United States Patent

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[54] **LARGE AREA PLASMA PANEL DISPLAY DEVICE**
4 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** .... **313/201,** 313/108 B, 313/217, 315/169 R
[51] **Int. Cl.** **H01j 11/02,** H01j 65/04
[50] **Field of Search** 313/108, 109, 109.5, 201, 217; 315/169; 340/166

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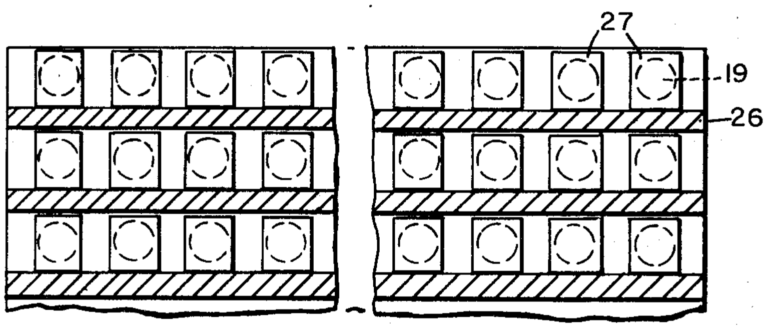
ABSTRACT: This invention is directed to a large area panel display device whereby a high-density plasma display is provided from a number of modular building blocks to minimize the gaps between modules to provide a high-density display device.



