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Coderre et al.

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[54] **ELECTRICAL LUMINESCENT DISPLAY DEVICES**

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[52] **U.S. Cl.** ..... **313/514;** 315/169 TV

[51] **Int. Cl.**[2] **H01J 1/62**

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

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Assistant Examiner—D. C. Nelms
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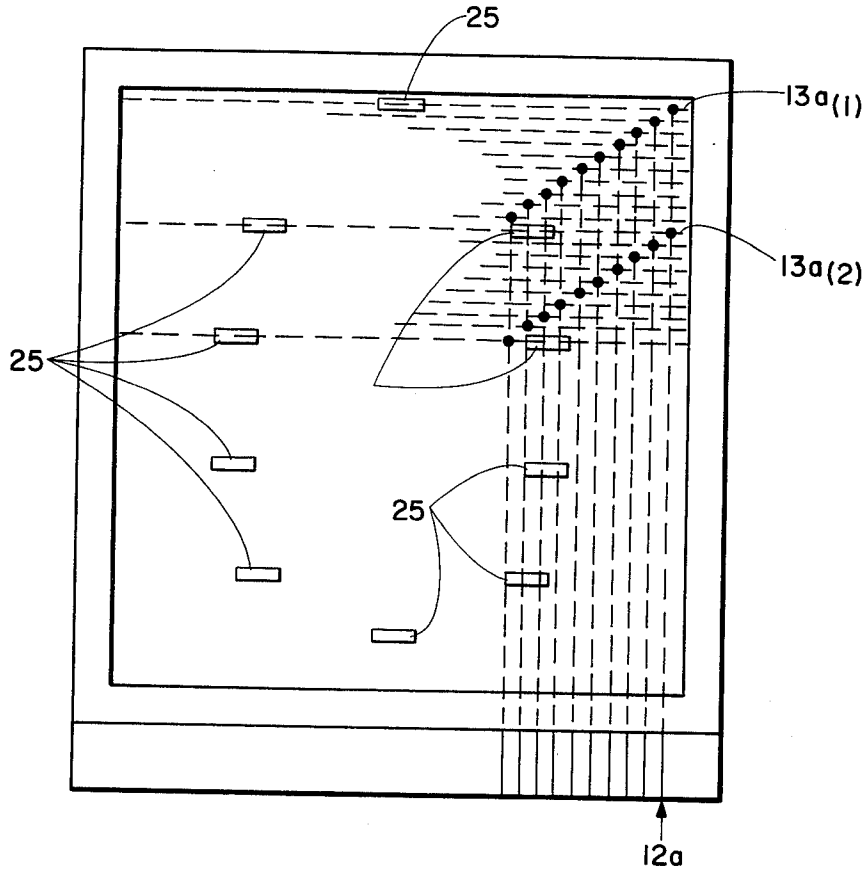
[57] **ABSTRACT**

An electroluminescent device in which a substrate and a transparent cover form an enclosed chamber in which is an electroluminescent fluid and an electrode structure. The electrode structure comprises a first grid of electrodes and a second grid of electrodes overlying the first grid and separated by an insulating layer. Each electrode of the first grid is connected to a number of electrodes of the second grid. A dielectric layer is placed over the second grid and apertures formed in the layer, the apertures aligned with electrodes of the second grid to form a plurality of patterns. On energization, luminescence occurs at the apertures. The electrodes of the second grid can be very closely spaced and a substantially continuous display or character can be formed.

