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Kurahashi et al.

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[54] **PLASMA DISPLAY PANEL DEVICE**

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** ..... **313/510,** 313/188, 313/201, 313/514, 315/169 TV

[51] **Int. Cl.** **H01j 7/42,** H01k 1/60

[58] **Field of Search** ..... 313/188, 201, 220, 109.5, 313/174, 203; 315/169 TV

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[57] **ABSTRACT**

A plasma display panel device has a pair of electrodes arranged to face with each other with a sealed discharging gap therebetween in which a dischargeable gas is filled. When a voltage is impressed between the electrodes an electrical discharge of the gas will be caused and provide luminescence to display a character, such as a letter or a figure in accordance with the selected electrodes. Only one insulating layer, which covers one of the pair of the electrodes, is needed to effectively operate the display.

A wall charge having an opposite polarity to that of the electrode voltage is provided on the insulating layer whereby a decrease of the electrode voltage can be prevented and the memory function, capable of turning "on" (to write) and "off" (to erase) by impressing a write pulse or an erase pulse, is formed. The single insulating layer enables a decrease of the operation voltage, a high resolution and an accurate writing and erasing to be realized.

3 Claims, 5 Drawing Figures

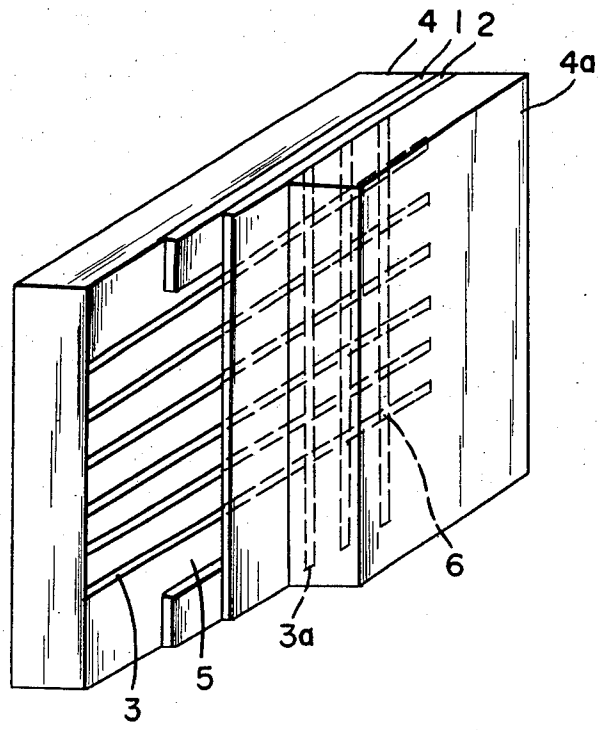
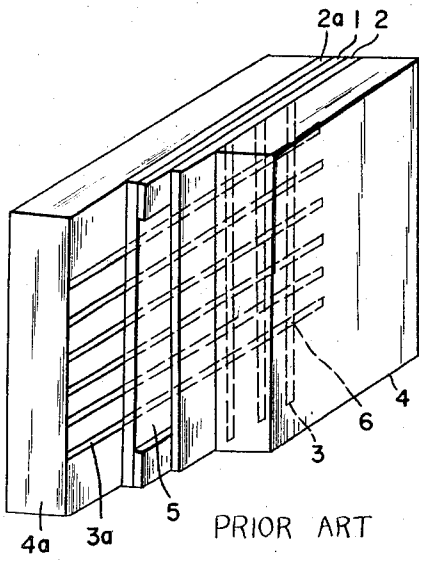


