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Maloney

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[54] **DISPLAY PANEL HAVING METAL CELL SHEET**

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[52] **U.S. Cl.** ..... **313/188**, 313/210, 313/217, 313/220, 315/169 TV

[51] **Int. Cl.** **H01j 61/04**

[58] **Field of Search** ..... 313/109.5, 210, 220, 313/188, 217; 315/169 TV, 84.6

[56] **References Cited**

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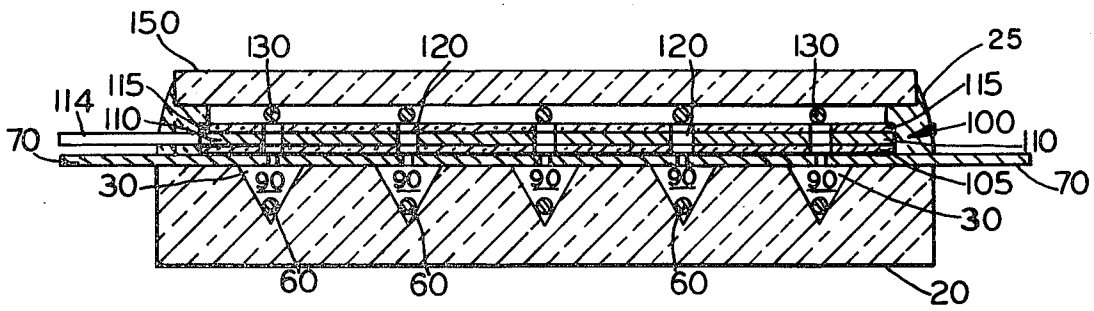
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[57] **ABSTRACT**

A display device including a plurality of communicating gas-filled display cells arrayed in a panel structure. A first layer includes a first plate having grooves in it, with first electrodes seated in the grooves, and second electrodes supported across them. A second layer includes a metal plate or sheet electrode having apertures in it and being insulated from the second electrodes and from third electrodes which are disposed above it. The first and second electrodes cross beneath the apertures and the third electrodes lie above the apertures, which serve as the display cells of the device.