8 Claims, 8 Drawing Figures



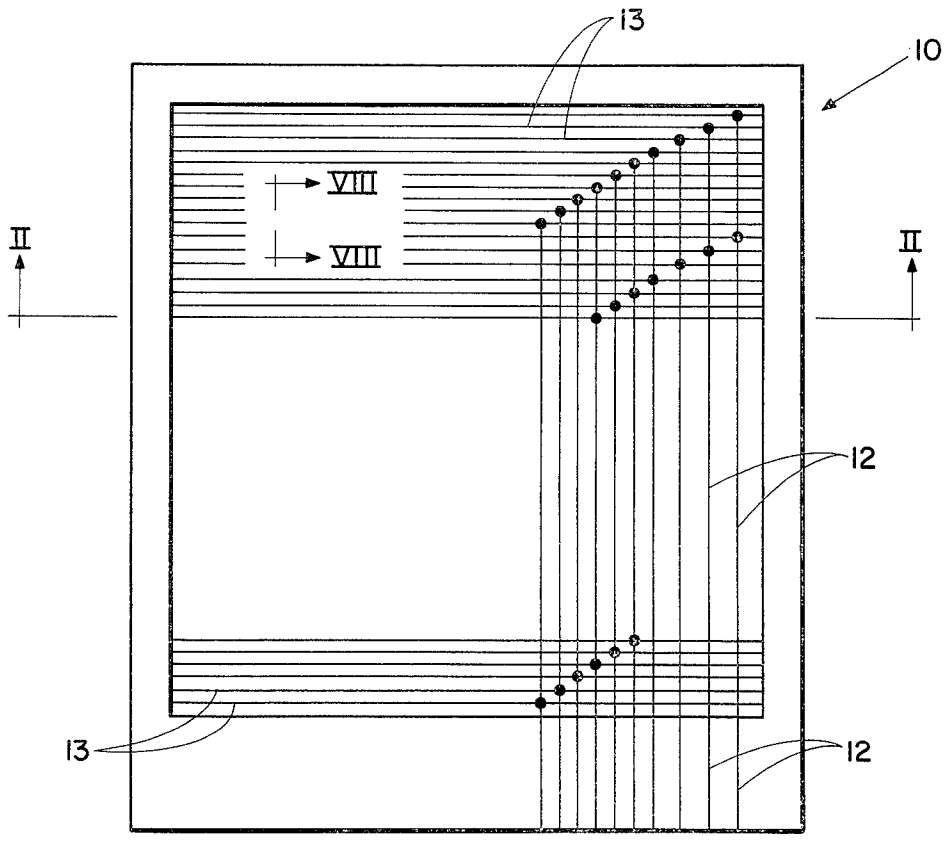


Fig. 1

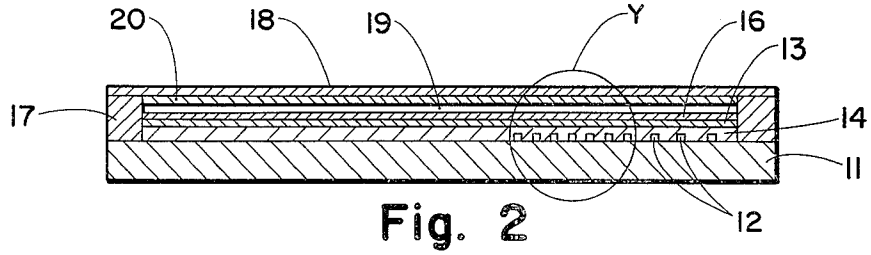


Fig. 2

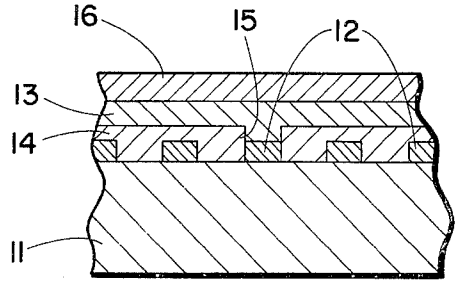


Fig. 3

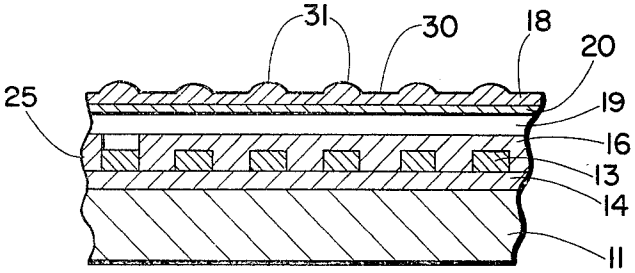


Fig. 8

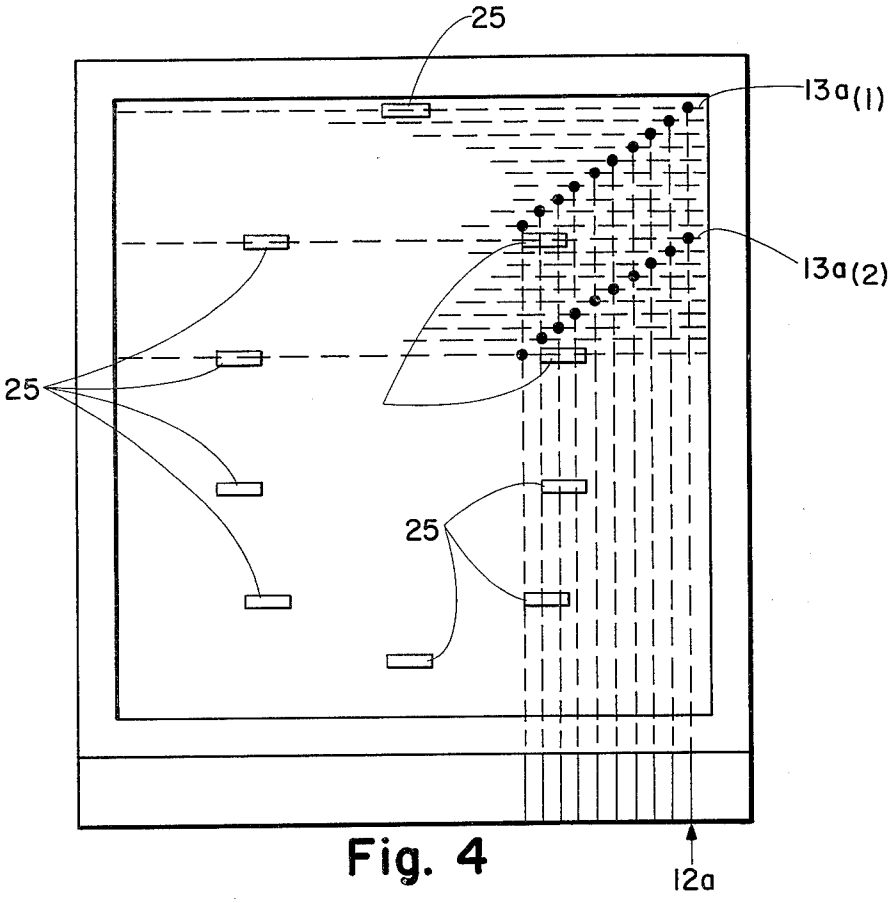


Fig. 4

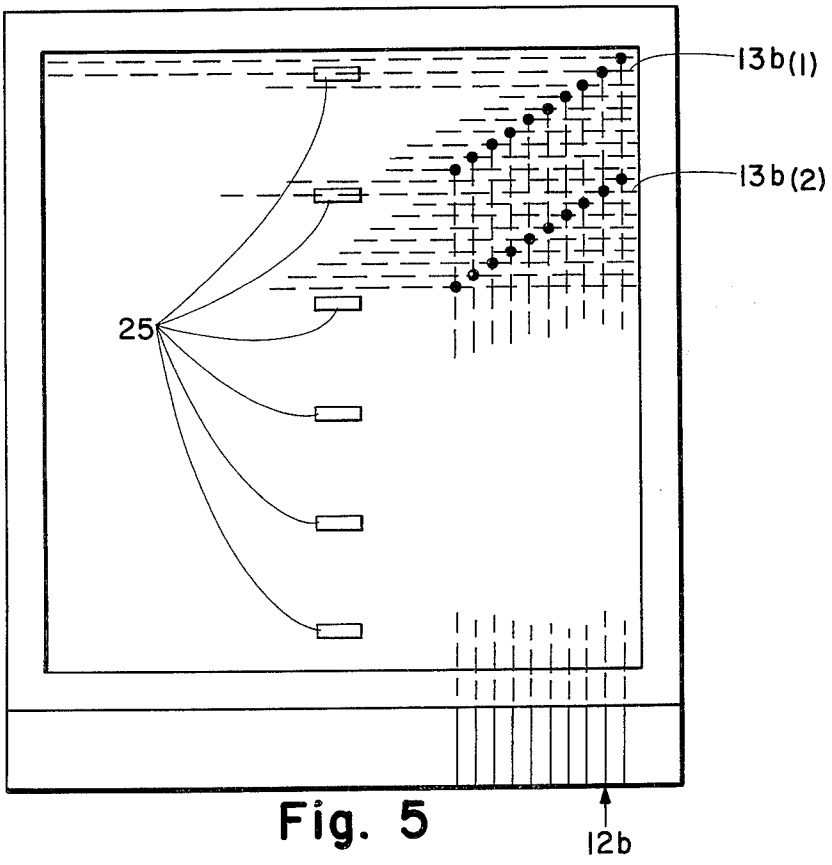


Fig. 5

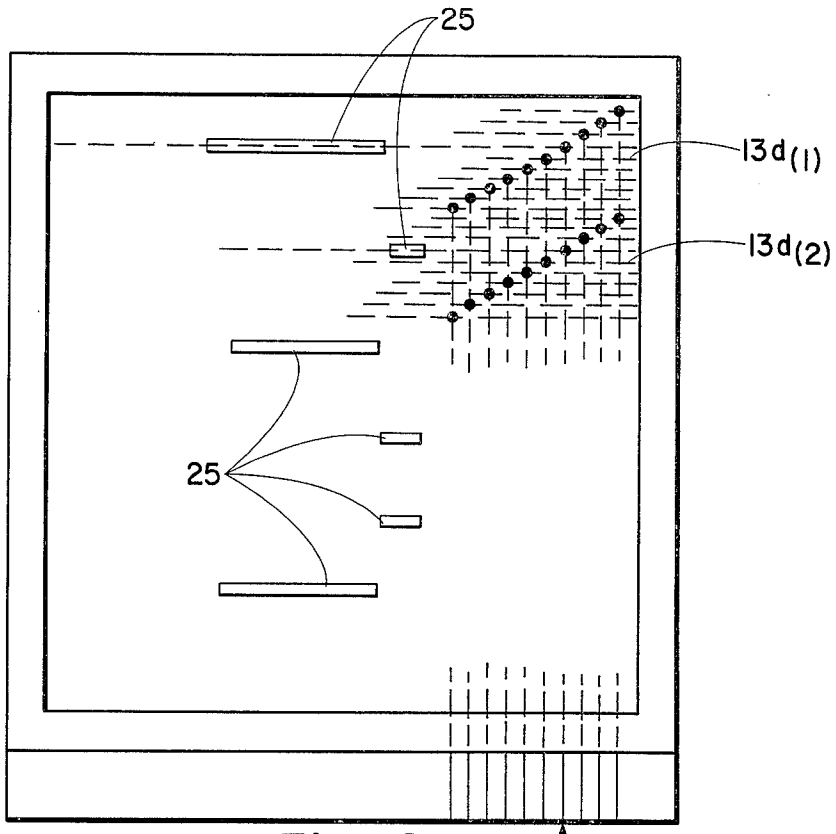


Fig. 6

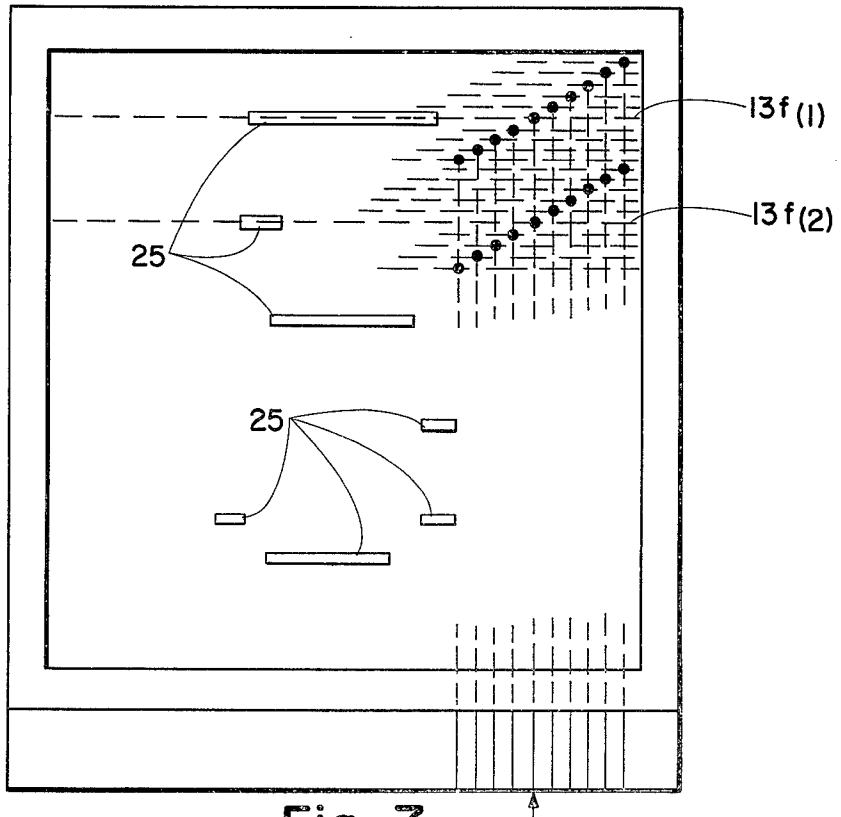


Fig. 7

ELECTRICAL LUMINESCENT DISPLAY DEVICES

This invention relates to electrical luminescent display devices, particularly of the type in which a plurality of electrodes are selectively energized, the energization resulting in the emission of light to form a predetermined light pattern.

Various devices exist for forming illuminated displays, for example incandescent filaments, light emitting diodes and gas-discharge tubes such as those