FIG. 1



PRIOR ART

FIG. 2

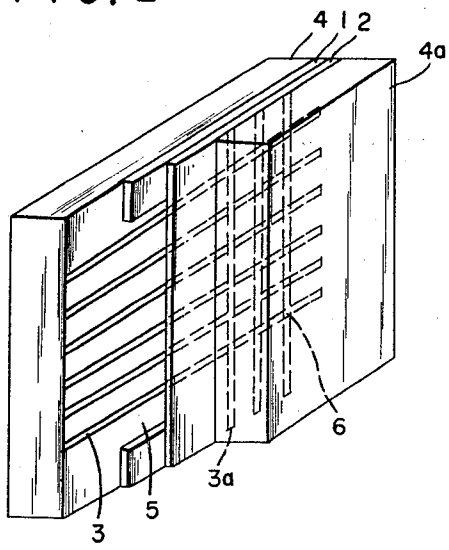


FIG. 3

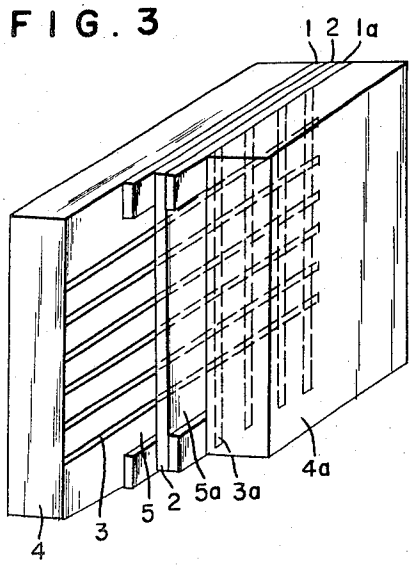


FIG. 4

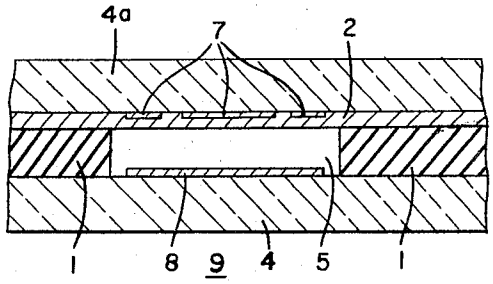
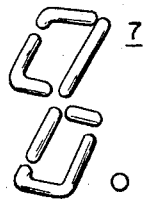


FIG. 5



PLASMA DISPLAY PANEL DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention generally relates to a plasma display panel device, and more particularly to a plasma display panel device having electrodes which form a matrix or mosaic type pattern for displaying characters, such as letters or figures.

2. Description of the Prior Art

In the past, various types of plasma display devices having matrix type electrodes have been developed. A separate insulating plate was adhesively provided on each of two groups of electrodes which were faced with each other.

The insulating plates provided, by electrostatic charge, a wall voltage which was of an opposite polarity to the applied electrode voltage, whereby the decrease of the electrode voltage would be prevented, and the memory function, capable of writing and erasing, was formed by impressing a write pulse or an erase pulse and thereby provided the desired operation.

While somewhat satisfactory, since the insulating plates were respectively provided on each group of electrodes, two sheets of the insulating plates between the two groups of electrodes were required and accordingly, the electric field intensity in the discharging gap was relatively low compared to the voltage impressed on the electrodes. As a result thereof a relatively high operation voltage was needed.

Moreover, the concentration of the electric field distribution on the electrodes was adversely affected by the insulating plates and broadened the discharge thereby preventing the attainment of a high resolution.

An additional problem with the prior art display panel device was that since the discharging gap was surrounded by the insulating plates, it was hard to provide the required free electrons which were necessary for the initiation of a discharge, thereby causing inaccurate writings to occur.

Still further in the past, it was also hard to locate the timing of the impressed pulses, during the discharge, for eliminating the wall charge at the time of turn off.

One attempt in the past to improve the above problems was to improve the electric field condition in the discharging gap by using thinner insulating plates. Accordingly, insulating plates having 50 – 14μm of thickness were preferably used. A problem here was that such plates have the disadvantage of being too brittle and were hard to make.

SUMMARY OF THE INVENTION

It is an object of this invention to provide a new and improved unique plasma display panel device.

It is another object of this invention to provide a new and improved unique plasma display panel device capable of operating at a relatively low voltage and which provides a high resolution for increasing reliability in writing and erasing.

It is still another object of this invention to provide a new and improved unique plasma display panel which is easily prepared by fixing an insulating layer to only one group of electrodes.

yet one further object of this invention is to provide a new and improved unique plasma display panel device wherein one group of electrodes are formed in a mosaic type pattern to simplify the display driving circuit and to enable characters and graphs to be displayed with high resolution.

Briefly, the foregoing and other objects are in one aspect attained in accordance with this invention by the provision of a plasma display panel device having a first group of electrodes which are provided on one surface of a first transparent insulating base plate and a second group of electrodes positioned to face the first group of electrodes and being provided on a surface of a second insulating base plate. Only one insulating layer is provided between the first group of electrodes and the second group of electrodes. A spacer is provided and forms an airtight sealed gap between the first group of electrodes and the second group of electrodes through the single insulating layer. A dischargeable gas is charged in the gap formed between the first group of electrodes and the second group of electrodes such that an electrical discharge of the gas is caused to display a character.

