United States Patent

[11] 3,571,647

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[45] Patented **Mar. 23, 1971**
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[54] **FLEXIBLE ELECTROLUMINESCENT STRUCTURES**
17 Claims, 15 Drawing Figs.

[52] **U.S. Cl.** **313/108,** 313/109.5
[51] **Int. Cl.** **H05b 33/02**
[50] **Field of Search** 313/108, 109.5, 210

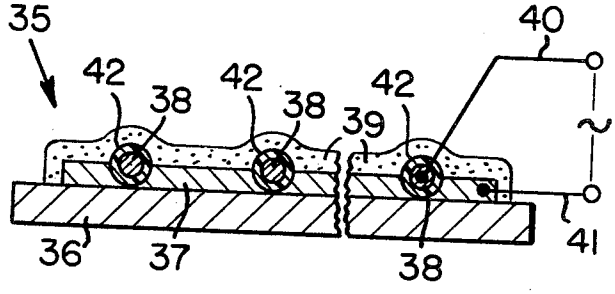
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Primary Examiner—Roy Lake
Assistant Examiner—Palmer C. Demeo
Attorney—B. Edward Shlesinger

ABSTRACT: Each cell comprises a first electrode made of a deformable, electrically conductive material, and a second electrode in the form of one or more insulated, electrically conductive wires or meshes mounted on, secured to, or imbedded in, the surface of the deformable electrode. A layer of electroluminescent phosphor covers the conductors defining the second electrode, and the exposed portions of the deformable electrode. The deformable electrode is on a substrate which may be rigid or flexible, and electrically conductive or nonconductive. Fabric may be coated or impregnated with the deformable electrode; and the conductors defining the second electrode may be sewn on one or both sides of the fabric beneath a layer of electroluminescent material. When an AC voltage is applied across the electrodes, the phosphor layer luminesces with an intensity greatest in the vicinity of the second electrode.