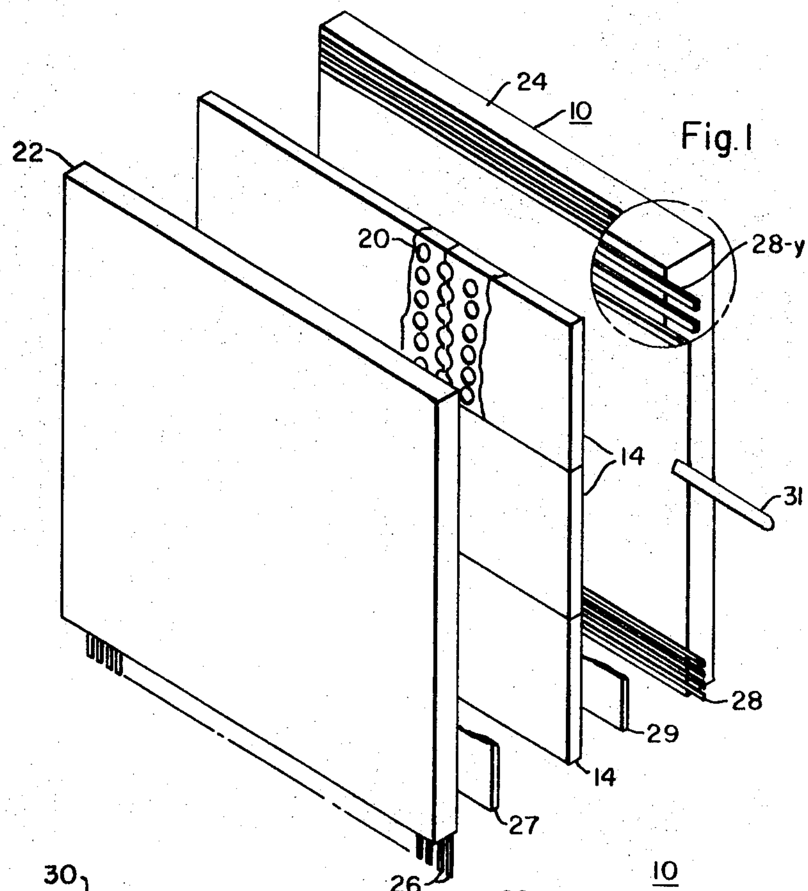

24
10
22
20
28-y
14
31
28
29
14
27
26

Fig. 1

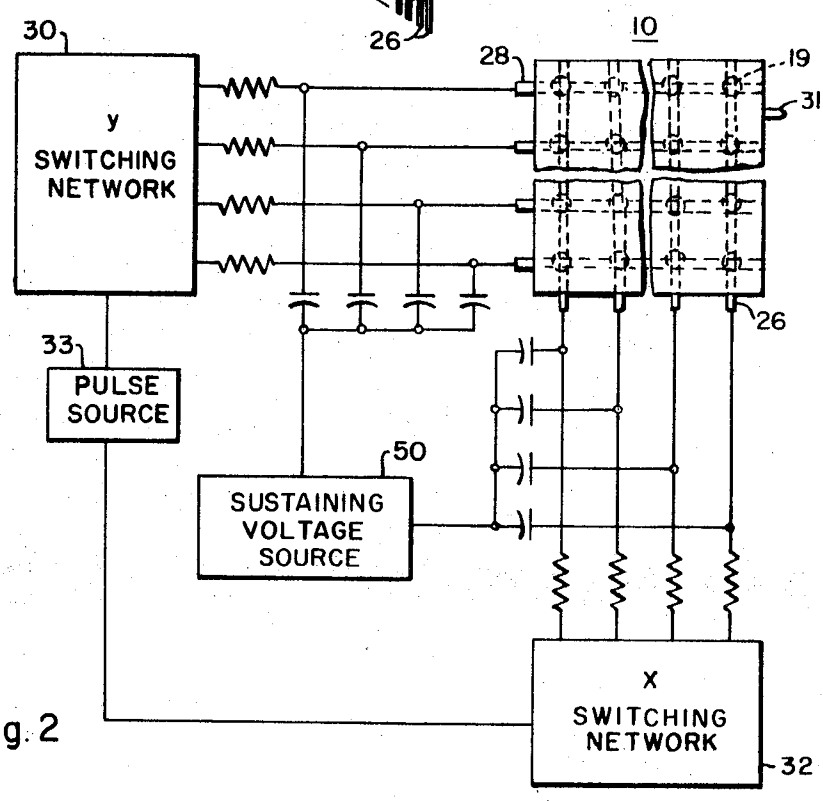

30
y
SWITCHING
NETWORK
10
28
19
31
26
33
PULSE
SOURCE
50
SUSTAINING
VOLTAGE
SOURCE
X
SWITCHING
NETWORK
32

Fig. 2

Fig. 3

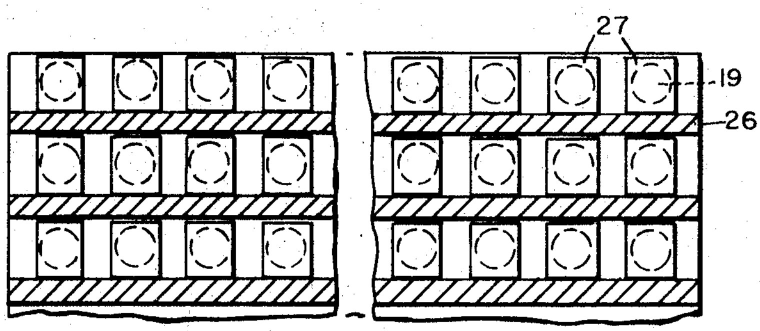
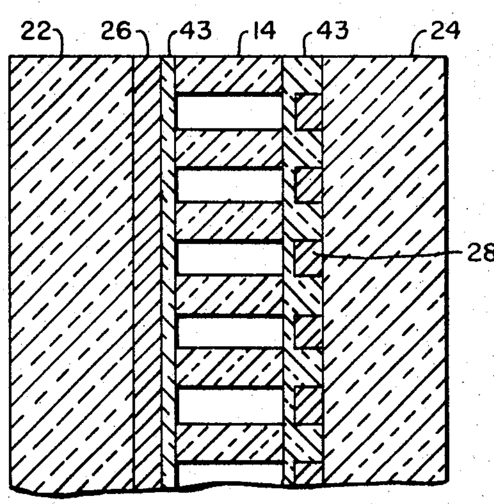


Fig. 4



WITNESSES

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LARGE AREA PLASMA PANEL DISPLAY DEVICE

BACKGROUND OF THE INVENTION

This invention is directed to an inexpensive, high-brightness, flat, display device utilizing gas discharges as the source of light. This type of device has been referred to as the plasma display. The conventional plasma display consists of layer-type structure made up of three thin plates in which there are two outer plates and an apertured inner plate. Transparent conductive electrodes are provided on the outside surface of these outer plates to provide a cross grid arrangement. Each aperture or opening in the inner plate defines a display element. The apertures are filled with a suitable gas mixture and the individual display elements can be ignited by applying a coincident voltage of appropriate magnitude to the selected crossed grid conductive members on the outer surface of the outer plates. In this manner, the desired individual gas cells or display elements may be excited to form a display corresponding to the excited cells. By suitable excitation of the cross grid arrangement, image may be displayed in a well known manner. A further improvement to the above-described display device is set forth in U.S. Pat. application Ser. No. 773,468 filed Nov. 5, 1968 by H. Goldie et al. and assigned to the same assignee as this invention. The above-mentioned copending application describes a modular construction for a display device. This copending application is directed to the concept of providing a large area display by positioning a plurality of evacuated modules between two electrode plates. The seal region of each module results in a structure with loss of resolution between modules.

