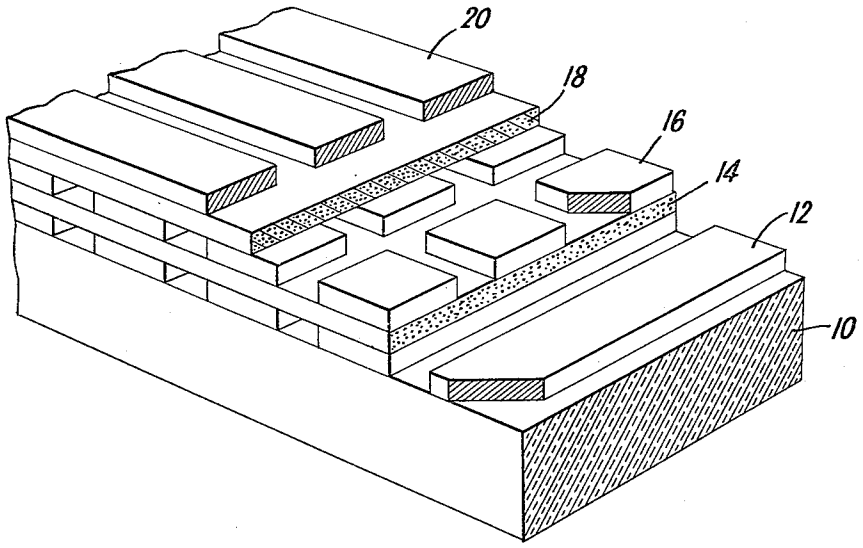
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ELECTROLUMINESCENT DEVICE

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ELECTROLUMINESCENT DEVICE

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My invention is directed toward electroluminescent image display devices.

One type of electroluminescent display device, known as a crossed-grid electroluminescent panel, comprises an electroluminescent layer, one surface of which carries a first array of discretely spaced horizontal conductors, the opposite surface of the layer carrying a second array of discretely spaced vertical conductors. When a suitable voltage is applied between any one horizontal conductor and any one vertical conductor, that portion of the electroluminescent layer (known as a cell) which is connected between these conductors will luminesce.

The applied voltages can be switched or commutated in such manner as to successively energize each cell in turn, thus producing an effect analogous to cathode ray tube "scanning." Under certain circumstances, however, electroluminescent panels of this type will produce spurious luminous effects. These spurious effects can be produced in the following manner. When a positive potential, as for example +V, is applied to a selected horizontal conductor and a more negative potential, as for example, —V, is applied to a selected vertical conductor, all other conductors being held at an intermediate potential, as for example 0, a potential difference of 2V is established between the two selected conductors, and the electroluminescent cell connected between these two conductors will luminesce brightly. At the same time, however, a potential difference of V is established between the selected conductor of each array and the unselected conductors of the other array, and the cells connected between these conductors will luminesce dimly and produce a spurious luminescent pattern.

It is an object of the present invention to improve electroluminescent devices in such manner that spurious luminescent patterns can be eliminated.

Another object is to provide a new and improved electroluminescent panel characterized by the absence of spurious luminescent effects.

Still another object is to eliminate spurious luminous effects in electroluminescent devices of the crossed-grid type by incorporating an electrically non-linear layer and an impedance matching film into the electroluminescent panel.

These and other objects of my invention will either be explained or will become apparent hereinafter.

In accordance with the principles of my invention, I employ a crossed-grid structure provided with a first array of parallel, separated electrical conductors and a second array of vertical, parallel, separated electrical conductors, the conductors in the second array being oriented at an angle other than 0° with respect to the conductors in the first array. An electroluminescent layer is interposed between said arrays. A layer of electrically non-linear material is interposed between the electroluminescent layer and one of the arrays. (This non-linear layer, in response to a voltage applied thereto, exhibits an electrical impedance which decreases as the voltage is increased.) An impedance matching film is interposed between the electroluminescent layer and the non-linear layer, this film being composed of a plurality of separate area-type electrodes, electrically insulated from each other. These electrodes are so arranged that an electrode is positioned at each point at which

a first array conductor crosses over a second array conductor.

When an alternating voltage is applied between a selected horizontal conductor and a selected vertical conductor, the corresponding selected cell will luminesce to a degree dependent upon the magnitude or amplitude of this voltage. Due to the properties of the non-linear layer and the impedance matching film, no spurious luminescent pattern is produced, and the illumination from the selected cell is displayed against an essentially dark background.

