressed on the electrode in this case will appear as a starting potential of glow discharge.

As will be apparent from the foregoing description, the electrodes **8**, **9** and **11** forming the anodic elements of the C.D. tube of the invention are made to have an extremely poor degree of secondary electron emission by the surface treatment. Therefore, the starting potential of glow discharge of said anodic electrodes is apparently higher than a starting potential of glow discharge of the cathodes **5** having cleaned pure metal surfaces as well as a maximum value of A.C. voltage at which the C.D. tube is intended for operation.

Further, when the C.D. tube is energized by alternating current, glow will be started at an instantaneous voltage. Therefore, a preferred arrangement may be such that the cathodes **5** are made to discharge and the anodes are kept from discharging at a value $\sqrt{2}$ times the effective value in the case of a sine wave.

Or more precisely, a relation

$$E=\sqrt{2}\tilde{E}$$

exists between the effective value

$$\tilde{E}$$

of sine wave A.C. voltage and the maximum value E thereof. When the starting potential of glow discharge of the cathode **5** is expressed as E_k, and that of the anodes **8**, **9** and the lead **11** as E_A, a relation $E_k < E_A$ exists as a result of said surface treatment. When a negative voltage is impressed on the cathode **5**, glow discharge is developed at the cathode **5** due to the relation $E_k < E$, but when a negative voltage is likewise impressed on the anodic elements comprising the anodes **8**, **9** and the lead **11**, glow discharge will not take place at the anodic elements due to the relation $E_A > E$. It will be apparent therefore that the purpose of the present invention can be attained by the relation $E_K < E < E_A$. When, for example, the C.D. tube of the invention is operated by sine wave alternating voltage at 100 volts,

$$E = \sqrt{2}\tilde{E} \fallingdotseq 140V$$

and it will be readily known that $E_K < 130V$ and $E_A > 150V$ will be quite enough for the practical operation. It is needless to say that C.D. tube of the invention can be equally effectively operated by direct current, as will be apparent from the above principle, in the manner in which it has been operated heretofore.

What should be especially emphasized in the invention with regard to the operation by alternating current is the necessity that all of the anodic electrodes other than the cathodes **5** should be so formed as to have the starting potential of glow discharge higher than the maximum value of A.C. voltage at which the C.D. tube is operated. The surface treatment applied to the cup-like electrode **8** alone as in the case of conventional C.D. tubes will not be effective to attain the excellent effect which results from the invention.

What is claimed is:

1. A glow discharge character display tube, comprising: a closed vessel containing an ionizable gas, anode means mounted within said closed vessel, said anode means including electrode means electrically connected to said anode means, at least one cathode means mounted within said closed vessel in operable association with said anode means, individual ones of said cathode means each having a distinctive shape to represent a predetermined character, said anode means and said electrode means having surfaces of lower secondary electron emission and higher starting potentials of glow discharge than the surfaces of said cathode means such that when an alternating voltage is applied between said anode means and said cathode means a glow discharge is prevented from forming on said anode means during the alternate cycles of the alternating voltage when said anode means are negative with respect to said cathode means.

2. A gas-filled glow discharge character display tube according to claim **1**, wherein said surfaces of said anode means and said electrode means are carbonized to produce a lower secondary emission than said cathode means.

3. A gas-filled glow discharge character display tube according to claim **1** wherein said surfaces of said anode means and said electrode means are oxidized to produce lower secondary electron emission than said cathode means.

4. A gas-filled glow discharge character display tube according to claim **1**, wherein said surfaces of said anode means and said electrode means are plated with black chromium to produce a lower secondary emission than said cathode means.

5. In a glow discharge character display tube having a closed vessel containing an ionizable gas, anode means and a perforated electrode means mounted within said closed vessel, said electrode means being electrically connected to said anode means, at least one cathode means mounted within said closed vessel, in operable association with said anode means and said electrode means, individual ones of said cathode means each having a distinctive shape to represent a predetermined character, the improvement essentially consisting of said anode means and said electrode means having surfaces of lower secondary emission than the surfaces of said cathode means such that when alternating voltages are applied between said anode means, electrode means and said cathode means, a glow discharge is prevented from forming on said anode means and said electrode means during the alternate cycles of the alternating voltage when said anode and said electrode means are negative with respect to said cathode means.

6. A glow discharge display tube, comprising: a closed vessel containing an ionizable gas, anode means mounted within said closed vessel, said anode means including electrode means electrically connected to said anode means, at least one cathode means mounted within said closed vessel in operable association with said anode means, said cathode means having a distinctive shape to represent a predetermined character,

means for applying an alternating potential between said anode means and said cathode means, said anode means and said electrode means each having surfaces of lower secondary emission and higher starting potential of glow discharge than said cathode means.

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