SUMMARY OF THE INVENTION

This invention is directed to a large area display device consisting of a plurality of modular elements and assembled in such a manner to provide a large area high resolution display without loss of resolution between modules. This is accomplished by providing a plurality of modular perforated panel elements arranged side-by-side to form a large area display. The perforated module elements are sandwiched between two electrode panel members coextensive with the assembled perforated elements. The electrode panel members have electrodes provided thereon and insulating material between the perforated elements and the electrodes on the electrode panels. The insulating material may be modular form, a continuous sheet of similar area as the electrode panel members or a dielectric coating provided over the electrode surfaced electrode panel members to provide the necessary dielectric between the electrodes and the gas confined in apertures in the perforated elements. The panel display is sealed off at the outer edges of the electrode panel members. The panel is evacuated and then provided with a suitable gas mixture prior to sealing to provide the completed display panel.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a large area panel display device with a portion enlarged and incorporating teachings of this invention;

FIG. 2 is a front view of a display panel of the type shown in FIG. 1 with associated circuitry for control of the panel;

FIG. 3 illustrates a modified embodiment for providing electrodes on the panel which may be incorporated in FIG. 1; and

FIG. 4 illustrates a modified embodiment for providing a dielectric coating between the electrodes and cells of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring in detail to FIGS. 1 and 2, there is illustrated a large area panel display 10. The specific embodiment shown comprises nine module perforated elements 14. It is obvious that any number of modules 14 arranged side-by-side may be used depending on the size of the display desired. Each of the modules 14 include a large number of display elements 19 each formed by the excitation of the gas confined within an aperture 20. The number of display elements 19 is dependent upon the resolution desired from the display device. In the specific device, 400 display elements 19 are provided in each module 14. A typical module 14 may be a square of about 10 inches × 10 inches. The panel 10 provides three modules in each row and column. Each module 14 contains a plurality of rows and columns of display elements 19 which are aligned with rows and columns of adjacent modules. The panel 10 includes two outer electrode panels 22 and 24 of a suitable insulating material and of which at least one is transmissive to radiations from within the display elements 19. A suitable material is glass. The electrode panels 22 and 24 are provided with a plurality of spaced parallel electrically conducting strips 26 and 28 on the inner surfaces. In the specific embodiment shown, the electrode panel 22 is provided with a plurality of spaced parallel electrical conducting strips 26 which may be referred to as the X conductors. The other electrode panel 24 has a plurality of spaced parallel electrically conducting strips 28 which may be referred to as the Y conductors. These electrically conducting strips or coatings 26 and 28 may be of any suitable material such as gold and may be evaporated or applied in any desired manner to provide electrically conducting leads. At least one of the sets of strips 26 or 28 must be transmissive to light generated in the cell 19. This may be accomplished by providing a conductive strip 26 or 28 of a material such as stannic oxide which would be transmissive to the radiation from the display elements 19. It is also possible to make the back electrode reflective to increase the light output. One difficulty with such an arrangement is that such a layer thin enough to provide optical transmission may have a high resistance and with long strips the total current in each of the conducting strips 26 and 28 may be so high that regular current flow will cause heating and may destroy the conductive strips.

One possible solution to this problem is to provide a relatively thick nontransmissive-type coating such as copper in which windows are provided over the display elements 19. The windows may be provided with a coating of a suitable light transmissive material and will still not destroy the current carrying properties of the main strip. Another possible modification is to provide a continuous thick conductive strip located between a row or column of display elements 19 and provide electrically conductive thin tabs of light transmissive material from each display element 19 and associated conducting strip. Such an arrangement is shown in FIG. 3 in which a conducting strip 26 is illustrated with light transmissive tabs 27 provided in electrical connection with the strip 26 and over a display element 19.

The Y conductive strips 28 are brought out to the edge of the panel 10 and are connected to a suitable switching network 30. The X conductive strips 26 are brought out of the panel display 10 and connected to a suitable switching network 32.

