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[54] **PLASMA DISPLAY PANEL COMPRISING A FIRST EXTERNAL ELECTRODE FOR EACH DIGIT AND A SECOND EXTERNAL ELECTRODE FOR EACH SEGMENT**

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[52] **U.S. Cl.** ..... **313/484,** 315/169 TV
[51] **Int. Cl.** **H01j 7/42**
[58] **Field of Search** ..... 313/109.5, 220, 210; 315/169 TV, 169 R

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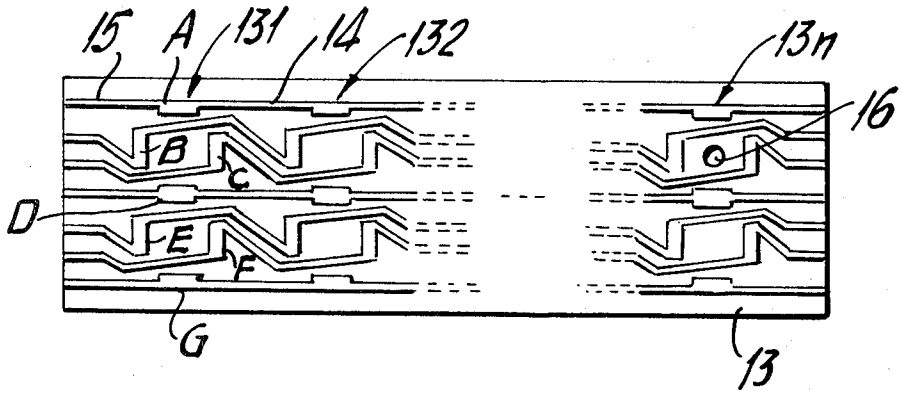
[57] **ABSTRACT**

In an external electrode plasma display panel for a plurality of digits, transparent first electrodes are placed in front of the segment-shaped voids of the respective digits formed in a central plate and second electrodes are placed at the back of the respective voids of the digits. The second electrodes for the corresponding voids of the digits are connected in series, with lead wires extending to the edge of the panel from the second electrodes for the respective voids of the digit placed at least at one of both ends of the digits.

