ELECTRICAL LUMINESCENT DISPLAY DEVICES

Inventors: William Michael Coderre; Carl Neil Berglund, both of Ottawa; Philip Robert Tillman, Kanata, all of Canada

Assignee: Northern Electric Company Limited, Montreal, Canada

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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 overlaying 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
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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 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 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 13d(l−n) are energized. Openings 25 have been formed over these electrodes 13al−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 13b(l−n). FIGS. 6 and 7 illustrate displays for numerals 3 and 5, with energization of power electrodes 12d and 12f respectively and consequential energization of electrodes 13d(l−n) and 13f(l−n) respectively. It will be seen that with energization of power electrodes 12d and 12f respectively and consequential energization of electrodes 13d(l−n) and 13f(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 additional 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 second grid 13.

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 only, 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 $\frac{1}{4}$ 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.

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 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.