A plasma display panel of the gas discharge type comprising a plurality of discrete electrically excitable gas-containing cells. Associated with each cell is a conductor array comprising a plurality of segments and a corresponding common conductor all positioned on the same surface. A transparent dielectric film is deposited over each segment conductor array and each corresponding common conductor, so that all the conductors are capacitively coupled, but physically isolated from the excitable gas.

A particular character is displayed on the plasma display device by alternately energizing a selected one of the segment conductors comprising the segment conductor array and the corresponding common conductor. The excitable gas immediately adjacent the energized segment conductors and the corresponding common conductor is ionized, with a resulting illumination which is visible to the human eye. The resulting illumination is confined to the area circumscribed by the energized segment conductors and the corresponding common conductor. In order to conceal the illumination generated by the common conductor, a mask is provided which contains a plurality of openings generally conforming in shape to the segmented conductor array and so positioned that the openings are aligned with a corresponding segment conductor. The illumination provided by the occurrence of the ionization is sufficient for the visual display of numeric, symbolic, and alphabetic information. The plasma display panel is hermetically sealed in order to prevent the escape of any of the excitable gas into the atmosphere.

4 Claims, 2 Drawing Figures
PLASMA DISPLAY PANEL HAVING DISPLAY AND COUNTER CONDUCTORS ON ONE PLATE

BACKGROUND OF THE INVENTION

This invention relates to a plasma display panel. Plasma display devices (or electroluminescent display devices, as they are sometimes referred to) which produce a glow upon the application of an electric field across a cell containing an excitable gas are well known. Devices of this type are exemplified in U.S. Pat. No. 3,127,535, issued Mar. 31, 1964, to Harold T. Wettereitheim; U.S. Pat. No. 3,327,154, issued June 20, 1967, on the application of Edwin R. Boweman; U.S. Pat. No. 3,499,167, issued Mar. 3, 1970, on the application of Theodore C. Baker et al.; and British Pat. Nos. 1,161,832 and 1,161,833, both of which are owned by the University of Illinois Foundation.

A problem generally common to most plasma and electroluminous devices is the inability to provide a structure which has small physical dimensions and which is also capable of simple and inexpensive fabrication. The prior art devices are characteristic in that they utilize conductors which are physically opposed to each other; that is, on different plane surfaces and separated from each other by the intervening excitable gas. One type of structure requires the deposition of conductors on a plurality of plates, which increases the cost of fabrication. Applicant's structure is novel in that it is a simple structure in which all the conductors are deposited on only one surface of the plasma panel. Applicant's structure also provides a display device particularly suited for AC operation with voltages of relatively low magnitude.

SUMMARY OF THE INVENTION

This invention relates to a hermetically sealed plasma display panel comprising first, second, and third plates, the second plate defining a plurality of cells when positioned between the first and third plates, wherein said defined cells are utilized for the containment of an excitable gas. On one side of each of the formed cells are positioned a segmented conductor array and a common conductor, the aforementioned conductors all being physically separated from the cell interior by a layer of a dielectric material such as glass. Each formed cell is capable of displaying information in the form of illuminated characters. The illumination necessary for the viewing of information on a particular cell is provided by applying an alternating electrical potential across the common conductor and a selected segment conductor or selected segment conductors of the segmented array of conductors corresponding to the cell selected for illumination. The alternating potential gives rise to the ionization of gas immediately adjacent to the energized conductors. The illumination provided by the excited gas is restricted to the areas immediately adjacent the energized conductors because of the pressure and the composition of the gas.

A nonconductive mask, having a plurality of openings therein, each opening generally having the same configuration and corresponding to one of the segment conductors, is positioned in the panel in such a manner that the openings in the mask are in alignment with the segment conductors of the segmented conductor array. The insulating masks eliminates any stray illumination which may occur due to changes in the pressure and also eliminates any illumination caused by the conductors which connect like segments of each cell to a power source. The insulating mask also prevents a viewer from observing the illumination adjacent the energized common conductor. The entire assembly is sealed by conventional glass sealing methods in order to prevent the escape of any excitable gas. In a second embodiment of the invention, the common conductor is illustrated in a position different from that of the first embodiment.

