

SPECIFICATION

Fluorescent display tube

5 This invention relates to fluorescent display tubes of the type commonly employed to display data in numeric and/or letter form.

A typical form of fluorescent display tube includes an anode substrate coated with anode segments of a fluorescing substance, a grid spacer placed over the substrate and the mesh of a grid electrode laid over the grid spacer. Other parts such as a cathode and a support structure are assembled on the stack to complete an electrode assembly, and a glass covering is sealed over the electrode assembly. Such configuration is fully described in U.S. Patent Specification No. 4,047,073. As is well known, the display tube is evacuated in the last stage of manufacture through a gas exhausting tube attached thereto. The anode arrangement of the display tube includes a number of segmented luminescent anodes or groups of anode segments and, in operation, only those anode segments which are held at positive potential are excited to emit light by bombardment of the electrons emitted from the cathode and accelerated by the control-grid potential, as the anode segments in each group are selectively excited to display a numeral or letter desired.

Accordingly, in operation of the fluorescent display tube, the anode segments in each group never emit light all at the same time and the combination of anode segments selected or excited to emit light by electron bombardment usually varies from time to time to display different numerals or letters in turn. In some cases, none of the anode segments in some group or other is excited so that there is no display in the digit position. Specifically, with the conventional mesh pattern of grid electrode incorporating meshes individual to the digital positions, among the electrons emitted from the cathode and proceeding through a mesh under the acceleration effect of the grid potential, those electrons approaching the anode segments held at positive potential excite such segments effectively and thereby cause them to emit light, but the remaining electrons passing through the mesh and approaching the other segments, not held at positive potential, and approaching the exposed insulating surface of the anode substrate are attracted back to the grid electrode. This behaviour of electrons gives rise to a sort of oscillation, which is known as Barkhausen oscillation. Such oscillation is particularly observed in the VHF range, though limited in intensity. However, when such display tubes are employed with television sets or other electronic appliances utilizing the VHF frequency range, weak electric waves resulting from the Barkhausen oscillation give rise to practical problems, interfering with the performance of the associated appliance to a marked extent.

It is therefore, an object of this invention to provide a fluorescent display tube suppressing the Barkhausen oscillation.

According to the present invention, there is provided a fluorescent display tube as defined in claim 1 below.

The invention will be described in more detail, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of an anode structure of a fluorescent display tube;

Figure 2 is a perspective view of a spacer frame having grid spacers and lead-in wires;

Figure 3 is a perspective view of a conventional grid frame having an array of wire meshes;

Figure 4 is a perspective view of a grid frame according to one embodiment of the present invention; and

Figure 5 is a cross-sectional view of a fluorescent display tube employing the improved grid electrodes shown in *Figure 4*.

Referring now to *Figure 1*, a number of groups of anode segments 11 are arranged on the anode substrate 1 in an array of patterns of substantially figure-of-eight configuration 10 and dots 12. A fluorescent material is provided on each segment. The anode segments 11 and 12 are electrically connected to a row of terminal areas 13 formed on the anode substrate 1. In *Figure 1*, the connections are not shown.

Referring to *Figure 2*, an array of grid spacers 21 is supported by a spacer frame 20. Each spacer 21 has a grid terminal lead-in-wire 22. In *Figure 3*, an array of conventional grids 31 is supported by grid frame 30. Each grid 31 comprises a uniform wire mesh 32 surrounded by a mesh frame 33. Each mesh region 32 has a large enough area to cover the whole region of the corresponding segment group 10 or 12.

Referring to *Figure 2* and *Figure 3*, as is described in the aforementioned U.S. Patent Specification, a grid frame 30 is put over a spacer frame 20, and after placing each grid mesh 32 upon the corresponding spacer 21 and securing them by welding for example, a grid member is formed by removing unnecessary portions, namely, the frames 20 and 30 and connecting pieces 34 pertaining to each mesh frame 33.

An embodiment of the present invention can be achieved by replacing the conventional grid 31 by the grid shown in *Figure 4*. The grid 41 is generally of the same pattern of mesh arrangement as shown in *Figure 3*, but mesh regions 42 include fine mesh shielding regions 45 and 46 which allow no passage of electrons.

In operation of a fluorescent display tube employing this grid electrode, it is to be noted that electrons tending to pass through the meshes 42 in the vicinity of any anode segments 11 having no positive potential are attracted by the shielding regions 45 and 46 while electron passage to the insulating regions of the anode substrate 1 that lie within the set of anode segments 11 is precluded by the shielding regions 45 and 46. Because of this, it will be readily appreciated that there is no occurrence of any negative electrical resistance and the Barkhausen oscillation is effectively suppressed.