2 Claims, 3 Drawing Figures



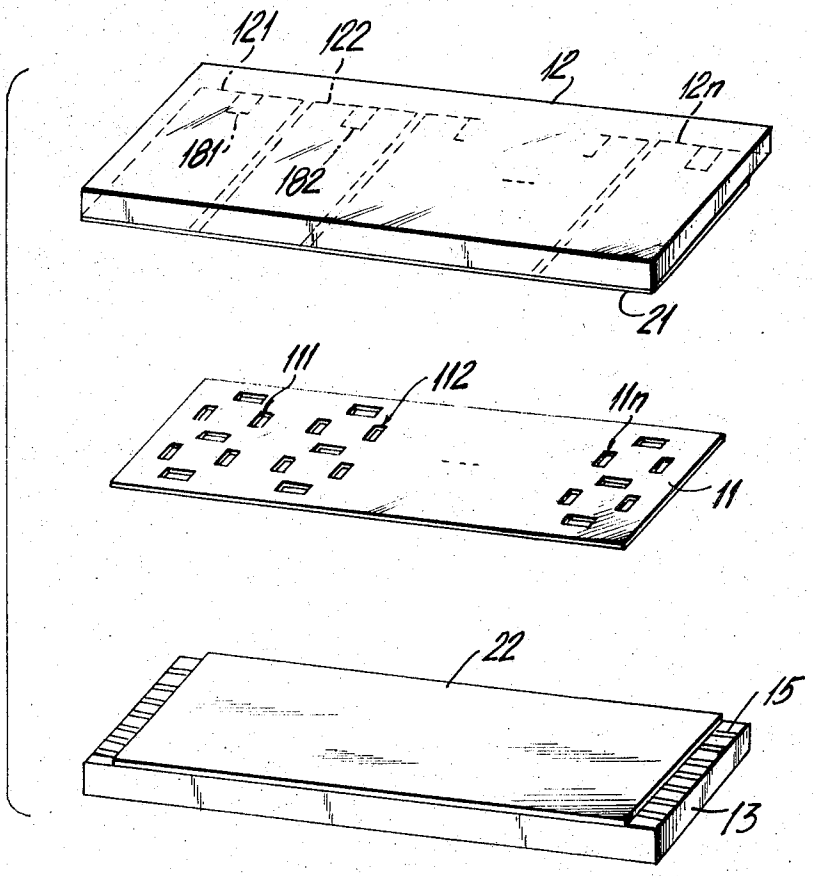


FIG.1

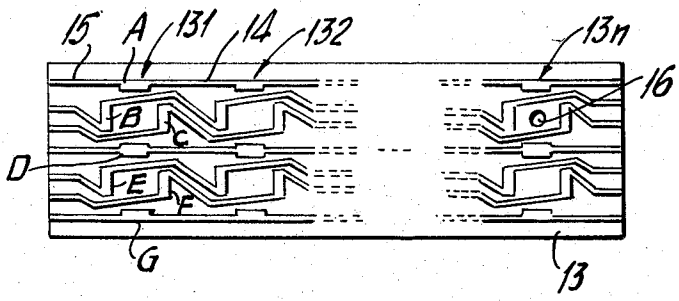


FIG.2

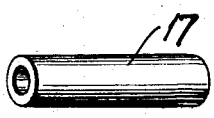


FIG.3

PLASMA DISPLAY PANEL COMPRISING A FIRST EXTERNAL ELECTRODE FOR EACH DIGIT AND A SECOND EXTERNAL ELECTRODE FOR EACH SEGMENT

BACKGROUND OF THE INVENTION

This invention relates generally to displays and more particularly to an external electrode plasma display panel for a plurality of digits or letters.

A plasma display panel generally includes a central plate having a plurality of through hole sets, a front plate, and a rear plate. The three plates are typically made of glass and are substantially identical in shape. These plates are stacked and sealed together around their peripheries. Each of the through hole sets consists of a predetermined number of segment-shaped voids arranged in a predetermined configuration, such as a figure of eight. The voids are filled with an ionizable gas, which is commonly neon or a mixture of neon and argon. The pressure of the ionizable gas in the voids may be several hundred Torr. The front and the rear plates are provided with first and second electrodes, respectively, placed on their surfaces facing the central plate at the positions of the respective voids. The first electrodes should be substantially transparent. The first and the second electrodes are covered with first and second insulating layer means, respectively. The first insulating layer means should be substantially transparent, and the second insulating layer means should preferably be colored black. The electrodes having the voids therebetween in which gas discharge is caused to occur are supplied with pulses of a high repetition frequency. Access to the electrodes for application therebetween of the pulses is provided by lead wires connected thereto through the through holes formed through the front and the rear plates on which the electrodes having the respective lead wires are placed. This construction is objectionable from the viewpoint of manufacture. Alternatively, the corresponding electrodes for the respective digits are connected in parallel by means of electroconductive connections formed on the front and the rear plates on which the parallel connected electrodes are placed. This results in an increase in the electrostatic capacity of the plasma display panel and a resulting increase in the power consumption of the pulses. With either of these means for providing access to the electrodes, it is necessary to initially test the plasma display panel to determine if the connection of te lead wires or the electroconductive connections to the electrodes is defective.

SUMMARY OF THE INVENTION:

It is therefore an object of the present invention to provide an electrode plasma display panel for a plurality of digits or letters, which can be easily manufactured.

It is another object of this invention to provide a plasma display panel of the type described, which has a reduced electrostatic capacity and which accordingly requires less electric power for providing the display.

It is still another object of this invention to provide a plasma display panel of the type described, which can be easily tested to determine if access to the electrodes from outside the panel is perfect.

According to this invention, a plasma display panel includes a central plate having a plurality of through hole sets, a front plate, and a rear plate which are stacked and sealed together around their peripheries. Each of the through hole sets consists of a predetermined number of segment-shaped voids arranged in a predetermined configuration and filled with an ionizable gas. A plurality of substantially transparent first electrodes are placed on the surface of the front plate facing the central plate and a plurality of second electrodes are placed on the surface of the rear plate facing the central plate. The first electrodes are placed at least at those portions of the front plate surface which confront the respective ones of the through hole sets. The first electrodes are covered with a substantially transparent first insulating layer at least at those portions of the first electrodes which confront the respective voids of through hole sets. The second electrodes are placed at those portions of the rear plate surface which are in registry with the respective ones of the voids of the through hole sets. The corresponding ones of the second electrodes are connected in series along the rear plate surface by means of electroconductive connections. A plurality of lead wires extend from the respective second electrodes placed in registry with the respective voids of a predetermined at least one of the through hole sets towards the periphery along the rear plate surface. The second electrodes for the through hole sets are covered with a second insulating layer at least at those portions of the second electrodes which are in registry with the voids of the through hole sets.

