

PATENT SPECIFICATION

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(54) LUMINESCENT SYMBOL DISPLAY PANEL

- (71) We, NIPPON ELECTRIC KAGOSHIMA, LIMITED, a Company duly organised and existing under the laws of Japan, of 12699, Takemoto, Izumi-shi, Kagoshima, Japan, do hereby declare the invention, for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-
- This invention relates to a luminescent display panel for displaying one or more symbols, namely a fluorescent or phosphorescent display panel, which comprises a substantially planar anode assembly, a glass cover having an integral peripheral flange hermetically sealed to the anode assembly, and a plurality of lead-in conductors hermetically sealed between the assembly and the glass cover. This invention relates also to a method of manufacturing a luminescent display panel.
- Luminescent display panels are commonly used for the selective display of a plurality of symbols such as numerals, letters or other symbols. In a known display panel, the said flange is hermetically sealed to the anode assembly by an interposed layer of fused glass frit. Within an evacuated space enclosed by the hermetically sealed anode assembly and glass cover, the display panel comprises a plurality of luminescent anode segments arranged for the display of the symbols, at least one hot cathode over the anode segments, and a grid between the cathode and the anode segments for each symbol. The display panel further comprises lead-in conductors extending to the anode segments, cathode, and grids. The lead-in conductors are arranged along the flange and hermetically sealed through the fused glass frit layer.
- It is also known to provide a transparent and electroconductive film on that surface of the glass cover which faces the anode assembly, i.e. the inside surface. The display panel is operated by making the cathode emit thermal electrons and by selectively supplying electric voltages to the anode segments and the grids by an external electric circuit so as to make the electrons bombard the selected anode segments. The display panel is usually placed together with the external circuit in a casing having a transparent window plate for allowing the display to be viewed therethrough. The film serves to prevent accumulation of stray electrons and other charges on the inside surface of the glass cover, being held at cathode potential by bringing one end of the or each cathode into electric contact with the film through a support for the cathode, and also as an electrostatic shield for shielding the display panel from electric charges which inevitably accumulate on the casing window plate. The film is, therefore, more effective when its resistivity is as low as possible. Attempts have, therefore, been directed towards reduction of the film resistivity. On the other hand, it has been usual on sealing the glass cover to the anode assembly to press them together so as to avoid formation of pin holes through the fused glass frit layer around the lead-in conductors. Some or all of the lead-in conductors for the grids and anodes are, therefore, liable to make poor or even good electric contact with the film portion formed on the flange inside surface and are then undesiredly shorted to the cathode which

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adversely affects the yield of the luminescent display panels.

It is, therefore, an object of the present invention to provide a luminescent display panel for which the yield of manufacture is better.

According to the present invention, there is provided a luminescent display panel comprising a substantially planar anode assembly including a plurality of luminescent anode segments, a glass cover having a window area surrounded by an integral peripheral flange, a fused glass frit layer hermetically sealing the anode assembly and flange together to enclose an evacuated space enclosing the anode segments, at least one hot cathode, and at least one grid between the cathode and the anode segments, a plurality of lead-in conductors extending to the anode segments, cathode and grid and being hermetically sealed in the fused glass frit layer, and a transparent and electroconductive film covering the inside surface of the window area for preventing accumulation of electrons emitted by the cathode whereas around the flange, at least the portion of the flange confronting the lead-in conductors is free from the film or has thereon a resistive film whose resistance per square is at least ten times that of the film over the window area.

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

Figure 1 is a schematic perspective view, partly cut away, of a luminescent display panel;

Figure 2 is a fragmentary bottom view of a glass cover for use in a luminescent display panel, such as shown in *Figure 1*, according to a preferred embodiment of the present invention; and

Figure 3 schematically shows a partial perspective view of a frame for use in making glass covers.

