Dec. 22, 1959 E. G. FRIDRICH 2,918,594

VARIABLE COLOR ELECTROLUMINESCENT LAMP

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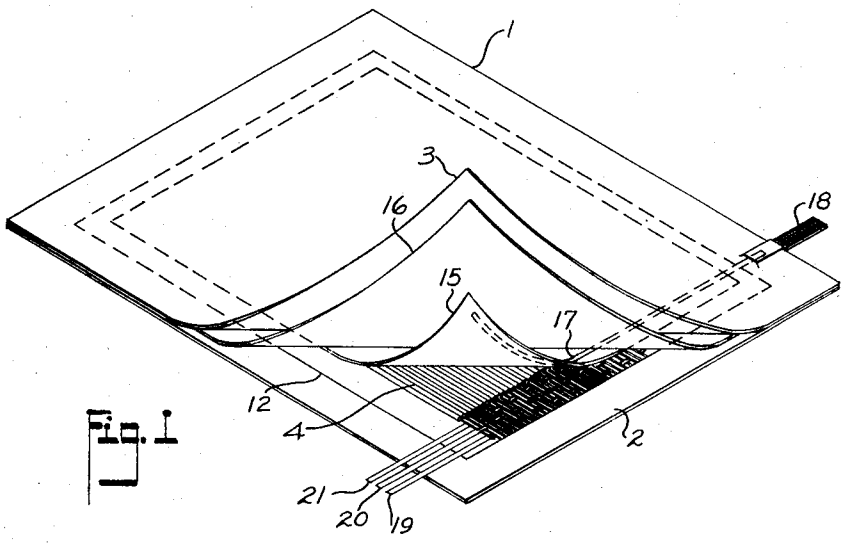


Fig. 1

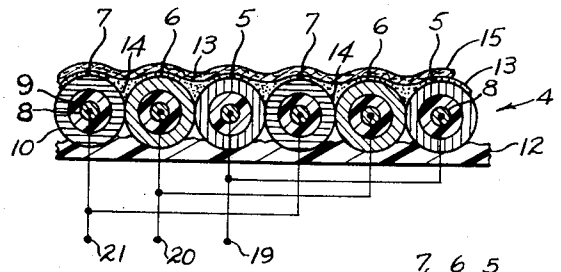


Fig. 2

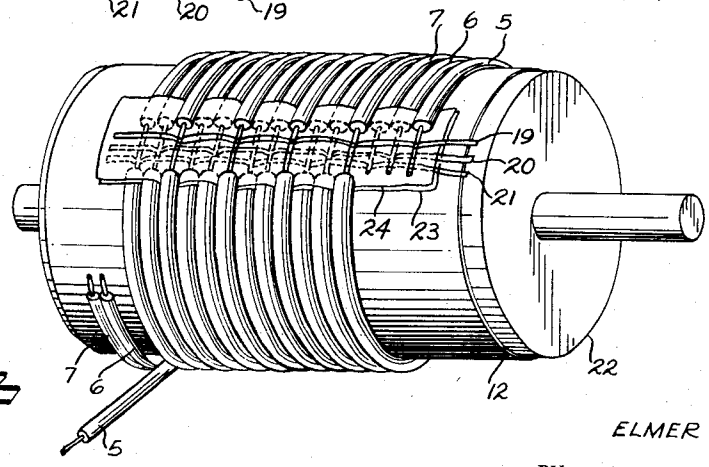


Fig. 3

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VARIABLE COLOR ELECTROLUMINESCENT LAMP

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Application August 1, 1958, Serial No. 752,532
6 Claims. (Cl. 313—108)

This invention relates to electroluminescent cells or lamps, that is to lamps in which an electroluminescent phosphor is excited by an electric field to emit light, and is particularly concerned with a variable color electroluminescent lamp.

An electroluminescent cell generally comprises a layer of phosphor capable of generating light under the action of an electric field, sandwiched between a pair of conducting plates, films or grids one of which is transparent or at least light-transmitting. The color of the light produced is generally determined by the choice of phosphor. Some rather minor changes in color may be effected by varying the applied voltage or its frequency but the variations in color thus obtained are generally not great enough to permit the lamp to be described as a variable color lamp.

It has been proposed to make a variable color electroluminescent lamp in the form of a sandwich containing several layers of phosphors of different colors with transparent conductive layers interleaved between them. In theory at least, by selecting one or the other of the phosphor layers to be energized, it is possible to change the color of light produced by the lamp. The difficulty with this proposal is that the electroluminescent phosphors currently available are not in general transparent so that the front layer or layers of phosphor will absorb a very high proportion of the light produced by the rear layer.

The object of the invention is to provide a new and improved variable color electroluminescent lamp.

A more specific object of the invention is to provide a variable color electroluminescent lamp wherein the phosphors producing the various colors are located in the same plane of the lamp relative to the viewer and wherein transmission of light of one color through the phosphor used to produce light of another color is avoided.