13 Claims, 5 Drawing Figures



2 Sheets-Sheet 1

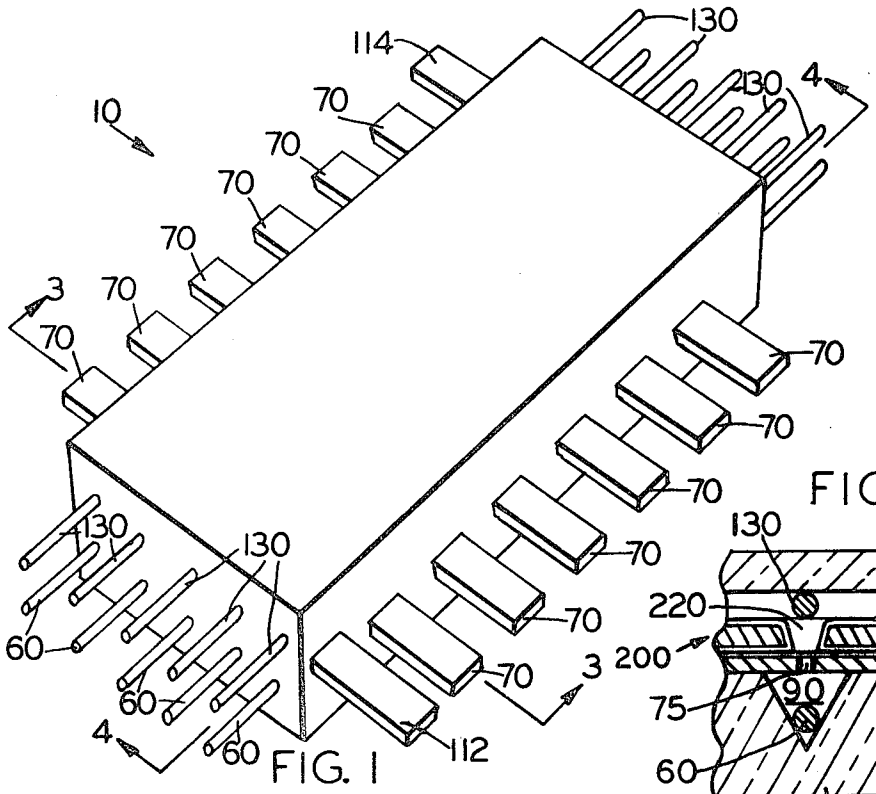


FIG. 1

FIG. 5

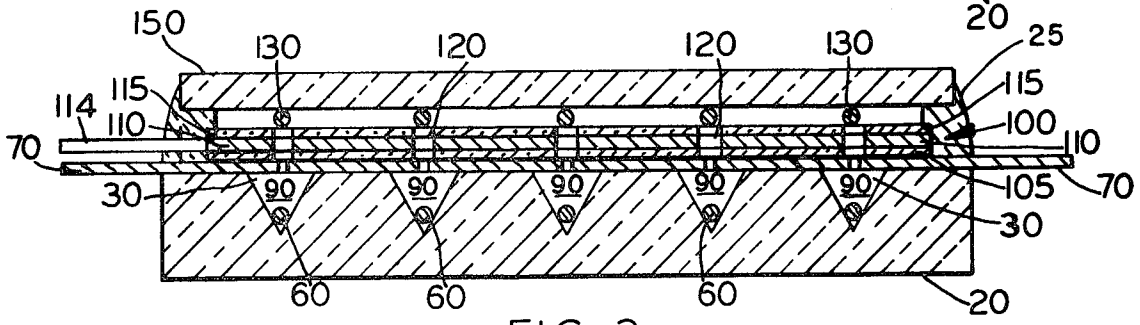


FIG. 3

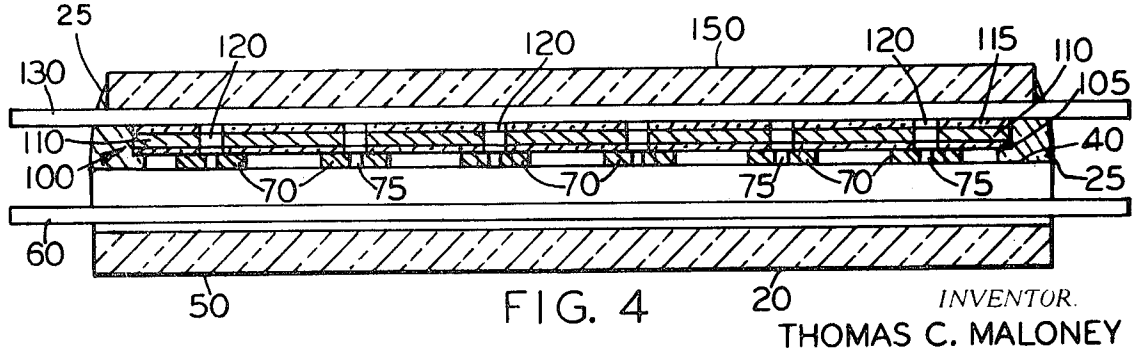


FIG. 4

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2 Sheets-Sheet 2

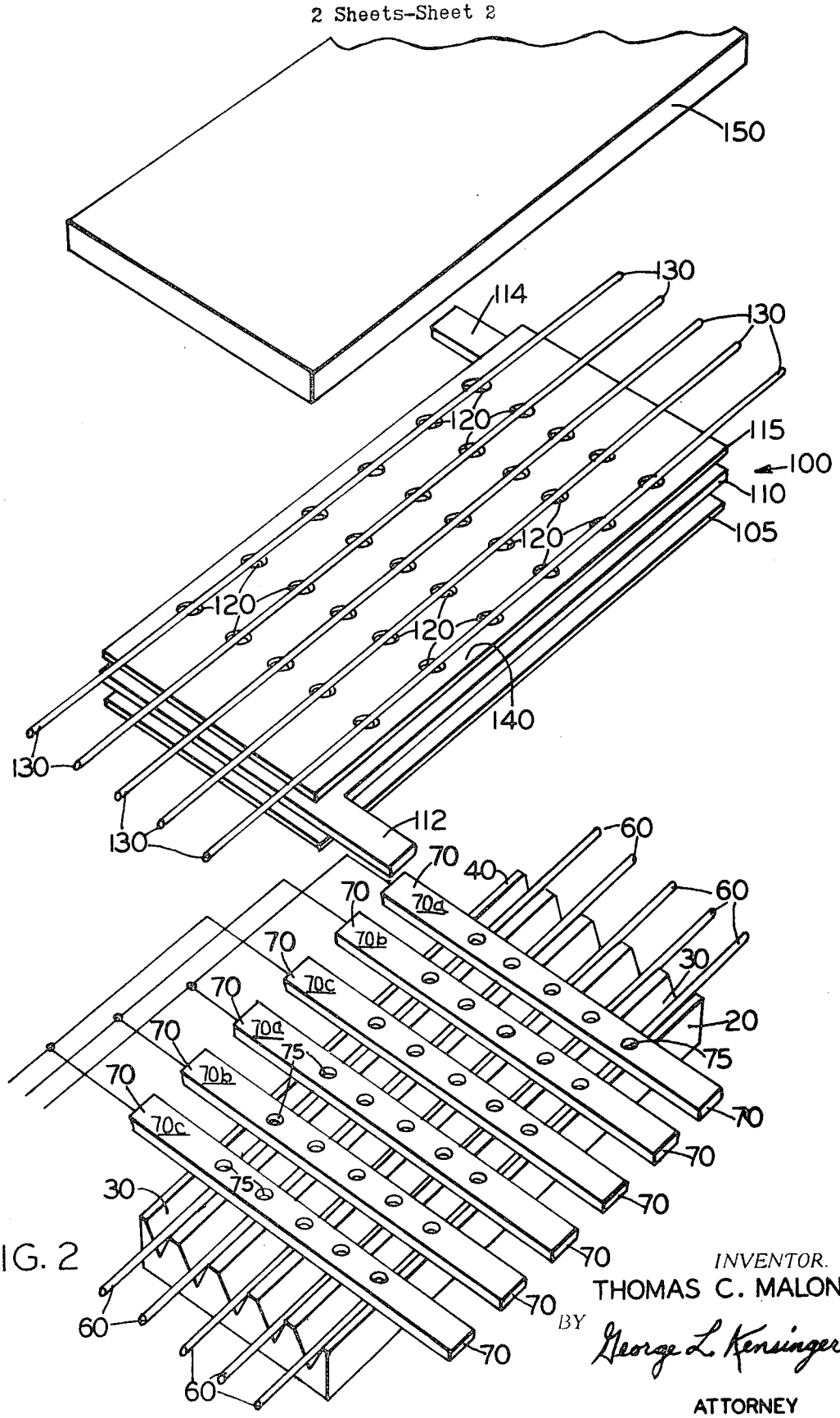


FIG. 2

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DISPLAY PANEL HAVING METAL CELL SHEET

BACKGROUND OF THE INVENTION

Display panels comprising a plurality of gas-filled cells which can be ionized selectively to display a message are known in the art. A display panel has been developed recently which has two layers of communicating cells, a first layer being used as a scanning or addressing layer for sequentially addressing the display cells, one by one or column by column, and a second layer into which information is inserted to be displayed, and perhaps stored, as the first level is scanned. These multi-layer devices have been constructed of several layers of glass or other insulating material with groups of thin wires or strip electrodes suitably positioned between them, in alignment with a matrix of closely spaced apertures in a glass or ceramic center sheet which serve as the gas cells.

The apertured center sheet defines the display cells and spaces the display control electrodes from the cathodes, a group of electrodes common to both the scanning cells and the display cells and usually separating the two groups of cells. The center sheet usually must be relatively thick in order to provide an adequate potential threshhold for ionization or breakdown and suitable glow in the display cells. The center sheet also must be thick enough for fabrication and assembly when the cells are spaced close to each other. The center sheet usually comprises glass or ceramic formed or drilled to provide the necessary apertures, which is expensive.

The apertures in the center sheet are usually of small diameter and the sheet is generally opaque or is coated with opaque material so that light will be visible only at the activated display cells. This restricts or limits the viewing angle in such devices because the edges of the small apertures in the center sheet increasingly obscure the glow in the display cells as the viewing angle is increased.

It has not been possible to reduce the thickness of the glass or ceramic center sheets enough to improve adequately the viewing angle of the display. With given operating potentials applied to the electrodes of the device, the center sheet has had to be of corresponding thickness in order to provide the desired operational characteristics. Also, the diameter of the holes in the center sheet could not be enlarged too greatly in devices having closely spaced display cells.

These problems are compounded in multiple register display panels such as those described in B. Caras Pat. application Ser. No. 21,125, filed Mar. 19, 1970, now U.S. Pat. No. 3,654,508. The subject invention is also applicable to improving the angle of view of the display devices disclosed in Ogle et al Patent application Ser. No. 850,984 and in J. A. Ogle application Ser. No. 855,448, both filed Aug. 18, 1969.