To the accomplishment of the above and to such further objects as may hereinafter appear, the present invention relates to a plasma display panel, substantially as defined in the appended claims and as described in the following specification taken together with the accompanying drawing in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an exploded perspective view on one embodiment of the present invention with the thicknesses of the elements of the embodiment shown exaggerated;

FIG. **2** is a plan view of a rear plate for use in the embodiment depicted in FIG. **1**, together with the second electrodes, electroconductive connections, and lead wires formed on one surface of the rear plate; and

FIG. **3** is a perspective view of an exhaust pipe for use in manufacturing a plasma display panel.

DESCRIPTION OF THE PREFERRED EMBODIMENT:

Referring to FIG. **1**, an external electrode plasma display panel for a plurality of digits comprises a central plate **11**, a front plate **12**, and a rear plate **13**. The central plate **11** is a rectangular soda glass sheet and is about 15–200 microns thick. The central plate **11** is provided with a row of through hole sets **111**, **112**, . . . and **11***n*. Each of the through hole sets consists of a predetermined number of segment-shaped voids arranged in a predetermined configuration, such as, as shown in the embodiment of FIG. **1**, a figure of eight. These voids may be formed by photoetching the central plate **11**. The front plate **12** is a glass sheet having substantially the same outline as the central plate **11** and is about 2 mm thick. The front plate **12** may be wider than the central plate **11** in the direction perpendicular to the row of the through hole sets **111**, **112**, . . . , and **11**n. The front plate **12** is provided with a plurality of

first electrodes **121, 122, . . .**, and **12*n*** on one of its surfaces to cover, when superposed on the central plate **11** with the front plate surface having the first electrodes **121, 122, . . .**, and **12*n*** directed toward the central plate **11**, at least those portions of the front plate surface which are in registry with the through hole sets **111, 112, . . .**, and **11n**. To form the first electrodes **121, 122, . . .**, and **12*n***, a substantially transparent electroconductive film, such as a film of stannic oxide, is placed on the front plate surface and is subsequently divided into separate electrodes **121, 122, . . .**, and **12*n*** by etching, by electrolysis, or mechanically.

Referring to FIGS. **1** and **2**, the rear plate **13** is a glass sheet having substantially the same outline as the central plate **11** and is about 3 mm thick. The rear plate **13** is preferably longer than the central plate **11** in the direction of the row of the through hole sets **111, 112, . . .**, and **11*n***. The rear plate **13** is provided with a plurality of second electrode sets **131, 132, . . .**, and **13*n*** on one of its surfaces. Each of the second electrode sets **131, 132, . . .**, and **13*n*** consists of a plurality of separate second electrodes A, B, C, D, E, F, AND G. The number of the separate second electrodes is equal to the number of segment-shaped voids of each of the through hole sets **111, 112, . . .**, and **11n**. The second electrodes A through G should be in substantial registry with the segment-shaped voids of the through hole sets **111, 112, . . . 11*n*** when the rear plate **13** is superposed on the central plate **11** with the rear plate surface having the second electrodes A through G directed toward the central plate **11**. The corresponding second electrodes, such as the second electrodes A, of the second electrode sets **131, 132, . . .**, and **13*n*** are connected in series by electroconductive connections **14** formed on the rear plate surface. A plurality of lead wires **15**, the number of which is equal to the number of second electrodes A through G of each of the second electrode sets **131, 132, . . .**, and **13*n***, extend from the respective second electrodes A through G of each of the second electrode sets **131** and **13*n*** placed on both ends of the row of the second electrode sets **131, 132, . . .**, and **13*n*** to the adjacent edge of the rear plate **13**. The corresponding lead wires **15** on both ends of the second electrode row are thus electrically connected through the second electrodes A through G and the electroconductive connections **14**. Preferably, the connection between each pair of the corresponding lead wires **15** should be as short as possible. The second electrodes A through G, the electroconductive connections **14**, and the lead wires **15** may be formed at the same time by screen printing. More particularly, commercially available silver paste may be applied to the rear plate surface through a pattern for printing these elements and then baked in an electric furnace at a temperature between 500°C and 600°C. In a manner known in the art, an exhaust hole **16** is formed, as by ultrasonic machining or drilling, through the rear plate **13** at a position offset from the second electrodes A through G, the electroconductive connections **14**, and the lead wires **15**, before forming the latter elements on the rear plate surface. The exhaust hole **16** is for subsequent attachment to an exhaust pipe **17** (FIG. **3**).