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SHEET 1 OF 2

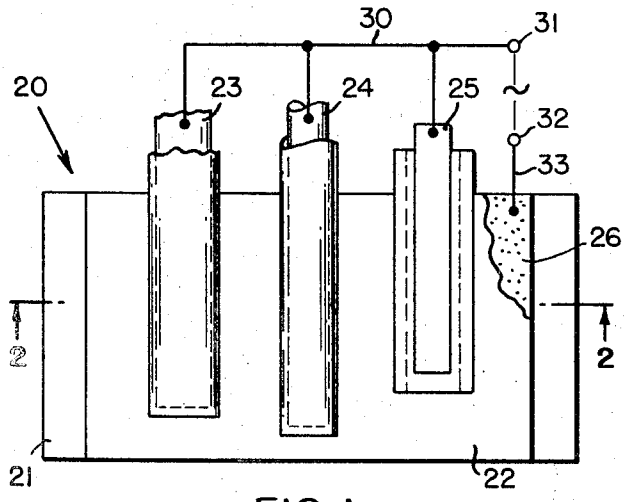


FIG. 1

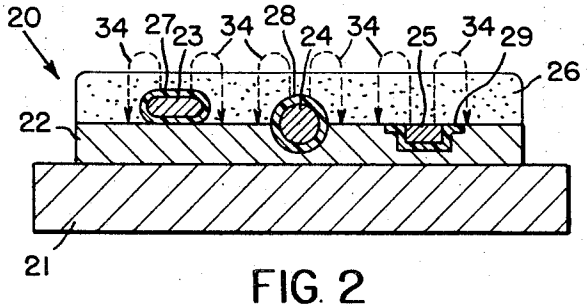


FIG. 2

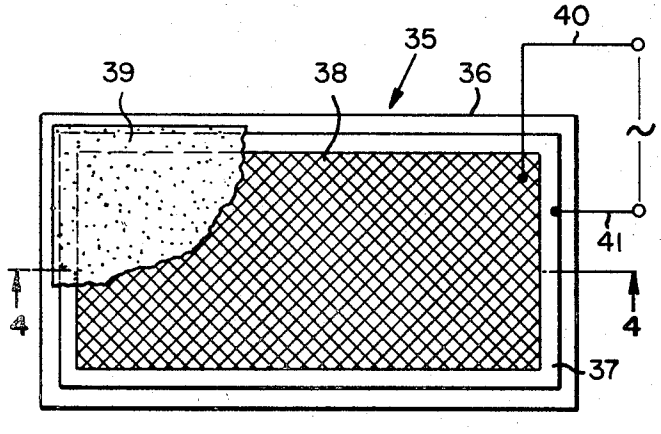


FIG. 3

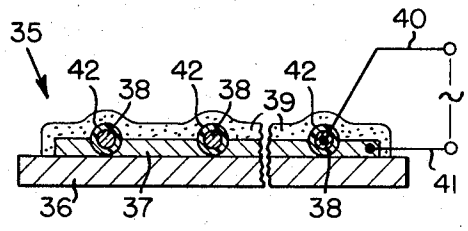


FIG. 4

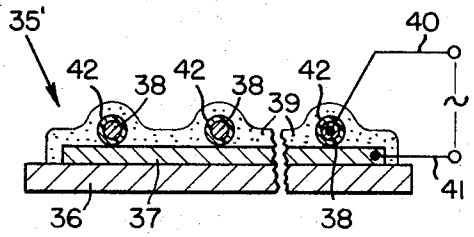


FIG. 5

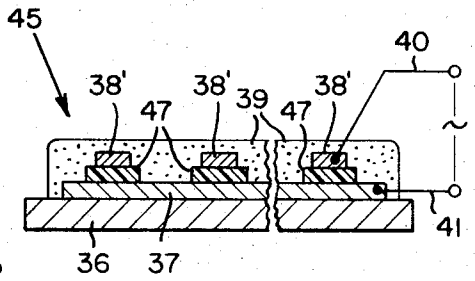


FIG. 6

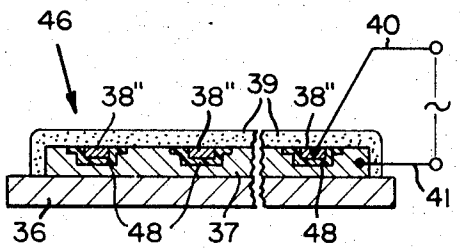


FIG. 7

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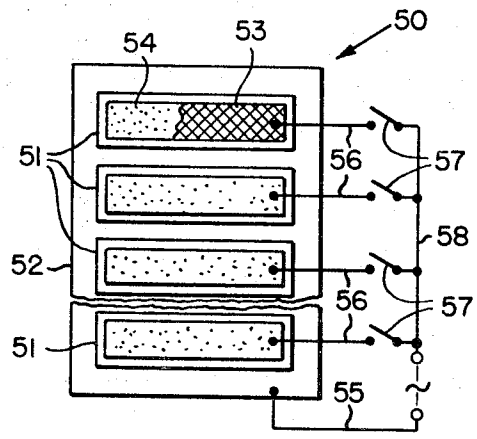