The electroluminescent cell acts electrically as a lossy luminous capacitor. The non-linear layer acts electrically as a network constituted by a non-linear resistor shunted by a capacitor. Thus, each horizontal conductor is connected to each vertical conductor through a circuit consisting of the electroluminescent capacitor and the non-linear network connected in series.

When full excitation voltage is applied across the circuit, the impedance of the network should be low relative to that of the cell so that a large portion of the applied voltage appears across the electroluminescent cell, and light is produced. On the other hand, when 50% or less of the full excitation voltage (i.e. that portion of the applied voltage which will produce spurious light signals), is applied across the circuit, the impedance of the network should be high relative to that of the cell so that only a small portion of the applied voltage appears across the electroluminescent cell and no spurious light is produced.

I have found that the combination of the non-linear layer and the impedance matching film adjusts the impedance of the non-linear network in the manner desired. More particularly, at full excitation voltage the non-linear network acts essentially as a resistance of low value, and the electroluminescent cell will luminesce in the desired manner. Further, at 50% or less of the full excitation voltage, the non-linear network acts essentially as a pure capacitance, the relative values of the network capacitance and the cell capacitance being such that only a small proportion of the entire voltage drop appears across the electroluminescent cell, and spurious light signals are not produced.

The impedance matching film serves to adjust the capacitance of the non-linear layer with respect to the capacitance of the electroluminescent cell so as to produce the spurious signal suppression as described above. In the absence of this film, proper impedance ratios cannot be obtained. The net result is that, in my invention, spurious signals cannot be suppressed without the use of the impedance matching film.

An illustrative embodiment of my invention will be described in detail with reference to the accompanying FIGURE.

There is shown a glass substrate **10**, one surface of which is coated with a plurality of horizontal transparent conductors including horizontal conductor **12**. An electroluminescent layer **14** is applied over the horizontal conductors. An impedance matching film is applied over the electroluminescent layer, this film comprising a plurality of electrically conductive squares **16** arranged in rows and columns, each row being in registration with a corresponding horizontal electrode. An electrically non-linear layer **18** is applied over the squares **16**. A set of vertical conductors including vertical conductor **20** is applied over the non-linear layer **18**. When an alternating voltage is supplied between the horizontal electrode **12** and the vertical electrode **20**, those sections of the non-linear layer **18** and the electroluminescent layer **14**, together with the included conductive square **16**, which are subtended between these electrodes, constitute a cell which luminesces in accordance with the amplitude of the ap-

plied voltage, the light emitted travelling through the transparent electrode **12** and the glass substrate **10**. The impedance of the non-linear layer in all other regions but that section subtended between electrodes **12** and **20** has such a high impedance relative to that of the electroluminescent layer that spurious luminescent patterns are eliminated.

Typically, the horizontal and vertical conductors can be formed from tin oxide and the conductive squares can be formed from tin oxide or an opaque metal such as gold. Indeed, the vertical conductors can also be formed from such an opaque material, and, if the horizontal conductors are sufficiently narrow, there also can be formed from an opaque metal.

The non-linear layer can be formed, for example, of cadmium sulfide particles embedded in a glass enamel as disclosed, for example, in my copending patent application Serial No. 796,156 filed February 27, 1959.

The electroluminescent layer, as known to the art, can be formed of electroluminescent zinc sulfide particles also embedded in a glass enamel.

The percentage of resistance of layer **14** with applied voltage is determined by the properties of the material. However, for a voltage of specified frequency and amplitude, the absolute resistance of this layer is determined by its thickness and increases therewith. The impedance of the electroluminescent layer is likewise determined by its thickness. Typically, the non-linear layer can be .008 inch thick and the electroluminescent layer can be .002 inch thick.

The ratio of the capacitive impedance of the non-linear layer to that of the electroluminescent layer can be varied by varying the ratio of the width of the vertical electrodes to the width of the conductive squares. Typical ratios fall within the range 0.25–0.50.

The electrode squares can be, for example, 0.25 inch on a side. A typical horizontal electrode width will be that of the squares, i.e. 0.25 inch.

When an alternating voltage of 250 volts R.M.S. at a frequency of 6000 c.p.s. was applied to a panel having the composition and dimensions previously indicated, it was found that the ratio of the total light emitted from the selected cell to the total light emitted from any other cell was substantially in excess of 10,000:1, i.e. all spurious light signals were reduced to negligible amounts.