SUMMARY OF THE INVENTION

Accordingly, it is an object of this invention to provide a display panel of thin construction and of increased viewing angle.

Another object of the invention is to reduce the cost of apertured center sheets for multi-layer display devices and to increase the effective threshhold potential for ionization of the cells.

A further object of the subject invention is to provide a multi-layer cellular display panel in which the apertures forming the cells can be shaped for better viewability and spaced closer together.

Briefly, a gas-filled display panel embodying the subject invention includes a plurality of insulating plates and electrode arrays interleaved to provide rows and columns of display cells and electrodes for operating them. The top and base plate of the panel structure is of glass or ceramic, as desired, and a center sheet separating the layers of cells is formed of metal or other conductive material insulated from the electrodes on either side of it.

In operation of the display device, the conductive center sheet usually assumes a potential intermediate the operating potentials applied to the display cell electrodes. According to a feature of the invention, terminal leads may be provided from the center sheet for applying a potential thereto or for monitoring the potential on it, if desired.

Other objects, advantages and features of the invention will become clear from the following description of the preferred embodiments, wherein:

FIG. **1** is a perspective view of an information display device suitable for practicing the invention;

FIG. **2** is an exploded view illustrating the internal construction of an exemplary display panel incorporating the invention;

FIG. **3** is a sectional view showing an elevation of the display device of FIG. **1** taken at **3—3**;

FIG. **4** is a sectional view showing an elevation of the display device of FIG. **1** taken at **4—4**; and

FIG. **5** is an enlarged sectional view of a display position showing another embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. **1** to **4**, a display panel **10** embodying the invention includes a first insulating plate **20** of glass, ceramic, or the like having a plurality of parallel slots, grooves or channels **30** formed therein and extending from the top surface **40** toward the bottom surface **50** thereof. For purposes of illustrating and describing the invention, the panel is oriented so that the slots extend horizontally. Relatively few slots have been shown, to simplify the drawing, but it should be understood that, in most applications, plate **20** would be considerably wider and would have many more slots in it. The slots may have any suitable cross-section.

First electrodes **60** are seated at the bases of the slots and, since the slots are parallel, so are the electrodes. Electrodes **60** may be wires or strips of any suitable shape, secured by a cement such as a glass frit or the like at the ends of slots **30** or at any other suitable location. These electrodes may alternatively be plated or evaporated or otherwise formed in the slots.

The panel also includes second electrodes **70** seated on the top surface **40** of first plate **20.** The second electrodes **70** are also parallel to each other, and they are oriented generally perpendicular to the first electrodes **60,** although they can be skewed. The electrodes **70** may also be flat strips or wires or the like, and they may be seated in slots (not shown) formed in the top surface **40** of plate **20,** if desired. The region at which each second electrode **70** crosses a first electrode **60** defines a gas cell **90.** Each electrode **70** has an aperture **75** at this region if it is a flat strip, or it is suitably shaped or offset, so that communication can take place from electrode **60** through or around electrode **70** to other ele-

ments disposed above electrodes **70** (to be described).

A second insulating plate **100** having a plurality of apertures or cells **120** arrayed in rows and columns is seated on the top surface of the electrodes **70** with each aperture or cell aligned with an aperture **75** and with a cell **90** defined by a crossing of a second electrode **70** and a first electrode **60**. Each aperture **120** thus comprises a cell which is vertically aligned with a cell **90** formed by the first and second electrodes and the portions of the slot **30** between them.

The insulating plate **100** is composed of a metal sheet **110** having an insulating layer **105** on its bottom side and an insulating layer **115** on its top surface. The holes or apertures **120** for the display cells extend through the three layers of plate **100** in registration with apertures **75** in second electrodes **70**. These apertures **120** are cylindrical in shape and expose metal sheet **110** to the display cells in one preferred embodiment, as shown in FIGS. **3** and **4**. Metal center sheet **110** is provided with terminals or leads **112** and **114**, either or both of which may be used for applying a bias potential in the region of the display cells or for electrically monitoring the operation of the cells. The metal center sheet thus serves as an auxiliary electrode of the device in establishing contact with the electric fields and electric discharges in the cells. Such a bias potential can raise or lower the ionization potential threshhold depending upon its polarity.