FIG. 8

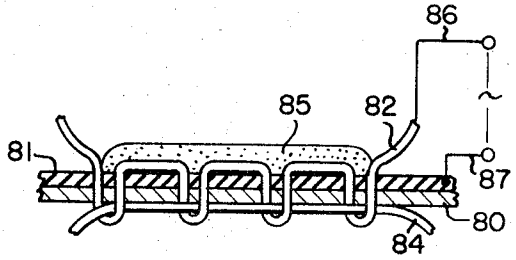


FIG. 12

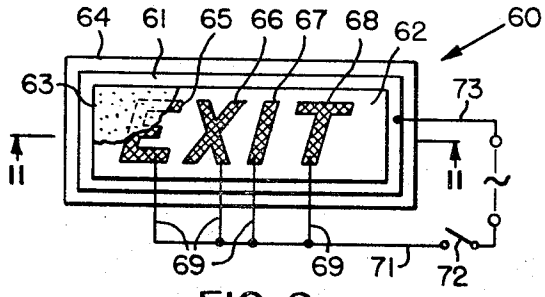


FIG. 9

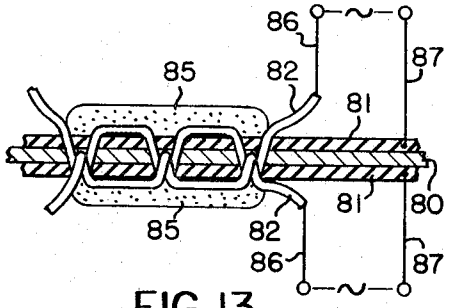


FIG. 13

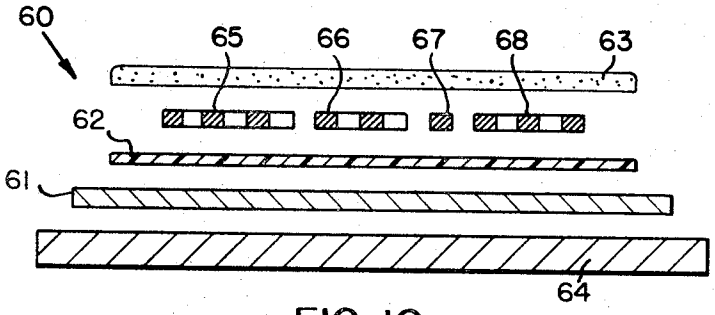


FIG. 10

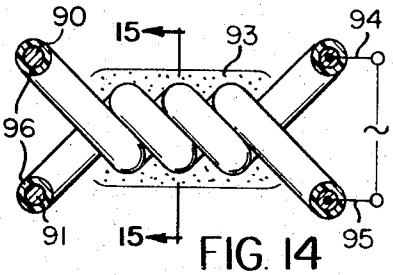


FIG. 14

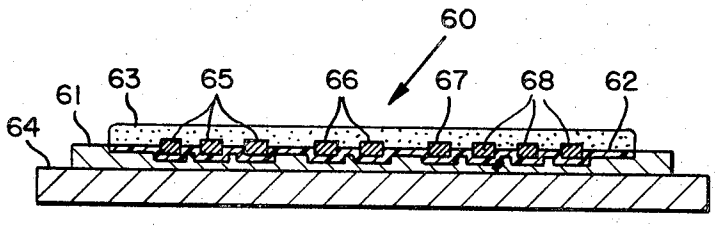


FIG. 11

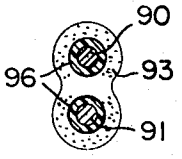


FIG. 15

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FLEXIBLE ELECTROLUMINESCENT STRUCTURES

This invention relates to electrical illuminators, and more particularly to electroluminescent lamps, panels, and cells of the type utilizing a phosphorescent light source.

Illuminators or cells of the type described are based upon the phenomenon that, when electroluminescent phosphor is positioned in a fluctuating electric field, as for example between a pair of conductors connected to an alternating current power source, the phosphor will be excited to luminescence. Heretofore most of these cells have been either of the sandwich type, wherein the phosphor is positioned between two parallel conductor plates, one of which is light transmissive, or of the planar type, in which the phosphor is positioned between a plurality of parallel wire conductors that are mounted on a flat, dielectric substrate.

In my copending U.S. Pat. application Ser. No. 715,158, filed Apr. 2, 1968, now U.S. Pat. No. 3,531,676, I have disclosed an improved cell in which a phosphor-coated, grid-type electrode is separated by an intervening dielectric layer from a second grid or plate-type electrode. Although this construction is particularly advantageous for producing by stamping or punching them out of large, flat sections to any desired shape, it has been found desirable to simplify still further the cell construction to increase its versatility and economy.

It is an object of this invention, therefore, to provide an improved, electroluminescent cell, which is more versatile, and in most cases more economical to produce, than prior such cells.

Another object of this invention is to provide an improved electroluminescent cell in which at least one deformable, planar-type electrode is employed to expedite the manufacture and repair of such cells.

A further object of this invention is to provide an improved cell of the type described in which the phosphor layer is in contact with both electrodes of the cell.

Other objects of the invention will be apparent hereinafter from the specification and from the recital of the appended claims, particularly when read in conjunction with the accompanying drawings.