referred to as NIXIE tubes. Depending upon the form of the device there are certain disadvantages and/or inconveniences. For example the NIXIE tube produces a fully formed character in its entirety but each character is produced on a different plane. Therefore there is a severe practical limit to the number of characters a tube can produce.

Light emitting diodes are generally used in segmental displays, that is the display device has a plurality of segments each individually energized. The characters are positioned on a common plane. It is necessary to provide a logic function to obtain energization of selected segments to produce a certain desired character as each segment is used for more than one character. Other forms of segmental displays exist, such as plasma gas discharge, incandescent and fluorescent, but again some form of logic function is necessary.

Another disadvantage of segmental displays is the limitation of the number of characters which can be reproduced with such displays. The number of characters which can be produced depends upon the number of segments, which is limited by practical considerations. Further, the larger the number of segments, the more complex the logic function necessary to select the particular segments required for a particular character.

Typical conventional segmental arrays use seven segments, which can produce all numerals but is very restricted in producing alphabetic characters. A matrix display using points or dots of light, arranged in a 5 × 7 display, for example, is another form in common use but this involves accessing of a large number of elements.

The present invention provides a display device which has a high variability in character formation, thus enabling a large number of different characters to be formed, and without the need for a logic function to provide segment sharing as in segment arrays. Each character is formed independently of any other character. Also the characters are formed in a common plane. As a further feature a high degree of character definition can also be obtained.

This invention will be understood by the following description of certain embodiments, by way of example, in conjunction with the accompanying drawings, in which:

FIG. 1 is a plan view showing electrode arrangement;

FIG. 2 is a cross-section on the line II—II of FIG. 1 illustrating the various layers;

FIG. 3 is an enlarged view of the area encircled at Y in FIG. 2;

FIGS. 4 to 7 illustrate the display of numerals; and

FIG. 8 is a cross-section as on the line VIII—VIII of FIG. 1, to an enlarged scale and illustrating a modification thereof.

