United States Patent

[11] 3,634,714

[72] Inventors **Donald E. Anderson; Richard L. Swisher, both of Northfield, Minn.**

[21] Appl. No. **11,564**
[22] Filed **Feb. 16, 1970**
[45] Patented **Jan. 11, 1972**

[73] Assignee **G. T. Schjeldahl Company Northfield, Minn.**

[54] **ELECTROLUMINESCENT DISPLAY DEVICE WITH APERTURED ELECTRODES**
6 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** ..... **313/108 A,** 313/108 B, 315/169 TV
[51] **Int. Cl.** **H05b 33/02**
[50] **Field of Search** ..... 313/108 R, 108 A, 108 B, 109.5; 315/169 R, 169 TV

[56] **References Cited**

UNITED STATES PATENTS

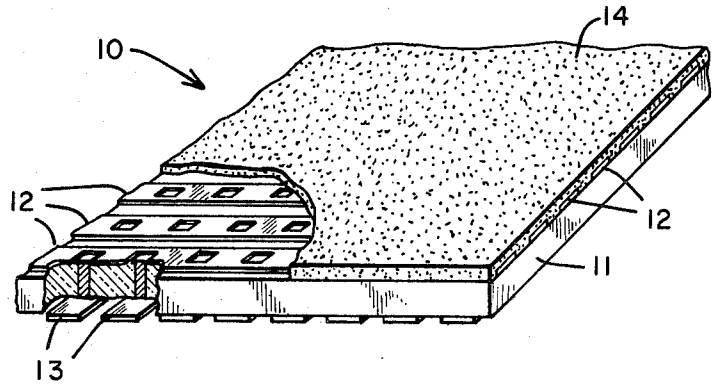
2,980,816	4/1961	Payne	313/108 A
2,988,661	6/1961	Goodman	313/108 A
3,068,440	12/1962	Mash	313/108 B X
3,504,214	3/1970	Lake et al.	313/108

FOREIGN PATENTS

1,275,583	8/1968	Germany	313/108 B

Primary Examiner—Roy Lake
Assistant Examiner—Palmer C. Demeo
Attorney—Orrin M. Haugen

ABSTRACT: A matrix addressable electroluminescent device comprising a substrate member having electrode receiving upper and lower surfaces with a first plurality of individual relatively spaced ribbon electrodes secured to the upper surface of said substrate and forming a pattern array thereon, and a second plurality of individual relatively spaced ribbon electrodes secured to the lower surface of said substrate, disposed orthogonally to said first plurality of electrodes and forming a plurality of intersection points with said first plurality of electrodes. Means are provided for coupling an electrical signal to individual electrodes in each of said arrays, and a plurality of openings are formed in the surface of each electrode in the upper electrode array, the openings defining window areas having an inner periphery defining the opening, and an isolated electrode island disposed on said upper surface within said opening and being spaced from the inner periphery of the opening so as to define an annular gap zone therewith. A plurality of bores are formed through the substrate generally at the intersecting points and an electrical conductor is disposed along the bore and extending therethrough, with each conductor coupling one of said first electrodes to one of said isolated electrode islands. The electroluminescent material responds to differences in potential applied between the electrodes, and illumination occurs in the area of the annular gap zone.