In the drawings:

FIG. 1 is a plan view generally illustrating the principles of construction of electroluminescent cells according to this invention, part of the phosphor upper coating having been removed for clarity in illustration;

FIG. 2 is a section on the line 2–2 of FIG. 1;

FIG. 3 is a plan view showing an electroluminescent cell or lamp made in accordance with one embodiment of this invention, a portion of the upper surface of this cell being cut away for purposes of illustration;

FIG. 4 is an enlarged, fragmentary sectional view taken along the line 4–4 of FIG. 1 looking in the direction of the arrows;

FIGS. 5, 6 and 7 are sectional views similar to FIG. 4, but illustrating, respectively, three different modifications of this cell;

FIG. 8 is a fragmentary plan view of an electroluminescent bar graph constructed from cells made in accordance with this invention;

FIG. 9 is an elevation of an electroluminescent sign made from such cells;

FIG. 10 is an exploded view showing the structure of this sign;

FIG. 11 is an enlarged sectional view of this sign taken along line 11–11 of FIG. 9 looking in the direction of the arrows;

FIG. 12 is a fragmentary, transverse sectional view of a cloth cell made in accordance with a further embodiment of this invention;

FIG. 13 is a view similar to FIG. 12, but illustrating a modified form of this cloth cell;

FIG. 14 is an elevation illustrating still another embodiment of the invention; and

FIG. 15 is a section on the line 15–15 of FIG. 14.

Referring now to the drawings by numerals of reference, and first in the embodiment illustrated in FIGS. 1 and 2, 20 denotes an electroluminescent cell or lamp, which comprises a base or support 21, a normally flat, deformable electrode 22, secured to the upper face of the support 21, insulated electrodes 23, 24 and 25, and a layer 26 of electroluminescent phosphor, which covers the insulated electrodes 23, 24, 25, and the deformable electrode 22. FIGS. 1 and 2 illustrate generally the principles underlying the construction of cells according to this invention; and the three electrodes shown in these two FIGS. are of different cross-sectional shapes, and are differently mounted on the deformable electrode 22. Electrode 23 is oval in cross section and encased in an insulating sleeve 27 and placed on top of the deformable electrode 22. Electrode 24 is cylindrical, is encased in an insulating sleeve 28, and is partially embedded in the deformable electrode 22. Electrode 25 is rectangular in cross section, is encased on three sides, but not on its top, in an insulating jacket 29, and is embedded in deformable electrode 22 to have its upper face flush with the upper face of the electrode 22. Ordinarily these three differently shaped electrodes would not be used in the same cell, but a cell would have all oval, all circular or all rectangular cross-sectional electrodes. The three types are shown in the same cell just to illustrate the scope of the invention.

In FIGS. 1 and 2, the electrodes 23, 24, 25 are connected by a line 30 to a common terminal 31, and the deformable electrode 22 is connected by a line 33 to a terminal 32. The two main lines or leads from an AC current source are connected to the terminals 31 and 32 so that an alternating current flows from the source through the electrodes 23, 24, 25 and the deformable electrode 22 back to the source. The current excites the phosphor layer and causes it to glow. The lines 34 indicate the flux lines which cause electroluminescent light emission from the cell.

In the embodiment of the invention shown in FIGS. 3 and 4, 35 designates the cell, here comprising a dielectric substrate 36, a deformable plastic electrode 37, an insulated wire mesh electrode 38, which is embedded partially only in the deformable electrode 37, and a layer 39 of the electroluminescent phosphor, which is applied to the upper surface of the cell to cover both the insulated grid 38 and the deformable electrode 37. The several wires or conductors defining the grid 38 are, of course, electrically connected to one another, and are enclosed or jacketed in a thin coat of dielectric insulation 42 so that the grid will not short out on the lower electrode 37. The deformable electrode 37 can be made from a thermoplastic layer of silicone rubber or plastic elastomeric material made electrically conductive by the addition of a finely divided conductor, such as metal powder, graphite, or the like, which is blended with, or sprayed upon, the deformable layer. Alternatively, layer 37 can be made of a pressure-sensitive adhesive, which is made conductive by the addition of a finely divided conductor, such as metal powder, graphite, etc. The grid electrode 38 and the upper exposed portions of the deformable electrode 37 are coated or covered with the layer 39 of electroluminescent phosphor which may comprise zinc sulfide, doped with copper, chlorine, magnesium, etc. The phosphor layer 39 is in actual contact both with the insulated electrode 38, and with the portions of the deformable electrode 37 that extend through the interstices in grid 38.

The electrodes 38 and 37 are adapted to be connected in any conventional manner, as for example by the wire leads 40 and 41 respectively, to an alternating current power supply. When an AC voltage is applied to the leads 40 and 41 the electroluminescent phosphor is excited, and becomes luminous, or glows, until the voltage is removed.