An insulating sheet 27 of a suitable material such as SiO_2, having a thickness of about 10^{13} inch is provided between the electrode panel 22 and the assembly of modular elements 14. A similar sheet 29 is provided between the electrode panel 24 and the assembly of elements 14. The rectangular modular elements 14 may have a side dimension of about 10 inches and a thickness of 20×10^{13} inch with a tolerance of ±0.0005. The display elements 19 or openings 20 in the modular elements 14 may be placed side-by-side without loss of resolution between the modular elements 14. The modular elements 14 are positioned side-by-side as illustrated in FIG. 1 and the electrode panels 22 and 24 are then brought in to hold this plurality of modular members 14 together with the insulating spacers 27 and 29 provided between the electrode strips 26 and 28 and modular elements 14. The electrode panels 22 and 24 may then be bonded about their edges to provide a good vacuumtight seal such as by the use of glass frit to both mechanically secure the assembly as well as provide a good vacuum seal. A tubulation 31 may be provided for exhausting the plurality of openings 20 within the modular elements 14 and then a suitable gas introduced at a suitable pressure and the tubulation 31 tipped off. A suitable gas mixture is that of nitrogen and neon at a pressure of about 200 torr. It may be necessary to provide communication passages between the cell openings 20 to permit the evacuation and refilling with the suitable gas mixture. It may also be possible in some cases to dispense with the aperture members 14. It is also possible to fabricate the entire display within a suitable atmosphere so as to avoid the necessity of exhausting and filling with gas. The entire panel display would be sealed within the suitable gas mixture atmosphere.

In FIG. 4 there is illustrated a modification of the structure shown in FIG. 1 in which a suitable dielectric coating 43 is provided over the electrode face of the electrode panel 22 so as to dispense with necessity of the insulating spacer members 27 and 29. By this type of structure the uniformity and operational voltage margins can be increased. A few thousand angstroms of a suitable dielectric such as SiO_2 which is also transparent to radiation is deposited over the electrodes 26 and would insulate the electrodes 26 from the cells 19. Since the distance between the electrodes 26 and the cells 19 is now considerably less than the previous structure, the series impedance is much less. Thus the total current that can flow during the formative stage of the discharge is greater, which in turn allows for a more complete charging of the walls of cells 19 and consequently larger voltage margin. Furthermore, because the thickness of the dielectric coating 43 can be controlled easily with a high uniformity, the layer 43 is much more uniform than a thin substrate of insulating material such as glass. The thickness may be about one mil. Thus the cells are much more uniform in their characteristics. Furthermore, the dependence on the physical geometry is greatly reduced and is insensitive to variation in cell size.

In operation, a signal-sustaining voltage source 50 is connected capacitively to the conducting strips 26 and 28 and supplies the sustaining voltage for the whole display screen. The voltage source 50 may have a frequency of several hundred kilohertz and a voltage of several hundred volts. The discharge elements 19 which are initially on are maintained in the on state by the sustaining voltage from source 50 while elements 19 which are initially off remain off. The elements 19 are turned on or turned off by a firing input from a source 33 which provides appropriate voltages greater than the sustaining voltage to the selected X and Y electrodes through the switching networks 30 and 32. A more complete description of a plasma display may be found in an article by R. Wilson on page 113 of the publication "Recent Advances and Display Media" and identified as NASA SP-159 and available from the U.S. Government Printing Office, Washington, D.C.

Since numerous changes may be made without departing from the spirit and scope thereof, it is intended that all matter contained in the foregoing description and as shown in the accompanying drawings is illustrative and not limiting.

I claim as my invention:

1. A display panel comprising a plurality of individually controllable display elements, said panel comprised of two outer electrode panels provided with electrically conductive means on the inner surfaces of said panels to provide means for exciting selected display elements, said display-emitting light due to a gas discharge, said electrically conductive means on at least one of said panels comprised of a first portion of a low-resistance-type coating intermediate said elements and a second portion of a higher resistance than said first portion and located over said display elements and transmissive to radiation from said display elements.

2. A display panel comprising a plurality of display element, each of said display elements comprised of a cell filled with gas, said panel including two outer electrode panels, said electrode panels of insulating material provided with electrically conductive means thereon in operating relationship with said gas cells, a plurality of perforated modular elements of insulating material positioned between said outer electrode panels and arranged side-by-side, the walls of the openings in said perforated modular elements forming a portion of the walls of said cell, insulating means positioned between the electrodes on said electrode panels and said perforated modular elements with said gas cells defined by the walls of the opening in said perforated modular elements and said insulating means closing off said openings, the outer periphery of said electrode panels sealed to confine the gas within the region defined by said gas cells, said perforated modular elements are arranged side-by-side to provide a plurality of rows and columns of modular elements, each of said modular elements including a plurality of rows and columns of gas cells and aligned with rows and columns of gas cells in adjacent modular elements without discontinuity between elements, said first and second electrode panels of an area substantially equal to the combined areas of said modular elements, said electrically conductive means on said first electrode panel comprising a plurality of first electrically conductive strips, said first conductive strips provided on the inner surface of said electrode panel and substantially parallel to each other and extending across said first electrode panel, one of said first conductive strips in operating relation with a row of said gas cells from each common row of modular elements, said electrically conductive means on said second cover plate comprising a plurality of second conducting strips, said second conductive strips on the inner surface of said second electrode panel, and substantially parallel to each other and extending across said second electrode panel, one of said second conductive strips in operating relation with a column of said gas cells from each common column of modular elements to provide means of selectively exciting one of said gas cells in response to simultaneous excitation applied to said one of said conductive strips and said one of said second conductive strips, said electrically conductive strips are comprised of a first portion of relatively low resistance and a second portion of a higher resistance in which said second portion is substantially transmissive to radiation as emitted from said gas cells in response to excitation of said gas cells.