In particular, the total light output from the selected cell was about 20 foot lamberts while the maximum light output from any other cell was less than 0.001 foot lamberts.

What is claimed is:

1. An electroluminescent device comprising a first array of parallel separated electrical conductors extending along a first direction; a second array of parallel separated electrical conductors extending along a second and non-parallel direction; a single electroluminescent layer interposed between said arrays; a single electrically non-linear layer interposed between one of said arrays and said electroluminescent layer, said non-linear layer being symmetrically conductive; and an impedance matching film interposed between said electroluminescent layer and said non-linear layer, said layer, said film and said arrays forming an integral structure.

2. An electroluminescent device comprising a first array of parallel separated electrical conductors extending along a first direction; a second array of parallel separated electricl conductors extending along a second and non-parallel direction; a single electroluminescent layer interposed between said arrays; a single electrically non-linear layer interposed between one of said arrays and said electroluminescent layer, said non-linear layer being symmetrically conductive; and an impedance matching film interposed between said electroluminescent layer and said non-linear layer, said film consisting of a plurality of area-type electrodes electrically isolated from each other, said electrodes being positioned that an electrode is positioned at each point at which a first array conductor crosses over a second array conductor.

3. An electroluminescent device comprising a first array of parallel, separated, electrical conductors arranged in rows; a second array of parallel, separated, electrical conductors arranged in columns; a single electroluminescent layer interposed between said arrays; a single electrically non-linear layer interposed between said electroluminescent layer and one of said arrays, said non-linear layer being symmetrically conductive; and an impedance matching film interposed between said electroluminescent layer and said non-linear layer, said film consisting of a plurality of area-type electrodes electrically isolated from each other, said electrodes being arranged in rows and columns which are in respective registration with said rows and columns of the conductors.

4. An electroluminescent device comprising a first array of parallel separated electrical conductors extending along a first direction; a second array of parallel separated electrical conductors extending along a second and non-parallel direction; a single electroluminescent ceramic layer interposed between said arrays; a single electrically non-linear ceramic layer interposed between one of said arrays and said electroluminescent layer, said non-linear layer being symmetrically conductive; an impedance matching film interposed between said electroluminescent layer and said non-linear layer, and a glass substrate, said layer, said film, said arrays, and said substrate forming an integral structure.

5. An electroluminescent device comprising a first array of parallel separated electrical conductors extending along a first direction; a second array of parallel separated electrical conductors extending along a second and non-parallel direction, the conductors of one array being narrower than the conductors of the other array; a single electroluminescent layer interposed between said arrays; a single electrically non-linear layer interposed between one of said arrays and said electroluminescent layer, said non-linear layer being symmetrically conductive; and an impedance matching film interposed between said electroluminescent layer and said non-linear layer, said film consisting of a plurality of rectangularly shaped electrodes electrically isolated from each other, said electrodes being positioned that each electrode is in registration with one first array conductor and with one second array conductor, the long dimension of each electrode being equal to the width of the conductors in said other array.

6. An electroluminescent device comprising a first array of parallel, separated, electrical conductors arranged in rows; a second array of parallel, separated, electrical conductors arranged in columns, the conductors of said first array being narrower than the conductors of said second array, at least one of said arrays permitting the passage of light therethrough; a single electroluminescent ceramic layer interposed between said arrays; a single electrically non-linear ceramic layer interposed between said electroluminescent layer and said first array, said non-linear layer being symmetrically conductive; and an impedance matching film interposed between said electroluminescent layer and said non-linear layer, said film consisting of a plurality of square electrodes electrically isolated from each other, said electrodes being arranged in rows and columns which are in respective registration with said rows and columns of the conductors.

7. An electroluminescent device comprising a first array of parallel separated electrical conductors extending along a first direction; a second array of parallel separated electrical conductors extending along a second and non-parallel direction; a single electroluminescent layer interposed between said first and second arrays; a single electrically non-linear layer interposed between said electroluminescent layer and said first array, said non-linear layer being symmetrically conductive; and an impedance matching film interposed between said electroluminescent layer and said non-linear layer, said film consisting of a plurality

of rectangularly shaped electrodes electrically isolated from each other, said electrodes being positioned so that each electrode is in registration with one of the conductors of the first array and one of the conductors of the second array, the dimension of each electrode in said second direction being greater than the width of the conductors in said first array.

8. An electroluminescent device as defined in claim 7 wherein the ratio of the width of each conductor of the first array to the dimension of each electrode in the second direction falls within the range 0.25–0.50.

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