Insulating plate **100** is less brittle than all glass or all ceramic center plates due to the support of metal center sheet **110**. It may, therefore, be made thinner than corresponding glass or ceramic plates having the same number of apertures of the same diameter and still having adequate structural strength. In practice, insulating layers **105** and **115** are considerably thinner than metal center sheet **110** and serve as insulating coatings on the surfaces of the metal sheet. Furthermore, the use of a thinner center plate **100** may be allowed for electrically, by the application of a suitable bias potential to metal center sheet electrode **110**. The application of such a bias potential to center sheet electrode terminal **112** or **114**, or both, can raise the effective ionization potential threshhold in the display cells. This permits a thin center plate **100** to insulate and isolate the display cells from the scan control electrodes as effectively as a thicker glass or ceramic center plate.

The holes or apertures in insulating center plate **200** may alternatively be conical in shape and may expose the metal center sheet, or may leave it insulated, as shown in FIG. **5**. Metal center sheet **210** has apertures **220** in the shape of truncated conical holes formed in it and the edges of the apertures, together with the top and bottom surfaces, are coated with an insulating layer **225**. Conical holes may be produced in the center sheet by controlled chemical etching of the sheet, for example, and insulating layer **225** may be applied to it after the holes are formed.

Insulation layers **105** and **115** are preferably insulating coatings applied to center sheet **110** after apertures **120** have been formed in it, although insulating sheets having appropriately positioned apertures in them may also be employed. Insulating coatings **105** and **115** may be of ceramic or glass, such as fosterite, applied by spraying. Any other suitable glass, ceramic or the like may be applied to the surfaces of the metal center sheet as insulating layers **105** and **115** or **225**. The insulating coating may be applied by dipping center sheet **110** or **210**, by applying insulating material through a silk screen or by electrophoretic coating, for example. Insulating layers in the form of transfer coatings also may be applied to the surfaces of metal center sheets **110** or **210**.

In each case, the insulating coating is applied to the metal center sheet after the apertures in it have been formed, although this is not necessary since the holes could be formed by drilling or punching through the three layers of the plate. Transfer coatings of glass or like material may be applied to a metal sheet in which the apertures have been already formed. The assembly then is baked in an oven at a temperature sufficient to cause the surface tension of the heated transfer layer to open up apertures in the transfer coating layers over the apertures in the metal sheet.

The groupings of cells **90** in lower plate **20** along the slots **30** are referred to herein as rows of cells or apertures, and those in line with electrodes **70** as columns.

Third electrodes **130** are seated on the upper insulating layer **115** of the apertured plate **100**. The electrodes **130** are oriented parallel to and aligned with the first electrodes **60**, and each is aligned with a row of apertures **120** in insulating plate **100**. The electrodes **130** may also be flat strips or wires or the like, and they are either apertured or otherwise suitably shaped, so that a viewer looking through top plate **150** will see the glow discharges which occur in cells **120**.

In panel **10**, the electrodes **60, 70** and **130** may be secured in place by means of a suitable cement such as a glass frit (not shown). In the completed device, plates **20, 100,** and **150** are sealed together at their edges by means of a glass frit or the like **25** shown in FIGS. **3** and **4**. For convenience in making this seal, top plate **150** and bottom plate **20** are usually made somewhat larger than center plate **100**, also as shown in FIGS. **3** and **4**.

Panel **10** also includes an ionizable gas such as argon, neon, or the like, and preferably a Penning mixture of such gases, including a small quantity of mercury, all at a pressure suitable for the desired discharge. The gas may be introduced by means of a tubulation (not shown) suitably secured to the panel, or it may be introduced in any other suitable manner.

The operation of multi-cell display panels such as panel **10**, in which slots **30** operate as gas communication paths between adjacent cells, is described in detail in a co-pending application of Ogle and Holz, Ser. No. 850,984, filed Aug. 18, 1969, and reference is made to that application for a complete discussion of the operation. Briefly, in the operation of the device, electrodes **60** and **130** preferably serve as anodes and electrodes **70** as cathodes. Also, successive cathodes **70** are electrically connected together so as to form three or more alternating electrode sets **70***a*, **70***b*, and **70***c*, and each of the electrode sets is connected to a driving source (not shown). The lower cells **90** are scanned column-by-column by sequential energization of the alternating cathode sets **70**, and glow is produced in each column of cells **90** in turn. This sequential energization is repeated until the entire panel **10** has been scanned, and then continued so that the panel is scanned repetitively.