3. A display panel comprising a plurality of display elements, each of said display elements comprised of a cell filled with gas, said panel including two outer electrode panels, said electrode panels of insulating material provided with electrically conductive means thereon in operating relationship with said gas cells, a plurality of perforated modular elements of insulating material positioned between said outer electrode panels and arranged side-by-side, the walls of the openings in said perforated modular elements forming a portion of the walls of said cell, insulating means positioned between the electrodes on said electrode panels and said perforated modular elements with said gas cells defined by the walls of the opening in said perforated modular elements and said insulating means closing off said openings, the outer periphery of said electrode panels sealed to confine the gas within the region defined by said gas cells, said perforated modular elements are arranged side-by-side to provide a plurality or rows and columns of modular elements, each of said modular elements including a plurality of rows and columns of gas cells and aligned with rows and columns of gas cells in adjacent modular elements without discontinuity between elements, said first and second electrode panels of an area substantially equal to the combined areas of said modular elements, said electrically conductive means on said first electrode panel comprising a plurality of first electrically conductive strips, said first conductive strips provided on the inner surface of said electrode panel and substantially parallel to each other and extending across said first electrode panel, one of said first conductive strips in operating relation with a row of said gas cells from each common row of modular elements, said electrically conductive means on said second cover plate comprising a plurality of second conducting strips, said second conductive strips on the inner surface of said second electrode panel, and substantially parallel to each other and extending across said second electrode panel, one of said second conductive strips in operating relation with a column of gas cells

from each common column of modular elements to provide means of selectively exciting one of said gas cells in response to simultaneous excitation applied to said one of said conductive strips and said one of said second conductive strips, said electrically conductive strips are comprised of a first portion of relatively low-resistance-type coating and substantially nontransmissive to radiations from said gas cells and a second portion aligned with said gas cells of higher resistance than said first portion and being substantially transmissive to radiations from said gas cells.

4. A display panel comprising a plurality of display elements, each of said display elements comprised of a cell filled with gas, said panel including two outer electrode panels, said electrode panels of insulating material provided with electrically conductive means thereon in operating relationship with said gas cells, a plurality of perforated modular elements of insulating material positioned between said outer electrode panels and arranged side-by-side, the walls of the openings in said perforated modular elements forming a portion of the walls of said cell, insulating means positioned between the electrodes on said electrode panels and said perforated modular elements with said gas cells defined by the walls of the opening in said perforated modular elements and said insulating means closing off said openings, the outer periphery of said electrode panels sealed to confine the gas within the region defined by said gas cells, said perforated modular elements are arranged side-by-side to provide a plurality of rows and columns of modular elements, each of said modular elements including a plurality of rows and columns of gas cells and aligned with rows and columns of gas cells in adjacent modular elements without discontinuity between elements, said first and second electrode panels of an area substantially equal to the combined areas of said modular elements, said electrically conductive means on said first electrode panel comprising a plurality of first electrically conductive strips, said first conductive strips provided on the inner surface of said electrode panel and substantially parallel to each other and extending across said first electrode panel, one of said first conductive strips in operating relation with a row of said gas cells from each common row of modular elements, said electrically conductive means on said second cover plate comprising a plurality of second conducting strips, said second conductive strips on the inner surface of said second electrode panel, and substantially parallel to each other and extending across said second electrode panel, one of said second conductive strips in operating relation with a column of said gas cells from each common column of modular elements to provide means of selectively exciting one of said gas cells in response to simultaneous excitation applied to said one of said conductive strips and said one of said second conductive strips, said electrically conductive strips are comprised of a plurality of first portions of low resistance and substantially nontransmissive to radiation from said gas cells and second portions including a coating of a higher resistance material than said first coating and being substantially transmissive to radiations from said gas cell, said second portions extending over said gas cells and said first portion spaced from said gas cells.