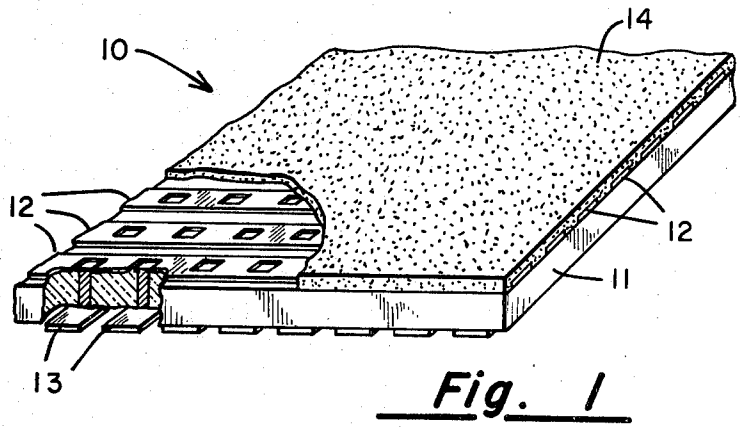


Fig. 1

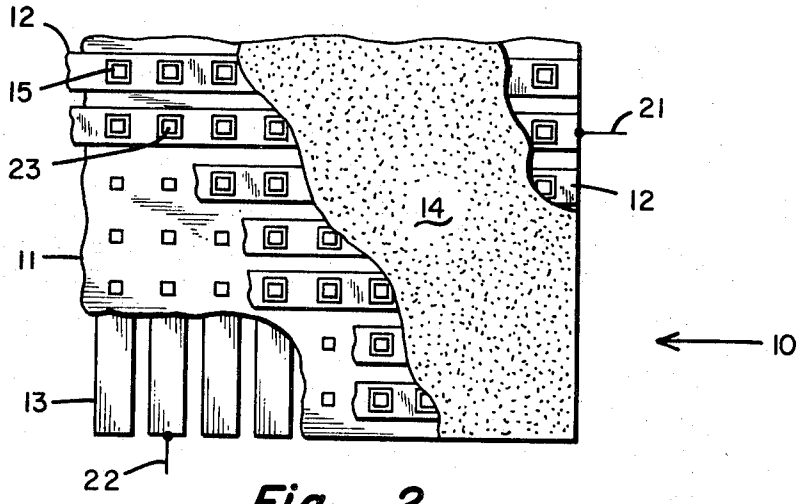


Fig. 2

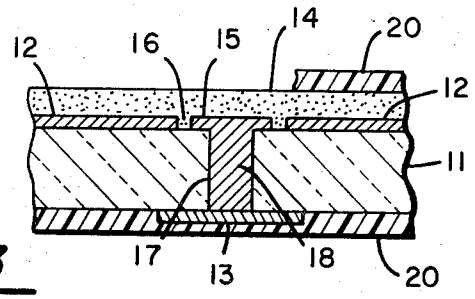


Fig. 3

INVENTORS
DONALD E. ANDERSON
RICHARD L. SWISHER

BY Orwin M. Haugen
ATTORNEY

ELECTROLUMINESCENT DISPLAY DEVICE WITH APERTURED ELECTRODES

The present invention relates generally to electroluminescent devices, and specifically to a matrix addressable electroluminescent device having a substrate member with electrodes applied to the upper and lower surfaces thereof, the electrodes being arranged in mutually orthogonally disposed rows and columns. The electrode arrangement provides a plurality of intersection points and the substrate is provided with a plurality of bores, one for each intersection point. Means are provided to couple the electrodes together on one surface, and the phosphor is applied to the surface and responds to electrical signals which are applied between the electrodes, and which occur at the inner surface of the phosphor.

Electroluminescent phosphors respond to the application of a voltage across oppositely disposed surfaces of a phosphor film. In these devices, the light energy is produced when voltage is applied to opposite surfaces of the film, the response being in the form of light of a certain predetermined wavelength.

The intensity of the light given off by the excited phosphor is normally at its greatest level at a point along the edge of the electrode. In this connection, with thin films of phosphors, the field applied to the gap areas formed in the electrode structure will excite the phosphor and illuminated response will be available through the thickness of the phosphor layer. In this arrangement, therefore, even though the electrodes are applied to opposite surfaces of the substrate, the active areas are all disposed along a single surface of the structure, thereby permitting reasonable inspection procedures to proceed prior to completion of the entire unit assembly.

By arranging the electrically conductive drive lines in mutually orthogonal row-and-column relationship, the system becomes matrix addressable, and signals may be applied to certain preselected lines so as to provide a visual readout of the applied signals. Such devices find application in the data processing field such as, for example, digital display devices and the like, and may also be utilized as the input portion to a light amplifier device.

Therefore, it is an object of the present invention to provide an improved electroluminescent device which comprises an electroluminescent phosphor disposed on the surface of a system of electrodes comprising individual orthogonally arranged drive lines disposed on opposite sides of a substrate, the substrate being perforated at the intersections of the drive lines, and a conductor arranged therein to provide a field along the opposite surface of the substrate so as to provide a system for visual readout of signals applied to preselected electrode pairs.

It is yet a further object of the present invention to provide an improved electroluminescent display device or panel having an electroluminescent phosphor applied as a film on one surface of a substrate and overlying an array of drive lines, the array of drive lines and the substrate having perforations formed therein so as to permit an electrical lead-through from drive lines formed on the opposite surface of the substrate, the arrangement being such that when an electrical field is applied across the individual drive lines, the phosphor element will become illuminated or activated in the area of the applied electrical field.