As illustrated in FIGS. **1**, **2** and **3**, a device **10**, in the present example for convenience is shown as an electrochemical luminescent cell, comprises a substrate **11**

on which are formed two grids of electrodes **12** and **13**. The two grids are separated by a dielectric **14**, although in FIG. **1** the two grids are shown, for clarity, without the intervening dielectric.

After formation of the first grid **12** and the dielectric layer **14**, small holes or rows **15** are formed, such openings providing for electrical connections to the electrodes of the second grid. When the second grid **13** is formed, the material of the electrodes fills the openings, as seen more clearly in FIG. **3**. Following formation of the second grid **13**, a further dielectric layer **16** is formed. This dielectric layer is opaque and acts as a mask. Openings are made in this layer corresponding with certain electrodes in grid **13** in accordance with the predetermined pattern or display to be made.

The cell is completed by a peripheral spacer member **17** bonded or otherwise attached to the substrate, and a transparent cover **18** which is bonded or otherwise attached to the member **17**. The thickness of member **17** is such that a space **19** is left into which is filled an electrochemical luminescent solution. A transparent electrode **20** is formed on the inner surface of the cover **18**.

The density of the electrodes in each grid is considerably higher than that shown in the drawings. Electrodes having a width of 0.0005 inches, with a spacing of a similar distance have been produced. The number of electrodes in a grid is thus very high although the size of the device is a limiting factor.

The actual display is formed by light emission at openings formed in the second dielectric layer **16** as described later. As seen in FIG. **1**, each electrode **12** is connected to a plurality of electrodes **13**. Thus on applying a voltage to one electrode **12**, a number of electrodes **13** are energized. As a result light emission will occur at each opening **25** associated with one of the energized electrodes **13**. The openings are in a predetermined pattern and thus a particular character is shown.

As an example FIG. **4** illustrates a display for a zero. Power is applied to electrode **12**(*a*) as indicated by the arrow. As a result electrodes **13***a*(*l–n*) are energized. Openings **25** have been formed over these electrodes **13***al–n*), to form a display for a zero. Illustrated in FIG. **5** is a display for a numeral **1**, in which power electrode **12**(*b*) is energized, and as a result energizing electrodes **13***b*(*l–n*). FIGS. **6** and **7** illustrate displays for numerals **3** and **5**, with energization of power electrodes **12***d* and **12***f* respectively and consequential energization of electrodes **13***d*(*l–n*) and **13***fl–n*) respectively. It will be seen that with energization of power electrodes **12***d* and **12***f* respectively and consequential energization of electrodes **13***d*(*l–n*) and **13***f*(*l–n*) respectively each character is positioned downwards, as seen in the drawings, by the pitch of the electrodes **13**. The distance between openings **25**, vertically, for a particular character, in the present example, is ten times the pitch of the electrodes **13**. The vertical distance depends upon the number of characters it is desired to produce. Thus for characters **0** to **9** the electrodes **13** are connected in series of 10. For a smaller number of characters the electrodes are connected in smaller series, and larger series for a larger number of characters.

The number of openings **25** actually provided for a character is considerably more than that illustrated. For example, with electrodes of 0.0005 inch width and 0.0005 inch space between, it is possible to provide 1,000 electrodes per inch. For 10 characters this per-

mits 100 electrodes per character, each electrode spaced 0.01 inch apart. Thus a 1 inch character would be formed by 100 lines -long or short depending on character and position in the character. With such close spacing the display would appear as a substantially continuous character. The maximum vertical displacement of one character from another would be 0.01 inch, that is the pitch of ten electrodes. As an alternative the electrode grids **12** and **13** could be repositioned by 90° so that the character displacement is sideways instead of vertical. Further the electrodes can be at an oblique angle relative to the cell structure. Also, it is not essential that the two grids be at right angles to each other, but it is likely to be preferred for manufacturing and for other reasons.