BRIEF DESCRIPTION OF THE DRAWING

Fig. 1 is an exploded isometric view of the plasma display panel in accordance with the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to Fig. 1, the plasma display panel is shown generally at 10. The panel includes plates 12 and 18, each having first and second sides, respectively. The plates 12 and 18 are preferably fabricated from a glass material. At least one of the plates is transparent or translucent, preferably the plate 12. The first side of the plate 18 has deposited thereon, by conventional techniques such as vacuum deposition, silk screening, electrolytic deposition, etc., a plurality of segmented conductor arrays 20a-n, each array comprising a plurality of segment conductors 21a-g. Each of the segmented conductor arrays 20a-n illustrated in Fig. 1 is shown as a seven-segment array, which may be utilized to form numerals. However, an array containing any number of segment conductors may be utilized in this invention without departing from the teachings thereof. Also conventionally deposited on the first side of the plate 18 are a plurality of common conductors 22a-n, which function as the common for each segment conductor of the arrays 20a-n, respectively. For purposes of simplicity in the description of the invention, only one display cell will be discussed. Therefore, unless otherwise noted, the segment conductors will be referred to by the reference numeral 21, an array by the reference numeral 20, and a common conductor by the reference numeral 22.

The surface area of any of the segment conductors in the segmented conductor array 20 and should also be greater than the combined surface area of at least half of the combined segment conductors 21 in order to lessen the current density experienced by the common conductor 22 when a plurality of the segment conductors 21 are energized in order to display a number; for example, the number 8. A segmented conductor array 20 and a corresponding common conductor 22 are deposited on the first side of the plate 18 for each cell formed in the plasma display panel 10. It is noted that all corresponding segment conductors of a pair of segment conductors 21 of each segmented conductor array 20 are connected together by conductors 30 and brought out to a terminal 26 for connection to a power source (not shown). However, if desired, each segment conductor 21 may be brought out individually and connected to a power source. The mode of connecting the corresponding segment conductors is determined by the type of operation which the common panel will undergo. A thin transparent, translucent, or opaque dielectric layer 24, preferably glass, is deposited over all the segment and common conductors located on the first side of the plate 18.

A spacing member 16, containing a plurality of openings defined by a plurality of frame members 28, is placed intermediate the plates 12 and 18. Each opening on the spacing member 16 defines one cell, which includes a segmented conductor array 20 and one common conductor 22. Each segmented conductor array 20 and the corresponding common conductor 22 are separated from any other adjacent segmented conductor array and its corresponding common conductor by the frame members 28, which are integral to the spacing member 16. The surface of the spacing member 16 is of such a roughness that gas can pass from one cell to another, thus providing cell pressure equalization. Although the spacing member 16 is shown as a rigid body containing a plurality of openings, the spacing member 16 may be eliminated, if desired, by placing a wall formation of glass-like material on the first side of the plate 18 between each combination of segmented conductor arrays and the corresponding common conductor in order to separate each segmented conductor 20 array and corresponding common conductor from adjacent combinations of arrays and common conductors, thereby defining a plurality of cells.

A mask 14, containing a plurality of openings thereon, is provided, each opening corresponding to one segment conductor 21 of each of the conductor arrays 20 positioned on the
plate 18 for the purpose of further defining the illumination which emanates from the energized segment conductors 21 and also for concealing the illumination generated by the common conductor 22. The mask 14 also conceals any illumination provided by the connecting segment conductors 30. It is noted that the display panel 10 does not require the mask 14 for its successful operation, since the illumination generated is restricted to the surfaces of the energized segment conductors and the common conductors 22. The mask 14 is shown as being stippled in order to illustrate that the mask 14 is dark in color.

The transparent plate 12 completes the assembly comprising the transparent plate 12, the mask member 14, the spacing member 16, and the rear plate 18. A chasotropic slip is made with glass frit and applied to the periphery of the assembly 10 in such a manner as to provide a gastight seal when properly cured. A glass tube (not shown) may be secured to the rear of the plate 18 in a similar manner, to be utilized for evacuating the plasma cells of air and for introducing the excitable gas, such as a mixture of neon, argon, and nitrogen, into those cells. As previously described, the terminals 26 and the common conductors 22 are connected to an alternating potential source (not shown) for the purpose of providing the alternating electric field.

Prior to a discussion of the operation of the plasma display panel 10, it would be in order to discuss some of the fundamental rules which apply to this type of display cell. Ionization in this type of cell is initiated by an alternating electric field which causes an electron multiplication process to occur in the area immediately adjacent the conductors which are experiencing the alternating electrical field. This multiplication process occurs until ignition (that is, ionization), at which time a gaseous discharge occurs, which provides the illumination necessary for the character display. The ionization of the gas also results in the deposition of electrical charges on the energized segment conductors and corresponding common conductor. The charges will have a polarity opposed to that which was impressed on the common and segment conductors and may be utilized in the control of the plasma display panel. The above process is reversible due to the alternating electric field, which is made necessary because the conductors are separated from the excitable gas by the thin dielectric layer 24.

An alternating field applied across a particular segment conductor 21a and common conductor 22a will give rise to the occurrence of illumination on the surface immediately adjacent the segment conductor 21a and the common electrode 22a. This glow will be sustained on both surfaces for as long as the alternating potential is applied to those conductors. The illumination provided by the common conductor does not cause any problems, because the illumination is masked out by the mask member 14 and thus is not visible to an observer.