Instead of embedding electrodes 38 part way into the deformable electrode 37, the grid electrode 38 may, if desired, merely be positioned on top of the surface of the electrode 37 as illustrated in the cell 35′ shown in FIG. 5. Moreover, as an alternative to pressing the grid 38 into the deformable electrode 37, it may be desirable in some instances either to cast

or mold the insulated electrode 38 directly into the deformable electrode which may be a liquid resin made electrically conductive by the addition of a finely divided metal powder, or the like. The cast assembly is then cured into a rigid or semirigid state.

Although the phosphor layer 39 covers both the grid electrode 38 and the exposed portions of the upper surface of the electrode 37, the electrode 38 is nevertheless completely enclosed in the layer of insulation 42, so that the phosphorous layer 39 does not actually come into direct contact with the metal conductors or wires of this electrode.

In the cells 45 and 46 of FIGS. 6 and 7, respectively, modified grid-type electrodes 38′ and 38″ are employed, which are similar to the grid 38, except that each is not completely enclosed in a layer of insulation, and its wires are rectangular in cross section rather than round.

In the cell 45, a grid-shaped layer of insulation 47, which is similar in configuration too, but only slightly larger than, the grid electrode 38′, is secured between the grid 38′ and the deformable electrode 37. The insulation grid 47 supports the associated grid electrode 38′ above the face of electrode 37, and engages only the underside of the grid electrode 38′, so that the remaining surface area of this grid electrode is exposed directly to the surrounding layer 39 of electroluminescent phosphor.

In the cell 46 the grid electrode 38″ is held in registering recesses or pockets in an insulating grid 48; and the grid-shaped layer 48 of insulation is embedded in the surface of the lower electrode 37, so that the upper face of the grid electrode 38″ is substantially coplanar with the upper surface of the deformable electrode 37. Also, the insulating grid 48 is in contact with all except the upper surface of the grid electrode 38″. In the cell 46, therefore, the upper surface only of the grid electrode 38″ is in direct contact with the overlying layer 39 of electroluminescent phosphor.

The electrically conductive portions of the grid electrodes 38, 38′ and 38″ can be stamped from electrically conductive blanks, and the associated insulation 42, 47 or 48 may comprise thin, deformable sheet plastic, insulating lacquer, or resins; or if aluminum conductors are employed, the insulation may be an anodized coating on the conductors.

FIG. 8 illustrates one practical application of the invention. This FIG. shows bar graph 50, comprising a plurality of deformable, flat electrodes 51, which are secured in spaced, parallel relation on the upper surface of base or substrate 52 made of a conductive material, such as metal. Secured on each electrode 51 is a rectangular grid-type electrode 53. Each of these grid electrodes 53, and its supporting, deformable electrode 51, are coated with a layer 54 of electroluminescent phosphor. Since the substrate 52 is electrically conductive, it functions as a common lead or ground for all of the plurality of deformable electrodes 51 in which the insulated conductive wires, or insulated mesh segments 53, are wholly or partially embedded. The support 52 may be connected by a single wire lead 55 to one side of an AC power supply. The leads 56 for the grid-type electrodes 53 are connected through separate switches 57 to a common line 58, that is connected to the opposite side of the AC power supply. In this manner, each individual cell on the bar graph 50, comprising an electrode 53 and a deformable electrode 51, may be selectively energized.

The electroluminescent sign 60 shown in FIGS. 9 to 11 comprises a plurality of conductive, specially shaped grid-type electrodes 65, 66, 67 and 68, which have the configurations of the letters E,X,I,T, respectively. These electrodes are embedded in a deformable electrode 61, which is similar to that employed in the embodiment illustrated in FIGS. 3 and 4 and insulated therefrom by a thin deformable insulating film 62. Deformable electrode 61 is supported on substrate 64 which may be made either of metal, electrically-conductive material or of insulating material. The wire leads 69 for the electrodes 65 to 68 are connected through a common lead 71 and a manually operable switch 72 to one side of an AC power supply, while the deformable electrode 61 is connected by its lead 73 to the opposite side of this supply source. The electrodes 65 to 68 and the insulating film 62 are covered with a layer 63 of electroluminescent phosphor, so that when the switch 72 is closed, the coating layer 63 glows in the vicinity of grids 65 to 68 to provide an illuminated EXIT sign.