Referring at first to *Figure 1*, a typical multi-digit luminescent display panel comprises a substantially planar anode assembly 10 comprising, in turn, a substrate of an insulator material, such as glass or a ceramic, a plurality of anode leads (not shown) thereon, an insulator layer applied to the substrate to cover the anode leads with through holes formed at predetermined positions, and a plurality of luminescent anode segments 11 for the symbols in the through holes in contact with the anode leads, as exemplified in United States Patent No. 3 849 686. A grid 12 for the anode segments 11 of each symbol and at least one hot cathode 13 extended over the grids 12 are fixed to a lead frame comprising lead-in conductors in the form of a plurality of metal strips 16 for the anode segments 11, a plurality of similar metal strips 17 for the

grids 12, and a pair of like metal strips 18 for the ends of each cathode 13. The lead frame is put on the insulator layer and fixed thereto by a mass 19 of fused glass frit. The metal strips 16-18 are preferably of a nickel-chromium-iron alloy consisting essentially of 42% (by weight) of nickel, 6% of chromium, and 52% of iron. The metal strips 16 for the anode segments 11 are brought into electric contact with the respective anode leads through holes in the insulator layer.

Referring now to *Figure 2*, a glass cover 20 for use in the display panel illustrated in *Figure 1* has four integral peripheral flange portions 21, 22, 23 and 24 conforming in general outline to the anode assembly 10. The glass cover 20 further has an indent 25 for an exhaust pipe 26 (*Figure 1*) and a flat window area surrounded by the flange portions 21-24 for enabling the displays given by the selected anode segments 11 to be viewed therethrough. The flat window area is joined to the flange portions by intermediate slanting portions which are deemed to be parts of the window area rather than the flange.

Referring back to *Figure 1*, the flange portions 21-24 are hermetically sealed to the anode assembly 10 by a layer 27 of fused glass frit so as to enclose an evacuated space in which the grids 12 and the cathode 13 are disposed. The metal strips 16-18 are hermetically sealed in the glass frit layer 27 along at least one of the flange portions 21-24, i.e. as shown by the flange portion 21, to serve as lead-in conductors 16-18 for the anode segments 11, grids 12, and cathode 13. Before it is sealed to the anode assembly, the glass cover 20 is provided with a transparent and electro-conductive film on the inside surface for the purposes already explained. In accordance with a known method, the film is formed by spraying tin chloride solution on to the inside surface of the glass cover 20, this having been heated. Various other metal compounds and methods of application are known.

The glass cover 20 shown in *Figure 2* has the transparent and electro-conductive film on the whole window area referred to above and on the flange portions 23 and 24 but not on the flange portions 21 and 22; in particular, the film is missing from the flange portion 21 under which the lead-in conductors pass. The inside surfaces of the flange portions 21 and 22 may also be covered with the material of the transparent and electro-conductive film but it is essential, so far as the flange portion 21 is concerned, that the film thereon should have a substantially higher electric resistance than the transparent and electroconductive film. For example, the resistance of the resistive film on the flange 21 should be 10 MΩ or more between

two adjacent lead-in conductors 16-18 equally spaced with a pitch of say, 2.5 mm. while the resistance per square of the transparent and electroconductive film should be less than that of the resistive film by a factor of at least 10. We have found that the resistive film prevents the lead-in conductors 16-18 from being shorted to each other.

Referring now to Figure 3, the glass cover 20 may be coated using a frame 30 of steel or other metal for carrying a plurality of similar glass covers. The frame has grooved cross-bars 32 and the covers are slid into the grooves so that the flanges 21 and 22 are covered. The frame can then be conveyed through a device whereat the material for the transparent and electroconductive film is sprayed on to the heated glass cover inside surface. With the width and depth of the grooves in the bars 32 empirically determined, it has been found possible to restrict the transparent and electroconductive film of each glass cover 20 substantially only to the inside surfaces of the window area and flanges 23 and 24 while the material which does get on to the flanges dotted in Figure 2 forms a film which is sufficiently resistive. Production is more efficient if the groove tolerances allow the formation of the resistive films simultaneously with the formation of the electroconductive film.

The glass cover 20 may also be coated by applying a powder to the inside surface of the flange portion 21 prior to the spraying step and, after the spraying step, removing the powder by the use of a solvent that dissolves the powder but does not attack the material of transparent and electroconductive film. A preferred powder material is calcium sulphate powder mixed with a small amount, such as about 10% by weight or less, of magnesium oxide powder. Use may be made of magnesium oxide powder alone. The solvent for these powder materials may be a nitric acid solution with a concentration of about 10%. It is preferred to wash the glass cover 20 in an ultrasonic water bath after the spraying step and before dissolving the powder and to rinse the glass cover 20 with water after dissolving the powder.