DESCRIPTION OF THE DRAWINGS

These and other objects and advantages of this invention will become more readily appreciated by reference to the following detailed description, when considered in connection with the accompanying drawings, wherein:

FIG. 1 is a partial cross-sectional schematic view of one embodiment of a conventional prior art plasma display panel device;

FIG. 2 is a partial cross-sectional schematic view of one preferred embodiment of a plasma display panel device using matrix type electrodes in accordance with this invention;

FIG. 3 is a partial cross-sectional schematic view of another preferred embodiment of the plasma display panel device using matrix type electrodes in accordance with this invention;

FIG. 4 is a front sectional view of still another preferred embodiment of the plasma display panel device using mosaic type electrodes in accordance with this invention; and

FIG. 5 is a schematic view of a segment electrode used for the embodiment of FIG. 4 for displaying a mosaic type numeral figure.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, wherein like reference numerals designate identical or corresponding parts throughout the several views and more particularly to FIG. 1 thereof wherein a conventional plasma display panel device is shown as including two sheets of a thin insulating glass plate (2) and (2*a*). The glass plates (2) and (2*a*) are separatedd by a spacer (1) to thereby form a discharging cell. Two transparent reinforcing glass plates (4) and (4*a*) are further provided and each of the same has a respective group of a plurality of strip type electrodes (3) and (3*a*) adhered on an outer surface of the insulating glass plates. A dischargeable gas, such as neon, is sealed in a discharging gap (5) which is located between the two separated sheets of the insulating glass plates (2) and (2*a*). An A.C. voltage is impressed between the two groups of the electrodes (3) and (3*a*) for electrically discharging the gas at the points of inter-section (6) of the electrodes (3) and (3*a*) to thereby sustain a luminescence, once

turned "on" by a write pulse until turned "off" by an erase pulse.

The main function of the thin insulating glass plates (2) and (2*a*) between the groups of electrodes (3) and (3*a*) and the discharging gap (5) is to separately trap ions and electrodes which are generated by the discharge and which are moved to different directions by the electrode voltage. In accordance with the charges so formed, a wall voltage having an opposite polarity to that of the electrode voltage is provided. The wall voltage will increase, depending upon the discharge, to thereby decrease the electrode voltage and to finally stop the discharge, such as to prevent any decrease or deterioration of the electrode which could be caused by a severe discharge.

The insulating glass plates (2) and (2*a*) enable the memory function which is one of the most advantageous characteristics of the display panel to be provided. The memory function results from the fact that portions of the applied A.C. voltage are lower than that necessary for causing ignition of a discharge and the same are usually impressed on the electrodes. When a lighting is required and the voltage of a narrow width pulse is impressed for causing a discharge, the wall voltage is formed to thereby reverse the polarity of the A.C. voltage, whereby the polarity of the wall voltage will coincide with that of the A.C. voltage. The wall voltage is thus combined with the A.C. voltage.

Accordingly, even though the A.C. voltage is low, a voltage which is higher than that required for ignition of a discharge will be impressed on the discharge gap so that the discharge is intermittently repeated for each reversing of the polarity of the applied A.C. voltage.

In order to stop a discharge, a negative pulse, like the lighting pulse, is impressed at the time of discharge to thereby eliminate the wall charge. While the insulating glass plates (2) and (2*a*) provide advantageous characteristics for the display panel, since they are each respectively combined with a group of electrodes, the electric field intensity in the discharging gap is relatively low compared to the voltage impressed on the electrodes. This results in the requirement of a high voltage operation. The concentration of the electric field distribution on the electrodes is also adversely affected by the insulating glass plates and tends to broaden the discharge, preventing a high resolution from being realized. Moreover, since the discharge gap is surrounded by the insulating plates, it is hard to generate the free electrons required for the initiation of the discharge, whereby the accuracy of lighting is inferior.

Referring now to the present invention, it will be seen that the above-mentioned disadvantages can be removed by providing an insulating material such as an insulating glass plate on the surface of only one group of electrodes. The other insulating material is eliminated.

FIG. 2 is a schematic view of one preferred embodiment of a plasma display panel device in accordance with this invention. The plasma display panel device is shown as including a pair of the reinforcing glass plates (4) and (4*a*) which are positioned to face with each other and which respectively have a plurality of crossed conductive strip type electrodes (3) and (3*a*). Only one sheet of an insulative layer (2), such as an insulating glass plate, is provided between the pair of reinforcing glass plates (4) and (4*a*). A spacer (1) is provided between the insulating layer (2) and one of the pair of the glass plate electrodes (3) or (3*a*).