Figure 5 illustrates the fluorescent display tube embodying the invention, comprising the anode

substrate 1 of Figure 1 with sets of anode segments 11 arranged thereon, the grid spacer 21 of Figure 2 and the grid 41 of Figure 4. Other parts, such as a cathode wire 55, cathode supports 56 and a glass covering 57 are provided in a conventional manner. A tube 58 for exhausting gases is attached to the substrate 1 and sealed off after the evacuation process.

As will be understood from the above description, when the electron passing region is restricted only in the area corresponding to the area of the anode segments 11 and 12, Barkhausen oscillation is most effectively suppressed. In that case, however, the field of vision is made very narrow. For this reason, the area of the shielding regions 45 and 46 is best made smaller than the area surrounded by the anode segments 11. A typical example of the dimensions of each grid 41 are as follows: the mesh region 42 is $16.5 \times 10\text{mm}$; the shielding regions 45 and 46 are $3.5 \times 4\text{mm}$ and $4 \times 4\text{mm}$, respectively, and the mesh frame is $18 \times 14\text{mm}$. These dimensions are determined for the case where the group of anode segments 10 has dimensions of $15 \times 8.4\text{mm}$.

In the foregoing embodiment, the grid for the dot portion 12 has no shielding region, because the actual width of the grid is small, say as 3mm wide. In Figure 4, furthermore, each mesh region 42 is slightly skewed clockwise, by about 10° degrees depending on the inclination of the figure-of-eight portions 10, thereby restricting the electrons passing outside the portion 10 as much as possible.

Although the shielding regions 45 and 46 have a excellent shielding effect, reflection of external light at the regions 45 and 46 does not occur because the regions 45 and 46 are fine mesh regions. When a mesh pattern is formed like a honeycomb and the length of one side of a hexagonal opening in the region 42 is 0.2mm , a fine mesh having shielding effect is obtained by shortening the length of one side of the hexagonal opening to less than 0.15mm . In that case, the frame width of each opening changes for instance, from $40\text{ }\mu\text{m}$ to 90 to $100\text{ }\mu\text{m}$. Such dimensions are effective in the range of driving voltages below 30V . Since the driving voltage of an ordinary fluorescent display tube is around 18V , the above dimension is practical. Since fine mesh regions are employed rather than solid regions, the field of vision is improved greatly.

CLAIMS

1. A fluorescent display tube comprising an anode substrate having at least one display pattern of anode segments mounted thereon, the anode substrate having insulating regions within the pattern of anode segments, a cathode member extending over the anode substrate and anode segments, and a grid member disposed between the anode substrate and the cathode member, the grid member having electron passage regions of relatively open mesh structure lying over the anode segments for permitting electrons to pass through to the anode segments, and having shielding regions of relatively fine mesh structure lying over the anode

substrate insulating regions within the pattern of anode segments, the shielding regions having a mesh fine enough to inhibit passage of electrons to the anode substrate while permitting light to pass therethrough.

2. A tube according to claim 1, wherein the mesh structure in both the electron passage regions and the shielding regions is formed in honeycomb patterns defining hexagonal openings therethrough.

3. A tube according to claim 1 or 2, wherein the shielding regions are smaller than the underlying anode substrate insulating regions within the pattern of anode segments.

4. A tube according to claim 1, 2 or 3, wherein the display pattern of anode segments comprises generally a figure-of-eight configuration.

5. A tube according to claim 4, wherein the figure-of-eight configuration of the anode segment display pattern is inclined and the electron passage regions and shielding regions are likewise inclined.

6. A tube according to any of claims 1 to 5, wherein the respective areas of the electron passage regions are not less than the respective corresponding underlying anode segments, and wherein the respective areas of the shielding regions are not greater than the respective corresponding underlying anode substrate insulating regions.

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substrate insulating regions within the pattern of anode segments, the shielding regions having a mesh fine enough to inhibit passage of electrons to the anode substrate while permitting light to pass therethrough.

2. A tube according to claim 1, wherein the mesh structure in both the electron passage regions and the shielding regions is formed in honeycomb patterns defining hexagonal openings therethrough.

3. A tube according to claim 1 or 2, wherein the shielding regions are smaller than the underlying anode substrate insulating regions within the pattern of anode segments.

4. A tube according to claim 1, 2 or 3, wherein the display pattern of anode segments comprises generally a figure-of-eight configuration.

5. A tube according to claim 4, wherein the figure-of-eight configuration of the anode segment display pattern is inclined and the electron passage regions and shielding regions are likewise inclined.

6. A tube according to any of claims 1 to 5, wherein the respective areas of the electron passage regions are not less than the respective corresponding underlying anode segments, and wherein the respective areas of the shielding regions are not greater than the respective corresponding underlying anode substrate insulating regions.