For purposes of illustration, the electrodes 65 to 68 have been illustrated (FIG. 9) as being cut or stamped from screening. However, it will be understood that each of these electrodes, if desired, may be made from a single, shaped, metal conductor partially or fully embedded in the underlying layer 62 of insulation. Similarly, the upper, mesh-type electrodes 53 employed in the bar graph 50 may be made, if desired, from solid, formed conductors rather than from a mesh-type conductor. Moreover, rather than using a single, solid layer of insulation 62 in the sign 60, the insulation beneath the letters may be formed in separate pieces each of which conforms to, and is slightly larger than, the associated letter-shaped electrodes 65, 66, 67 or 68, which it is to insulate from the deformable electrode 61. In such case the phosphor layer 63 will cover both the upper electrodes 65 to 68, and the exposed surfaces of the underlying electrode 61.

A novel departure from the use of an electroluminescent cell as a light source, is its application as decorative means, in the form of luminescent fabric for draperies, and for other special decorative effects. As illustrated, for example, by the embodiments shown in FIGS. 12 and 13, conventional fabrics made of fiberglass, rayon or other synthetic or natural fibers or yarns, can be made to emit light. First, the fabric 80 is impregnated or coated on one side (FIG. 12), or on both sides (FIG. 13), with an electrically conductive medium 81 such as silicone rubber, natural or synthetic rubber latex, or an elastomeric plastic, which has been treated with a fine, electrically-conductive metal powder such as silver. After the rubber or resin coating or impregnant has set or otherwise become nontacky, one or more insulated electrically conductive wires or threads 82 are sewn or stitched into the impregnated or coated fabric by a sewing machine to form various designs on one or both sides of the fabric. When the insulated conductors 82 are used to form a design on one side only of the fabric 80, as shown in FIG. 12, conventional, electrically nonconductive threads 84 may be used for locking the conductive threads 82 to the back or underside of the fabric 80. For electroluminescent emission to appear from both sides of the luminous fabric, the insulated conductive wire is stitched to appear on both sides as shown in FIG. 13, and the electroluminescent phosphor must be applied to both surfaces of the fabric. When designs are formed on both sides of the fabric (FIG. 13), the conductors 82 on one side may be used to interlock the conductors 82 on the opposite side of the fabric.

After the wires 82 have been sewn into fabric 80 to form the desired design, or designs, a layer 85 of electroluminescent phosphor is applied over the designs defined by the wires, so that the phosphor material contacts the exposed surfaces of the electrode 81 of the embodiment shown in FIG. 12 and both electrodes 81 of the embodiment shown in FIG. 11. Through this embodiment of the invention the electrically conductive threads 82 can be arranged to fashion intricate, decorative patterns on a dress or other fabric article to provide attractive and in some instances startling effects.

The conductive rubber layer or layers 81 function as one electrode of a cell, while the insulated wires 82 stitched into the fabric serve as the other electrode or terminal. In each decorative fabric cell the wires 82 are connected to a lead 86, and the other electrode, or electrodes, are connected to a lead 87. The electroluminescent phosphor layer 85 is applied over the fabric and over the stitched insulated wire patterns.

When an alternating voltage of sufficient amplitude is applied between the leads 86 and 87 of a respective fabric cell, light emission will occur from each phosphor coated side. The intensity of the light will, of course, be greatest in the immediate vicinity of a conductor 82.

A further modification of the invention is illustrated in FIGS. 14 and 15. I have found that a pair of conductive, insulated wires 90, 91 twisted together or a number of such wires braided together and covered with electroluminescent phosphor 93, will produce a pattern of light when the two wires, or the sets of wires, respectively, are energized with alternating current applied, for instance, through conductors 94, 95 connecting the wires to a source of alternating current. The wire assemblies can be bent or formed into numerals, letters, or figures for display devices. The insulation for the wires is denoted at 96.