Other and further objects of the present invention will become apparent to those skilled in the art upon a study of the following specification, appended claims, and accompanying drawing wherein:

FIG. 1 is a perspective view, partially cut away and partially in section, showing a matrix addressable electroluminescent display device fabricated in accordance with the present invention;

FIG. 2 is a top plan view of the display device shown in FIG. 1; and

FIG. 3 is a detail vertical sectional view, on a slightly enlarged scale, showing one unit cell prepared in accordance with the present invention.

In accordance with the preferred modification of the present invention, and with particular attention being directed to the drawing, the electroluminescent display device generally designated **10** comprises a base substrate member **11** having arranged or disposed thereon a plurality of individual electrically conductive drive lines **12—12**, these drive lines being arranged in integral rows upon the upper surface of the substrate member **11**. A second plurality of individual electrically conductive drive lines **13—13** is disposed on the lower surface of the substrate member **11**, these drive lines **13—13** being arranged in integral columns upon the under surface of the substrate **11**. An electroluminescent phosphor layer **14** is disposed on the upper surface of the substrate **11**, and overlies the electrically conductive drive lines **12—12**. As is apparent from a study of the drawing, the individual rows of conductors **12—12** and columns **13—13** form a plurality of mutual junction or intersection areas, these intersection areas being spaced apart through the thickness of the substrate member **11**.

The electrically conductive drive lines are preferably fabricated from deposited layers of a metallic conductor, such as, for example, silver, copper, aluminum or the like. These conductors may be applied by any suitable means, such as evaporative depositions, sputter depositions, electrolytic or electroless depositions, or by similar techniques.

Attention is now directed to FIGS. **2** and **3** of the drawing wherein it is observed that the conductors **12—12** are provided with perforate openings such as at **15**. This opening is formed in any desirable configuration, such as, for example, rectangular, square, or circular. Within the confines of the opening **15**, there is arranged an isolated electrode island, this island being disposed within the opening area **15**, and being spaced from the periphery so as to define an annular gap zone such as is shown at **16**. For ease of fabrication, it may be desirable to prepare a continuous conductor element on the surface of the substrate **11**, and thereafter utilize chemical milling or other techniques to remove selected portions of the conductor so as to provide the availability of the annular gap zone **16**.

With attention now being directed to FIG. **3** of the drawing, it will be observed that the substrate has a plurality of bores formed therein such as at **17**, the bores being formed substantially along or at the intersecting points of the conductors **12—12** and **13—13**. Also, in order to carry the signal from the conductors **13—13** to the individual isolated electrode islands **15—15**, a conductor **18** is deposited or other wise disposed within the confines of the bore **17**. While this conductor may be prepared from a conventional low resistivity electrically conductive material, it may also be desirable, in certain instances, to utilize a material which has a characteristic nonlinear impedance such as a nonlinear resistor material, the impedance level being inversely proportional to the applied potential. Such a substance is desirable in applications where the signal levels may excite the phosphor into a modest degree of activity, and thereby provide a faint glow which would lower the contrast obtained with other intentionally excited areas. Nonlinear resistor materials are, of course, commercially available, one suitable material being silicon carbide held in a suitable binder material such as an epoxy resin, polyester resin, or the like. It will be appreciated, of course, that silicon carbide of a particle size between 800 grit and 1000 grit may be utilized without binder as well.

As is apparent from the drawing, the annular areas provide openings which isolate individual matrix addressable areas, one from another. These openings have a substantial peripheral area so as to increase, enhance, or otherwise take advantage of high fields which exist at the edge portions of adjacent conductors, thereby obtaining a brighter glow in the excited electroluminescent phosphor.

By way of physical dimensions, one typical device fabricated in accordance with the present invention utilized evaporatively deposited silver electrodes having a center-to-center spacing of 20 mils, with the individual drive lines hav-

ing a width of 15 mils. The openings in the upper electrodes were generally square, and were disposed at the mutual junction points established between the individual drive line pairs. These openings were 11 mils on a side, and the isolated electrode islands formed therewithin were formed with a similar geometrical configuration, with a size of 7 mils along each side. Thus, the annular openings **16** bad a channel width of about 2 mils. Obviously, other configurations could be utilized, if desired, depending upon the requirements of the individual device being fabricated.