In an alternative arrangement, not illustrated, the transparent electrode can be replaced by a further grid. Such a further grid could be interleaved with the second grid **13** for example. Thus one way of arranging such grids would be to connect alternate electrodes of grid **13** to the first grid **12,** the other electrodes then connected in common to form an additonal electrode grid. With such an arrangement, and where the masking dielectric layer **16** is formed over the grid **13,** the opertures **25** would be aligned over both an electrode of grid **13** and also the adjacent electrode, or electrodes, of the additional electrode grid.

It is also possible to form the masking dielectric layer **16** spaced from the second grid **13.** Thus for example this layer could be formed on the inner surface of the cover **18,** either over the transparent electrode **20** if this is on the cover, or directly on the cover if the additional electrode is formed elsewhere, between the electrodes of the second grid for example as described above.

Further, although the dielectric layer **14** is shown as an independent layer formed over the first grid, it is possible to form this layer by, for example, anodizing the surface of the electrodes of the first grid to form an insulating or dielectric layer. The second grid can then be formed directly on top of the first grid. Electrical connections can be made by local removal of the anodized layer.

What is provided is a series of independent electrode grids, each grid electrically independent. The series of grids are interleaved to form an arrangement on a common plane.

Single characters are not the only form of display. Words or designs can also be produced. The size of display can be varied according to requirements. Thus displays from ¼ to 1 inch square are particularly suitable for single character formation, but displays at considerably larger size can be used for words and designs.

The invention is applicable to gas discharge light emission devices, in which case the space **19** is filled with a suitable gas.

Devices in accordance with the invention can be used in many ways, for example display arrays for calculators, indicators on instruments, automobile instruments, radio dials, and many other applications. By providing a large number of light emitting positions for a character, or other display, the actual shape visually produced can be considerably more normal for characters, and permit considerable detail for other forms such as designs.

It is possible to overcome, at least to some extent, any slight discontinuity in the appearance of a character, or other display, by giving the outer or viewing surface of the device a lens or similar structure. One such structure is seen in FIG. **8.** This is an enlarged cross-section through part of a cell, as in FIGS. **1** to **7** and it will be seen that the outer surface **30** of the front cover **18** is given a cylindrical lens structure, each cylindrical lens **31** aligned over an electrode **13.** By this means the emission from each electrode **13,** through related openings **25,** is diffused. It is also possible in certain instances to include a diffusing agent in the front cover **18.**

What is claimed is:

1. An electrical luminescent display device comprising:

a substrate and a transparent cover member spaced from the substrate to form an enclosed chamber;

a first grid of electrodes on said substrate;

a first dielectric layer comprising an insulating layer on the electrodes of said first grid;

a second grid of electrodes overlying said first grid;

means connecting each electrode of said first grid to a series of electrodes of said second grid, a different series of electrodes of said second grid connected to each electrode of said first grid;

an electroluminescent fluid in said chamber in contact with the electrodes of said second grid;

a second dielectric layer in overlying relationship with said second grid;

apertures in said second dielectric layer, said apertures aligned with the electrodes of said second grid to form a plurality of predetermined patterns;

an additional electrode electrically connected to the electrodes of said second grid by said electroluminescent fluid;

means for connecting an alternating driving voltage to said additional electrode and to individual electrodes of said first grid.

2. A device as claimed in claim **1,** said second dielectric layer in contact with said second grid, said electroluminescent fluid in electrical contact with the electrodes of said second grid through said apertures.

3. A device as claimed in claim **1,** said additional electrode comprising a transparent electrode on an inner surface of said transparent cover member.

4. A device as claimed in claim **1,** said electroluminescent fluid comprising an electrochemical luminescent solution.

5. A device as claimed in claim **1,** the electrodes of said first grid crossing the electrodes of said second grid at right angles.

6. A device as claimed in claim **1,** including switching means for selectively connecting said driving voltage to individual electrodes of said first grid.

7. A device as claimed in claim **1,** including light diffusing means on the outer surface of said cover member.

8. A device as claimed in claim **7,** said light diffusing means comprising a plurality of lens structures aligned with said electrodes of said second grid.

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