In order to aid those skilled in the art in the practice of the present invention, the following information for construction of one form of a display panel in accordance with the teachings of this invention is given by way of exemplification only. In the embodiment shown in FIG. 1, the mask member 14 was formed from dark-colored glass (thin plate etched or thick film screened) having a thickness of approximately 0.002 inch. The spacing member 16 and the plate 12 were formed from plate glass having a thickness of one-eighth inch. The segment conductors 21a-g and the common conductors 22a-n were formed from a material such as silk screen silver and were deposited to a thickness of 0.0005 inch. The surface area of the segment conductors 21a-g is, of course, dependent upon the amount of illumination desired. A gas mixture of 99.7% neon, 0.1% argon, and 0.2% nitrogen to a pressure of 35 millimeters of mercury at room temperature was utilized in the successful operation of the display panel. However, it was found that the display panel could be satisfactorily operated with pressures ranging from 16 to 70 millimeters of mercury. The alternating voltage used for exciting the gas mixture had a magnitude of 320 volts at a frequency of 20 kHz, with a pulse width of 6 microseconds. However, the panel was successfully operated at 210 volts. For optimum performance, the common conductor 22 is so positioned on the first side of the plate 18 that the distance from the segment conductor 21a, which is farthest away from the common conductor 22a, is not greater than twice the distance of the nearest segment conductor 21d from the common conductor 22. The brightness generated by the above-described display panel ranged from 40 to 76 foot lamberts.

A modification of the device shown in FIG. 1 and described above is shown in FIG. 2. In this embodiment, the common conductor is positioned at one side of the segmented conductor array rather than on the bottom. The mode of operation of the structure illustrated in FIG. 2 is similar to that shown in FIG. 1.

What is claimed is:

1. A plasma display device of the type wherein a plurality of gas-containing cells are utilized for the display of intelligence, comprising:
   a. a support member;
   b. a plurality of segmented conductor arrays and corresponding common conductors deposited on one surface of said support member;
   c. a dielectric layer deposited over said segment conductor arrays and said corresponding conductors;
   d. a-cell defining member positioned on said support member, each formed cell corresponding to the combination of one segmented conductor array and a common conductor;
   e. a translucent plate positioned on said cell-defining member, whereby forming an assembly which is hermetically sealed; and
   f. means for applying an alternating field to selected segment conductors of selected segmented conductor arrays and a corresponding common conductor therefor for the ionization of a gas immediately adjacent to said selected segment conductors.

2. A device according to claim 1 wherein said plasma display device further includes a mask member having a plurality of openings therethrough, said openings forming a plurality of arrays, whereby said arrays each correspond to one segmented conductor array for further defining illumination provided by the ionization of gas immediately adjacent selected segments of said segment conductor arrays.

3. A plasma display device comprising:
   a. a support member;
   b. a plurality of segmented conductor arrays positioned on said support member;
   c. a plurality of common conductors positioned on said support member, each common conductor corresponding to one segmented conductor array;
   d. a dielectric layer deposited on said support member, thereby coating all of said common conductors and segmented conductor arrays;
   e. a-cell forming member positioned on said support member, said cell forming member forming a plurality of cells and being so constructed that pressure-equalizing paths are formed between said formed cells;
   f. a mask member positioned on said cell-forming member, said mask member having a plurality of openings therethrough, each opening corresponding to one segmented conductor of said segmented conductor arrays;
   g. a-transparent member positioned on said mask member, said transparent member, said mask member, said cell-forming member, and said support member being hermetically sealed;
   h. means for introducing a gaseous medium into said formed cells; and
   i. means for alternately energizing selected segmented conductors of said segment conductor arrays and a corresponding common conductor therefor for the ionization of gas immediately adjacent said selected segmented conductors, thus displaying intelligence in the form of illumination.
4. A plasma display panel of the type wherein a plurality of gas-containing cells are utilized for the display of intelligence, comprising:

a plate;
an additional plate having positioned thereon a segmented conductor array and a corresponding common conductor for each cell, said segmented conductor arrays and said common conductors being coated by a thin dielectric layer;
a member for defining said cells, comprising a wall formation of glass-like material, positioned between the combination of a segmented conductor array and a corresponding common conductor thereof and an adjacent combination of a segmented conductor array and a corresponding common conductor thereof;
means for sealing said plate, said cell-defining member, and said additional plate together, thereby forming a gastight structure;
means for introducing a gaseous medium into said defined cells; and
means for energizing selected segments of selected segmented conductor arrays and corresponding common conductors for presenting intelligence in the form of illumination conforming to a particular configuration.

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