Since plate **20** is slotted, gas communication is provided between the adjacent columns of cells. As a consequence, when one column is glowing, it serves to prime the two adjacent columns. It is the presence of this selective priming which permits the cells in plate

20 to be scanned column-by-column using only three or more driving sources, as desired.

Simultaneously with the scanning, and synchronously with the scanning rate, information signals are applied to the anode electrodes **130**. Where ON signals are present on selected anodes, glow is transferred upwardly into cells **120**, at an intensity determined by the level of the ON signals, to display a visible message. As each column of cells is scanned in turn, and information signals are applied, a stationary but changeable display is distributed to the columns of display cells **120** and is visible through the top plate. The glow present in the lower cells **90**, however, is not visible through the top plate, so that the internal scanning operation in the panel does not interfere with the display.

Although the preferred embodiments of the invention have been described in detail, it should be understood that the present disclosure has been by way of example only. Many modifications and variations of the invention are possible in light of the above teachings. It is, therefore, to be understood that the invention may be practiced otherwise than as specifically disclosed.

What is claimed is:

1. A display panel comprising

a first insulating plate having top and bottom surfaces,

a plurality a first elongated electrodes disposed parallel to each other along the top surface thereof,

a plurality of second electrodes spaced from the first electrodes and oriented at an angle to said first electrodes and crossing a plurality of them,

a flat conductive member spaced from the second electrodes and having a plurality of apertures arrayed in a matrix, each aperture being aligned with a crossing of a second electrode and a first electrode and defining a gas cell,

a plurality of third electrodes spaced from the conductive member and from the second electrodes in alignment with a group of said apertures and the portions of the first and second electrodes which cross beneath them,

a second insulating plate situated parallel to the first plate, one of which being light transmissive, with the electrodes and the conductive member positioned between them, and

a gaseous atmosphere sealed in the region between the insulating plates and including an ionizable gas at a pressure capable of sustaining cathode glow discharge.

2. The display panel of claim **1** wherein the first insulating plate has a plurality of parallel grooves therein extending down from the top surface and each of the first electrodes is disposed in one of said grooves.

3. The display panel of claim **1** wherein the second electrodes comprise a plurality of flat conductors which substantially cover the associated apertures in said flat conductive member except for a small opening or an aperture in them at each gas cell to allow for priming of the cells.

4. The display panel of claim **1** wherein the flat conductive member carries an insulating layer which spaces it from the second and third electrodes.

5. The display panel of claim **1** wherein the third electrodes are elongated and are oriented in the same direction as the first electrodes, the second electrodes being elongated and crossing at least some of them.

6. The display panel defined in claim **5** wherein the first and third electrodes comprise conductive wires and the second electrodes comprise elongated flat strips having apertures at the regions where the second electrodes cross the first electrodes to allow for priming of the cells.

7. The display panel of claim **1** wherein the flat conductive member comprises an apertured metal sheet electrode carrying an insulating layer on its top and bottom surfaces and having an electrode terminal adapted for connection to biasing or monitoring apparatus.

8. A display device having a plurality of gas-filled display cells adapted to be energized singly or in groups to display a character or message comprising:

insulated housing means containing a gaseous atmosphere at a pressure capable of sustaining cathode glow discharge and having a light-transmitting window,

a conductive member situated in said housing and having a plurality of apertures spaced apart in at least one surface thereof for defining individual display cells,

first and second electrode means associated with each of the cells for recurrently ionizing the gas adjacent them, and

third electrode means associated with the display cells for selectively ionizing the gas in the cells and causing glow discharge in them.

9. The display device of claim **8** wherein the first and second electrodes comprise elongated conductors which cross each other at an angle adjacent the apertures in said conductive member.

10. The display device of claim **8** wherein the conductive member comprises a flat sheet having apertures through it, the first and second electrode means comprising a set of anodes spaced from one side of the sheet and the third electrode means being situated adjacent the other side of the sheet.

11. The display device of claim **8** wherein the conductive member comprises a flat metal sheet having apertures through it with larger openings adjacent the third electrode means than the openings adjacent the first and second electrode means.

12. The display device of claim **8** wherein the conductive member comprises a flat conductive layer carrying an insulating layer which spaces it from the electrode means.

13. The display device of claim **8** wherein the conductive member comprises an apertured metal sheet bearing an insulating coating on both sides, the first and second electrode means crossing each other at the cells adjacent one side of the sheet and the third electrode means being situated adjacent the other side of the sheet.

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