From the foregoing it will be apparent that the instant invention provides an improved form of electroluminescent cell, which is more versatile and compact than prior such cells. For example, the substrate or base for each cell may be made from a flexible material to permit the cell to be bent into a desired shape; and as illustrated more clearly in FIGS. 4, 7 and 11, the upper electrodes may be embedded into the lower electrode so that the electrodes are nearly coplanar, and thus more compact than prior such cells. Moreover, since the layer of electroluminescent material covers both electrodes, the cells can be made to glow brighter than prior such cells for a given voltage supply. Also, the flexible electrode can readily be removed and reapplied to the cell surface in order to replace wornout phosphor.

I claim:

1. An electroluminescent cell, comprising:
a support;
a first electrode mounted on said support;
a second electrode mounted on said first electrode;
insulation interposed between the confronting faces of said electrodes electrically to insulate one from the other;
means for connecting an alternating current potential across said electrodes;
said insulation and said second electrode covering a portion only of the face of said first electrode which confronts said second electrode; and
an electroluminescent material covering said second electrode and extending into contact with the remaining portion of said face of said first electrode.

2. A cell as defined in claim 1, wherein said insulation completely surrounds and encloses said second electrode to insulate it from both said first electrode and said electroluminescent material.

3. A cell as defined in claim 1, wherein:
said insulation surrounds a portion only of said second electrode; and
the remaining portion of said second electrode is in contact with said electroluminescent material.

4. A cell as defined in claim 1, wherein said insulation and said second electrode are embedded at least part way in said first electrode.

5. A cell as defined in claim 4, wherein said first electrode is made of a deformable material.

6. A cell as defined in claim 1, wherein:
said second electrode comprises an electrically conductive grid secured on said first electrode; and
said electroluminescent material extends through the interstices in said grid into contact with said first electrode.

7. A cell as defined in claim 6, wherein said insulation comprises a mesh-type layer of dielectric material having therethrough a plurality of openings which register with the interstices in said grid.

8. A cell as defined in claim 7, wherein said grid and said layer of insulation are embedded in said first electrode so that the outer surface of said grid is coplanar with said face of said first electrode.

9. A cell as defined in claim 1, including:
a third electrode mounted on said first electrode in spaced relation to said second electrode, and having a configuration different from that of said second electrode;
further insulation interposed between said third electrode and said first electrode to insulate said third electrode electrically from said first electrode;
said electroluminescent material extending over said third electrode and into contact with said first electrode in the space between said second and third electrodes; and
a pair of switches for selectively connecting said second and third electrodes to an alternating current power supply.

10. A cell as defined in claim 1, wherein said first electrode comprises a resilient layer of electrically conductive material.

11. A cell as defined in claim 10, wherein said layer comprises a pressure-sensitive adhesive containing finely divided metal particles to render the layer electrically conductive.

12. A cell as defined in claim 1, wherein:
said support and said first electrode comprise two, flexible layers secured back to back; and
said second electrode comprises an insulated electrical conductor sewn to said layers so that at least a portion of said conductor overlies the face of the flexible layer defining said first electrode.

13. A cell as defined in claim 1, wherein:
said support comprises a layer of fabric;
said first electrode comprises a first layer of flexible, electrically conductive material secured to one side of said layer of fabric; and
said second electrode comprises an insulated electrical conductor sewn to said layer of fabric so that portions of said conductor overlie the face of said layer of electrically conductive material to form a design thereon.

14. A cell as defined in claim 13, including:
a second layer of flexible, electrically conductive material secured to the opposite side of said layer of fabric; and
a further, insulated electrical conductor sewn to said fabric layer so that portions of said further conductor overlie the face of said second layer of electrically conductive material to form a design thereon, said connecting means being operable to apply an alternating current potential across said conductors and said layers of electrically conductive material, respectively, and said electroluminescent material covering both said conductors and said layers of electrically conductive material.

15. An electroluminescent cell comprising:
a substrate;
a deformable, plastic, conductive first electrode mounted on said substrate;
a plurality of shaped electrodes mounted on said first electrode and arranged thereon to form indicia;
means for insulating said plurality of electrodes from said first electrode and from one another;
electroluminescent material covering said plurality of electrodes and said first electrode at least in part; and
means for applying an alternating electric current across said electrodes.

16. A cell as claimed in claim 15, wherein said plurality of electrodes are conductive wire mesh.

17. A cell as claimed in claim 16, wherein said insulating means is a thin dielectric insulating film interposed between said plurality of electrodes and said first electrode and in which said plurality of electrodes is embedded.