ABSTRACT: Electroluminescent device means comprising a base substrate member having a plurality of individual electrically conductive drive lines arranged in integral rows upon the surface of said substrate, a film of an electroluminescent phosphor disposed on the surface of said rows of electrically conductive drive lines, a plurality of individual electrically conductive drive lines arranged in integral columns upon the surface of said phosphor and orthogonally overlying said rows at certain mutual junction areas; and means coupling a source of electrical energy to each of said electrically conductive drive lines in said rows and columns; said electrically conductive columns having isolated perforate openings formed therein at said junction areas, said openings having a large peripheral to area ratio and being disposed along said conductors in enclosed relationship therewithin.
The present invention relates generally to electroluminescent devices, and specifically to an electroluminescent device having a film of an electroluminescent phosphor disposed between mutually orthogonally arranged rows and columns of electrically conductive drive lines, the phosphor being arranged to respond to the occurrence of coincident electrical signals at the junction areas between said drive lines.

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. While electrically conductive transparent materials are available for use in connection with these devices, certain advantages may be achieved by utilizing opaque electrodes which are perforated in order to provide openings therein to permit the emission of light from the excited phosphor.

By arranging the electrically conductive drive lines in mutually orthogonal row and column relationship, 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, as digital display devices and the like, and may also be utilized as the input to a data amplifier device.

Therefore, it is an object of the present invention to provide an improved electroluminescent device which comprises an electroluminescent phosphor sandwiched between individual orthogonally arranged rows and columns of drive lines intersecting at certain mutual junction areas, at least one of the drive lines being perforated in the junction areas so as to form isolated openings having a large peripheral to area ratio.

It is yet a further object of the present invention to provide an improved electroluminescent display device or panel having an electroluminescent phosphor disposed as a film sandwiched between opaque mutually orthogonally disposed sets of drive lines, at least one of the sets of drive lines having perforate slotted openings formed therein at the junction areas established between said orthogonally arranged drive lines.

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 top plan view of an electroluminescent display device prepared in accordance with the present invention, and illustrating certain of the superimposed layers in partially removed or broken away relationship so as to illustrate each of the individual layers;

FIG. 2 is a top plan view, on an enlarged scale, illustrating the preferred configuration of the isolated perforate openings formed in the opaque conductors formed in one of the sets of drive line incorporated in the structure of FIG. 1; and

FIG. 3 is a vertical sectional view taken along the line and in the direction of the arrows 3-3 of FIG. 1.

In accordance with the preferred modification of the present invention, and in particular attention 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 surface of the substrate. An electroluminescent phosphor layer 13 is disposed on the surface of the rows of electrically conductive drive lines 12-12. A second plurality of individual electrically conductive drive lines 14-14 are arranged on the surface of the phosphor 13, these drive lines being arranged in integral columns overlying the rows 12-12, and being disposed orthogonally thereto.

The individual drive lines form mutual junction areas, these junction areas enclosing a layer of electroluminescent phosphor.

The electrically conductive drive lines are preferably fabricated from deposited layers of metal, such as, for example, silver, copper, aluminum, or the like. These conductors may be applied by means of evaporative depositions, sputter depositions, electrolytic or electroless depositions, or the like. These conductors, being opaque, would, of course, prevent the emission of light from the excited electroluminescent phosphor. Accordingly, a plurality of openings are formed in the drive lines 14-14, these openings being shown in FIG. 2 as at 15. As is apparent in the figure, the openings are isolated perforate slotted openings which are formed at the junction areas existing between the orthogonally arranged sets of drive lines. These openings have a large peripheral to area ratio, so as to increase, enhance, or otherwise take advantage of the high fields which exist at the edges of conductors, thereby obtaining a brighter glow in the excited electroluminescent phosphor.

Specifically, these perforate openings are in the form of an "O" having an electrically conductive segment bridging the inscribed area and the outer area, these bridging areas being shown at 16 and 17, for example. Thus, substantial glows are obtained adjacent the edges of the conductors, thus contributing to a greater or enhanced response in the electroluminescent phosphor structure.

By way of physical dimensions, one typical device fabricated in accordance with the present invention utilized silver electrodes having a center-to-center spacing of 20 mils, with the individual drive lines having a width of 15 mils. The perforate slotted openings were generally square, and were disposed at the mutual junction points established between the individual drive line pairs. These slots, which had a width of about 2 mils, are preferably about 12 mils on a side. Obviously, other perforate slotted configurations could be utilized, if desired, and depending upon the demands of the individual device under consideration.

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 wave length of about 5,500 Å, a suitable phosphor is that material designated by the code mark EL-CB/2 available from the United Mineral & Chemical Corp. of New York City. This material consists essentially of 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 cyaanoethyl starch or cycnoethyl sucrose being useful.

The electroluminescent display device of the present invention is preferably encapsulated within a layer of transparent material such as, for example, a layer of methyl methacrylate, epony, or the like. Encapsulating materials 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 rows and columns. Such means may be provided in the form of individual lead lines or the like such as at 18 and 10 on the drive lines 12-12, and at 20 and 21 on the drive lines 14-14. A coincidental pulse established along lines 18 and 20 will provide an output in the form of an excited phosphor in the mutual junction zone existing between the appropriate drive lines at 22.

The thicknesses of the phosphor layer 13 is preferably in the range of between about 0.25 and 1 mil. This thickness may be varied in accordance with the overall design, so that suitable signal magnitudes may be utilized consistent with the electrical properties and capabilities of the phosphor and its binder substance.
While the perforated opening in the panel shown in the drawing utilizes a specific configuration to provide bridging between the inner circumference and outer circumference of the opening, in certain instances, it may be possible to utilize capacitive coupling to provide a floating internal member which is otherwise electrically isolated from the remaining areas of the electrode. Such a device would, of course, be constructed essentially the same as the structure shown here, with the exception of the means for forming the isolated internal member.

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, where the amplifier device permits 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. Electroluminescent means comprising:
   a. a base substrate member;
   b. a first plurality of individual electrically conductive drive lines arranged in integral rows upon the surface of said substrate;
   c. A film of an electroluminescent phosphor disposed on the surface of said rows of electrically conductive drive lines;
   d. a second plurality of individual electrically conductive drive lines arranged in integral columns upon the surface of said phosphor, and orthogonally overlying said rows of drive lines to form mutual junction areas; and
   e. means coupling a source of electrical energy to each of said electrically conductive drive lines in said rows and columns;
   f. said electrically conductive columns having isolated perforate openings formed therein at said junction areas, said openings having a substantially constant transverse dimension and having a large peripheral to area ratio with a length to width ratio of about 6, and being disposed along said electrically conductive drive line in enclosed relationship therewithin.

2. The electroluminescent means as defined in claim 1 being particularly characterized in that said isolated perforate openings are slotted openings.

3. The electroluminescent means as defined in claim 2 being particularly characterized in that said slotted openings are in an "O" configuration having an electrical conductor bridging the inscribed and circumscribed area.

4. The electroluminescent means as defined in claim 1 being particularly characterized in that the longitudinal axes of said first plurality of electrically conductive drive lines is arranged at right angles to the longitudinal axes of the second plurality of electrically conductive drive lines.

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