Alternatively, the glass cover 20 may be coated by forming the transparent and electroconductive film on the whole inside surface of the glass cover 20 and, thereafter, grinding or otherwise mechanically removing at least part of the thickness of the film on the flange portion 21. Chemical etching of the film at the flange portion 21 may be resorted to, although it is somewhat troublesome at present to protect the film against the etchant over the inside surface of the window area.

It should be pointed out that the above-mentioned resistance of 10 MΩ or more for

the resistive film gives in effect the insulation between the display panel electrodes 11-13. Although the minimum values of the insulation depend on the external circuit, for a typical circuit the insulation should be about 10 MΩ or more between two adjacent lead-in conductors 16 for the anode segments 11, about 1 MΩ or more between two adjacent lead-in conductors 17 for the grids 12, and between a lead-in conductor 16 for the anode segments 11 and an adjacent grid lead-in conductor 17, and between a lead-in conductor 16 for the anode segments 11 and an adjacent cathode lead-in conductor 18, and about 100 kΩ or more between a grid lead-in conductor 17 and an adjacent cathode lead-in conductor 18.

WHAT WE CLAIM IS:-

1. A luminescent display panel comprising a substantially planar anode assembly including a plurality of luminescent anode segments, a glass cover having a window area surrounded by an integral peripheral flange, a fused glass frit layer hermetically sealing the anode assembly and flange together to enclose an evacuated space enclosing the anode segments, at least one hot cathode, and at least one grid between the cathode and the anode segments, a plurality of lead-in conductors extending to the anode segments, cathode, and grid and being hermetically sealed in the fused glass frit layer, and a transparent and electroconductive film covering the inside surface of the window area for preventing accumulation of electrons emitted by the cathode whereas, around the flange, at least the portion of the flange confronting the lead-in conductors is free from the film or has thereon a resistive film whose resistance per square is at least ten times that of the film over the window area.

2. A luminescent display panel according to claim 1, wherein the glass cover is rectangular, the lead-in conductors lead in along one long side of the cover and the portions of the flange along this side and the opposite side have the resistive film thereon.

3. A luminescent display panel according to claim 1 or 2, wherein the resistive film has an electric resistance of at least 10 MΩ between each pair of adjacent lead-in conductors.

4. A luminescent display panel according to claim 1 or 2, wherein the resistive film provides minimum electric resistances of 10 MΩ between each pair of adjacent lead-in conductors for the anode segments, 1 MΩ between each pair of adjacent lead-in conductors for the grids, and between a lead-in conductor for anode segments and an adjacent lead-in conductor for the grid, and between a lead-in conductor for anode segments and an adjacent lead-in conductor



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Alternatively, the glass cover 20 may be coated by forming the transparent and electroconductive film on the whole inside surface of the glass cover 20 and, thereafter, grinding or otherwise mechanically removing at least part of the thickness of the film on the flange portion 21. Chemical etching of the film at the flange portion 21 may be resorted to, although it is somewhat troublesome at present to protect the film against the etchant over the inside surface of the window area.

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2. A luminescent display panel according to claim 1, wherein the glass cover is rectangular, the lead-in conductors lead in along one long side of the cover and the portions of the flange along this side and the opposite side have the resistive film thereon.

3. A luminescent display panel according to claim 1 or 2, wherein the resistive film has an electric resistance of at least 10 MΩ between each pair of adjacent lead-in conductors.

4. A luminescent display panel according to claim 1 or 2, wherein the resistive film provides minimum electric resistances of 10 MΩ between each pair of adjacent lead-in conductors for the anode segments, 1 MΩ between each pair of adjacent lead-in conductors for the grids, and between a lead-in conductor for anode segments and an adjacent lead-in conductor for the grid, and between a lead-in conductor for anode segments and an adjacent lead-in conductor

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for the cathode, and 100 k Ω between a lead-in conductor for the grid and an adjacent lead-in conductor for the cathode.

- 5 A method of making a luminescent display panel according to claim 1, wherein the electroconductive film is formed by spraying material on to the inside surface glass cover and at least the said portion of the flange is masked sufficiently so that any
10 sprayed material thereon produces only a resistive film.

6. A method of making a luminescent display panel according to claim 1, wherein the electroconductive film is formed by
15 spraying material on to the inside surface glass cover and at least the said portion of the flange is first treated with a powder is dissolved after deposition of the film so as to remove the part of the film deposited over
20 the powder.

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Agents for the Applicants.
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