It should be understood that at least one of the reinforcing glass plates (4) and (4*a*) should be made transparent, so that the luminescence caused by a gaseous discharge can be seen exterior to the device.

It should further be understood that the strip type electrodes (3) fixed to the reinforcing glass plate (4) are arranged in parallel in a horizontal direction while the strip type electrodes (3*a*) fixed to the reinforcing glass plate (4*a*) are arranged in parallel in a vertical direction. The two groups of electrodes (3) and (3*a*) thereby form matrix type electrodes which three dimensionally cross each other.

The insulating layer, such as the sheet of the insulating glass plate (2), is directly fixed on the strip type electrodes (3*a*) of the reinforcing glass plate (4*a*) and thereby covers the electrodes (3*a*). The insulating glass plate (2) is made of a material which is capable of forming a wall charge and is preferably glass having a high content of lead and a low melting temperature point. The invention is not so limited, however, and it is possible to use a heat resistant organic material, such as polyimide or polyamide, for the insulating glass plate (2). The spacer (1) is made of either an insulating or a conductive material and is fixed to the surface of the insulating layer (2) which is opposite to that surface which is fixed to the electrodes (3*a*). The reinforcing glass plate (4*a*) which has one group of the electrodes attached thereto is arranged so as to connect the spacer (1) to the reinforcing glass plate (4) which has the other group of electrodes attached thereto. A discharging gap (5) is formed between both groups of the electrodes (3) and (3*a*) for charging a dischargeable gas, such as neon, in the discharging gap. The groups of electrodes (3) and (3*a*) and the insulating layer (2) forms an air-tight seal.

In operation, when an A.C. voltage impressed to cause an electric discharge on the strip type electrodes selected from the groups of the electrodes (3) and (3*a*), the electrons or ions so generated will be trapped on the insulating layer (2) in accordance with the polarity of the electrode voltage and thereby form a wall voltage. It should be understood that the electrode voltage is cancelled by the wall voltage in order to prevent a severe discharge. When the polarity of the A.C. voltage impressed on the electrodes is reversed, then the same will coincide with that of the wall voltage so that the A.C. voltage will be added to the wall voltage and thereby impart the memory function.

With the present invention, since one group of the electrodes, shows as group (3), is exposed in the discharging gap (5), the electric field intensity in the discharging gap (5) will be relatively high compared with that of the prior art wherein two insulated layers were used. Accordingly, the operation voltage can be decreased. Since with the present invention, the concentration of the electric field on the electrodes is high, a panel having high resolution and writing and erasing is formed.

Also with the present invention because of the mobility of the ions in the discharging gap, it should be apparent that when the polarity of the exposed group of electrodes is positive and the polarity of the insulating group of electrodes is negative and an erase pulse is impressed, it will be easy to eliminate the wall charge and thereby accurately erase the luminescence.

FIG. 3 is another embodiment of the plasma display panel device of this invention, wherein spacers (1) and (1*a*) are respectively fixed to both surfaces of the single sheet of the insulating layer (2) and each group of the electrodes (3) or (3*a*) is attached to each spacer to thereby form two discharging gaps (5) and (5*a*) on both sides of the insulating layer (2).

In this embodiment, it should be understood that the electrons and the ions are trapped on the insulating layer (2) to form the wall voltage in a manner like that of the embodiment shown in FIG. 2. Accordingly, it is again possible to avoid a severe discharge and to provide the desired memory function. Since in the present embodiment both groups of the electrodes are exposed in each of the discharging gaps, it is possible to provide the advantage of a decrease in the operation voltage to result in a high resolution display device having high writing and erasing accuracy.

The above described embodiments use two groups of a plurality of strip type electrodes (3) and (3*a*) which are arranged in a matrix form. However, the means for impressing a voltage to the matrix shaped electrodes is complicated, when the embodiment is used for simply displaying numerical figures, and the like. Under such conditions the mosaic shaped electrode is preferred, as hereinafter described.