The substrate member **11** is fabricated from any suitable base material such as, for example, microslide glass or the like. This material forms an excellent substrate for evaporatively deposited silver, copper, or aluminum. The electroluminescent layer **15** may be prepared from any suitable electroluminescent phosphor material. These phosphor materials are, of course, commercially available. For the generation of light energy having a wavelength of about 5500A a suitable phosphor is that material designated by the code mark EL-CN/2 available from the United Mineral & Chemical Corp. Of New York City. This material consists essentially of a zinc sulfide phosphor doped with a modest quantity of copper halide, such as the bromide and chloride. Suitable binders are employed to provide for a coherent film of the phosphor, binders such as cyanoethyl starch or cyanoethyl sucrose being useful.

The electroluminescent display device of the present invention is preferably encapsulated with a layer of transparent material, such as, for example, methyl methacrylate, epoxy resin, or the like. Such an encapsulating layer is shown at **20**, the encapsulation covering the entire surface of the structure. Transparent encapsulating materials with good electrical properties are, of course, commercially available.

Means are provided for coupling a source of electrical energy to each of the electrically conductive drive lines arranged in the respective rows and columns. Such means may be provided in the form of individual lead lines or the like such as at **21** and **22** on the drive lines **12** and **13** respectively. A coincidentally applied signal pulse established along the leads **21** and **22** will provide a visual output in the form of an excited phosphor in the mutual junction zone existing between these drive lines such as at **23**.

The thickness of the phosphor layer **14** is preferably in the range of between about 0.25 and 1 mil. The voltage required to excite the phosphor is preferably in the range of between about 25 volts and 2,500 volts, it being appreciated that higher signal magnitudes may be utilized consistent with the electrical properties and capabilities of the phosphor and its binder substance.

While the structure shown in the drawing utilizes a conductive element to provide the application of signal pulses to the gap area **16**, it may be possible to utilize the bore **17** as an area to retain other circuitry components. Such a device would, of course, be constructed essentially the same as the structure shown here, with the exception of operations being utilized to prepare other active or passive elements to be disposed within the confines of the bore areas.

As has been indicated hereinabove, the device of the present invention may be utilized in connection with digital data processing systems, but may also find use in other areas. For example, the device may be utilized as a light amplifier driver, where the amplifier device per se changes the output of the individual slots into a more readable or coherent light output. Other uses, of course, exist for the structure.

What is claimed is:

1. A matrix addressable electroluminescent device comprising:

a. a substrate member having electrode receiving upper and lower surfaces;

b. a first plurality of individual relatively spaced ribbon electrodes secured to said upper electrode receiving surface and forming a pattern array thereon;

c. a second plurality of individual relatively spaced ribbon electrodes secured to said lower electrode receiving surface and disposed orthogonally to said first plurality of ribbon electrodes, and forming a plurality of intersection points with said first plurality of individual conductors;

d. means for coupling an electrical signal to individual electrodes in each of said arrays;

e. a plurality of openings formed in the surface of each of said first plurality of electrodes, said openings defining window areas having an inner periphery defining the opening and an isolated electrode island disposed on said upper surface within said opening and being spaced from said periphery so as to define an annular gap zone with said inner periphery; and

f. a plurality of bores formed through said substrate generally along said intersecting points with an electrical conductor being disposed along said bore and each conductor coupling one of said first electrodes to one of said isolated electrode islands; and

g. a film of an electroluminescent phosphor disposed along the upper surface of said substrate member overlying said first plurality of electrodes and said isolated electrode islands and being disposed within said annular gap zones between spaced apart edges of said first plurality of electrodes and said island electrodes.

2. The electroluminescent device defined in claim **1** being particularly characterized in that a layer of a transparent encapsulating material is disposed about the outer surfaces thereof.

3. The electroluminescent device as defined in claim **1** being particularly characterized in that said annular gap zone has a uniform transverse width.

4. The electroluminescent device as defined in claim **1** being particularly characterized in that the longitudinal axes of said first plurality of ribbon electrodes are mutually parallel, one to another, and the longitudinal axes of the second plurality of ribbon electrodes are mutually parallel, one to another, with the axes of said first plurality of electrodes and said second plurality of electrodes being arranged at right angles, one to another.

5. The electroluminescent device as defined in claim **1** being particularly characterized in that the electrical conductor disposed along said bores has an impedance characteristic which is inversely proportional to the applied electrical potential.

6. The electroluminescent device as defined in claim **1** being particularly characterized in that said bores are substantially cylindrical.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,634,714 Dated January 11, 1972

Inventor(s) Donald E. Anderson and Richard L. Swisher

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 3, line 15, "15" should read -- 14 --. Line 20, "EL-CN/2" should read -- EL-CB/2 --.

Signed and sealed this 30th day of May 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
☆ U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334