Referring again to FIG. **1**, the first electrodes **121, 122, . . .**, and **12*n*** are provided with terminals **181, 182, . . .**, and **18*n***, respectively, as shown. Terminals **181, 182, . . .**, and **18*n*** are preferably silver layers applied to the respective first electrodes **121, 122, . . .**, and **12*n*** by screen printing, by a brush, or otherwise. The first electrodes **121, 122, . . .**, and **12*n*** are covered with a first insulating layer **21** at least at their portions confronting, when the front plate **12** is superposed on the central plate **11** in the manner mentioned above, the through hole sets **111, 112, . . .**, and **11*n***, except at their portions on which the terminals **181, 182, . . .**, and **18*n*** are formed. To form the first insulating layer **21**, powder glass may be spread over the exposed surfaces of the first electrodes **121, 122, . . .**, and **12*n*** by screen printing, sedimentation, electrodeposition, spraying, or other technique and then fired into a uniform glass layer in an electric furnace at a temperature between 500°C and 600°C. The thickness of the first layer **21** may be between 10 microns to 30 microns. The first layer **21** should preferably be transparent to provide a clear display. Similarly, the second electrodes A through G are covered with a second insulating layer **22** of a like thickness. The second insulating layer **22** may also cover the electroconductive connections **14** and is preferably colored black in order to provide a clear display.

With the front plate assembly and the rear plate assembly placed on both sides of the central plate **11**, and with the exhaust pipe **17** brought into registry with the exhaust hole **16**, glass frit is applied to the periphery of the plate stack and the abutting end of the exhaust pipe **17** and is subsequently glazed at a temperature between 400°C and 450°C. The voids within the plate stack are evacuated in a known manner and then filled with an ionizable gas, such as neon or a mixture of neon and argon, at a pressure of several hundred Torr. The exhaust pipe **17** is eventually sealed with glass frit to complete the external electrode plasma display panel. The plasma display panel is operable by applying pulse voltages to the front plate terminals **181, 182, . . .**, and **18*n*** and to the rear plate lead wires **15** selectively in the manner known in the art as dynamic driving.

An important feature of the external electrode plasma display panel according to the present invention resides in the structure of the second electrodes A through G, the electroconductive connections **14**, and the lead wires **15**. The integral construction of these elements remarkably facilitates the manufacture of the plasma display panel. The shortest possible connections of these elements reduce the conductive elements which do not contribute to the display, and also reduce the electrostatic capacity between the first and second electrodes. The latter fact reduces the electric power of the voltage pulses that is consumed by the panel without contributing to the display. In addition, it is possible with the lead wires **15** extended to the opposing edges of the rear plate **13** to quantitatively test if there are any defects, such as a short, breakdown of the connection, or anomaly in the resistance in the second electrodes A through G, the electroconductive connections **14**, or the lead wires **15**.

While the present invention has thus far been described in conjunction with a preferred embodiment, it will readily be possible for those skilled in the art to modify the embodiment in various manners. For example, the first electrodes **121, 122, . . .**, and **12*n*** may be made of titanic oxide or indium sesquioxide. They may be formed of an opaque material into a mesh structure. It should therefore be understood that the expression "substantially transparent" used in this specification and the appended claims does not refer to the optical

nature of the material of the first electrodes **121, 122, . . .**, and **12***n* but to the first electrodes per se. The second electrodes A through G may be made of gold, platinum, an alloy of molybdenum and manganese, or any other conductive material. The central plate **11** may be a mica sheet or a metal sheet having an insulating coating. The rear plate **13** may be a ceramic plate. The insulating layers **21** and **22** may cover only the surface portions of the first electrodes **121, 122, . . .**, and **12***n* and the second electrodes A through G that confront the segment-shaped voids **111, 112, . . .**, and **11***n*.

What is claimed is:

1. In a plasma display panel for a plurality of identical characters including:

first and second supporting members,

a plurality of identical sets of character-forming electrodes on said second supporting member,

a common electrode for each set on said first supporting member, and

means associated with the common electrode to enable a first electric potential to be applied thereto,

the improvement which comprises:

electroconductive means on said second supporting member in coplanar relation to said character-forming electrodes for connecting corresponding electrodes in each set in series so that corresponding electrodes in each set and the connecting electroconductive means therebetween form a continuous line segment free of branches, and

plural lead wires extending from first ends of each of the serially connected character-forming electrodes disposed at one end of said continuous line segment for applying a second electric potential to the corresponding electrodes connected to said each character-forming electrode coincident with said first potential, whereby a potential difference of predetermined magnitude may be produced between the energized corresponding electrodes and a common electrode for a selected set.

2. The plasma display panel of claim **1**, further comprising second lead wires extending from the second ends of each of the serially connected character-forming electrodes disposed at the other ends of said continuous line segments, said second electric potential being also applied to said second lead wire.

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