FIG. 4 is a front sectional view of a display panel in accordance with this invention for displaying characters. In FIG. 4, the reference numeral (4*a*) designates a transparent glass base plate and the reference numeral (7) designates segment electrodes which show a numerical character in a mosaic form. The segment electrodes (7) are fixed on the surface of the glass base plate (4*a*). Each electrode has a terminal for enabling a voltage to be impressed thereon. The reference numeral (2) designates a transparent insulating layer, such as glass, which covers the segment electrodes (7). The reference numeral (1) designates a spacer, and the reference numeral (8) designates a position setting electrode having a plate or net shape and having a terminal for impressing a voltage thereon. The position setting electrode (8) is fixed on the insulating base plate (4), such as made of glass or ceramic. The glass base plate (4*a*), having the electrodes (7), and the base plate (4), having the electrode (8), are faced with each other and are air-tight sealed through the spacer (1) to preserve the gap (5), wherein neon or the like is charged to form a gas therein.

A display element (9) for displaying characters is thus formed by the combination of the electrodes (7), the electrode (8) and the gas gap (5). It should be understood that a desirous number of such display elements are arranged to form a numeral display panel for enabling many characters to be displayed.

In the embodiment shown in FIG. 4, the segment electrodes (7) are covered by the insulating layer (2), however, it is possible to modify the same such that the position setting electrode (8) is covered by the insulating layer and thereby expose the segment electrodes (7) in the gas gap (5).

It is also possible to modify the embodiment of FIG. 4 such that a single continuous metal plate of sufficient strength can be used as the position setting electrode (8) thereby eliminating the base plate (4), if the gap between the groups of electrodes can be air-tight sealed.

It is also possible with the embodiment of FIG. 4 to provide other modifications such as having the base plate (4) formed into one piece with the spacer (1). In the plasma discharge system of the present embodiment, it is possible as is well known to provide a memory function by impressing a write pulse having a voltage such as of 10 KH_z between the electrodes (7) and the electrode (8) to maintain the plasma discharge along the segment electrodes (7) and thereby to display a character. On the other hand, it is well known that it is possible to eliminate the display by impressing an erase pulse.

When the shape of the numerical character shown in FIG. 5 is used as a mosaic type letter, it should be understood that the number of segment electrodes (7) is 7, while the number of position setting electrodes (8) is 1. Accordingly, it is possible to display the numeral of 1 — (0) and a dot and non-mark by selectively impressing a voltage to the eight electrodes, whereby the display driving circuit is greatly simplified as compared to one using matrix type electrodes.

As stated above, it should now be apparent that in accordance with this invention, the manufacture of a display device is simplified since only one insulating glass plate is used for arranging two groups of electrodes. Moreover, the important functions of providing a decrease in the operation voltage, having a high resolution and having accurate writing and erasing, is greatly improved compared to that of the heretofore conventional display panel devices.

Obviously, numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described herein.

Accordingly, what is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A plasma display panel comprising:
- a first base plate having an inner surface and an outer surface,
- a first electrode disposed adjacent to the inner surface of the first base plate,
- a second base plate having an inner surface and an outer surface,
- a spacer disposed between the first base plate and the second base plate,
- a second electrode disposed adjacent to the inner surface of the second base plate,
- the second electrode being further disposed opposite the first electrode and a gap formed therebetween by said spacer,
- a continuous insulating layer having an inner surface and an outer surface disposed within the gap,
- the gap being otherwise occupied in its entirety by a dischargeable gas,
- the first electrode being disposed between the inner surface of the first base plate and the outer surface of the insulating layer,
- whereby an electrical discharge of the gas in the gap occasioned by application of a voltage of a given polarity to the first and second electrodes establishes a wall voltage of opposite polarity on the inner surface of the insulating layer.

2. A plasma display panel in accordance with claim 1 wherein one of the electrodes comprises a plurality of electrode segments.

3. A plasma display panel comprising:
a first base plate having an inner surface and an outer surface,
a first electrode disposed adjacent to the inner surface of the first base plate,
a second base plate having an inner surface and an outer surface,
first and second spacers disposed between the first base plate and the second base plate,
a second electrode disposed adjacent to the inner surface of the second base plate,
the second electrode being further disposed opposite the first electrode and a gap formed therebetween by said spacers,
a continuous insulating layer having first and second surfaces disposed within the gap,
the gap being otherwise occupied in its entirety by a dischargeable gas,
the insulating layer being so disposed so as to permit a first portion of the dischargeable gas to be disposed between the first electrode, the first spacer and the first surface of the insulating layer and being so disposed so as to permit a second portion of the dischargeable gas to be disposed between the second electrode, the second spacer and the second surface of the insulating layer.

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