A variable color electroluminescent lamp in accordance with the invention comprises a composite structure of wires or conductors coated with phosphors alternating in color according to a cyclic pattern. The coated conductors are assembled in a repeating order permitting them to be turned on one color at a time or in combination for blending of colors.

In a preferred embodiment, the assembly or grid of phosphor coated wires is coated with a thin film of slightly conducting transparent lacquer over which is applied a sheat of conducting glass paper. This assembly is then encapsulated between sheets of light transmitting thermoplastic material such as polyethylene. A feature of this construction is the optical effect of apparently more uniform brightness of the lighted area over that of an equivalent ray of flat strips. This effect results from the reflection and refraction of light in the valleys between adjacent coated wires.

For further objects and advantages and for a detailed description of a preferred variable color electroluminescent lamp in accordance with the invention and of the manner of making same, attention is now directed to the following description and accompanying drawing. The features of the invention believed to be novel will be more particularly pointed out in the appended claims.

In the drawing:

Fig. 1 is a pictorial view of a laminated variable color electroluminescent lamp embodying the invention, the various constituent layers being delaminated or peeled back at one corner to show the internal construction.

Fig. 2 is a cross sectional view to a much enlarged scale of a portion of the lamp of Fig. 1.

Fig. 3 is a pictorial view illustrating a stage in the making of the coated wire assembly used in the lamp of Fig. 1.

Referring to the drawing and more particularly to Figs. 1 and 2, there is shown a flat rectangular electroluminescent lamp **1** embodying the invention. The electrically active layers of the lamp are encapsulated or encased between a lower sheet **2** and an upper sheet **3** of thermoplastic material welded together along their margins. Examples of suitable materials are polyethylene, polytetrafluoroethylene, chlorotrifluoropolyethylene, and polystyrene. A preferred material consists of high density polyethylene film of 0.003 inch thickness.

The electrically active elements of the lamp comprise a layer **4** of fine wires coated with phosphor and laid side by side in the form of mat. In a three-color lamp, the wires are associated in groups of three, the wires numbered **5**, **6** and **7** corresponding respectively to the colors red, green and blue indicated by conventional color hatching. Each coated wire comprises a metal core **8**, for instance of copper, an insulating coating **9** therearound, and a phosphor coating **10** around the insulating coating. The wire core **8** may consist of one mil copper wire. The insulating coating **9** may consist of barium titanate dispersed in a suitable high dielectric constant binder, for example cyanoethylcellulose plasticized with cyanoethylphthalate, or an epoxy resin. Phosphor layer **10** consists of a suitable electroluminescent phosphor likewise dispersed in a high dielectric constant binder which conveniently may be the same as that used for the insulating layer **9**. The insulating layer and the phosphor layer may each be between **1** and **2** mils thick so that the overall diameter of the coated wires conveniently may be between 5 and 9 mils. The wire layer or mat may comprise for instance 150 wires per inch in width.

The choice of phosphor to be included in the coatings on the wires depends upon the colors desired in the finished lamp. In a three-color electroluminiscent lamp, a suitable phosphor for the red producing wires **5** is zinc sulfide activated with manganese and copper, for instance about 0.7% manganese and 0.15% copper. A suitable phosphor for the blue producing wires **6** is zinc sulfide activated with copper and chlorine in a relatively low concentration, for instance 0.5 mole percent copper and 0.5 mole percent chlorine prior to firing. A suitable phosphor for the green producing wires **7** is zinc sulfide activated with copper and chlorine with a relatively high proportion of chlorine, for instance 0.5 mole percent copper and 2 mole percent chlorine in the prefired material. The foregoing phosphors have been given by way of example only and other phosphors known to the art and suitable for producing the colors desired may be used.

As best seen in Fig. 2 the assembly of phosphor coated conductors is pressed and partly embedded in a base sheet **12** of heat sensitive flexible plastic film, adhesively treated if desired. A suitable material for base sheet **12** is a low density polyethylene film. A thin film **13** of a transparent lacquer which is at least slightly conductive is sprayed over the coated wires to assure that the electrical field will be substantially uniform over the upper half of each phors on the front or viewing side of the cell. At the coated wire surface. The lacquer film penetrates cusplike at least in part into the spaces between the coated conductors as indicated at **14**; this is beneficial in achiev-

ing the desired uniformity of electric field across the phos-same time it has the optical effect of increasing the apparent uniformity of the lighted area, that is it tends to obliterate the line structure. A suitable material for the slightly conductive lacquer is a cement or resin such as an epoxy resin having dispersed in it a mass of conducting glass fibers. For instance a piece of conductive glass cloth may be shredded by chopping on the bias and the mass of fibers then stirred into the cement which is then applied to provide the layer **13**.

The conductive lacquer surface is considerably flatter than the corduroy textured phosphor coated wire surface proper and a sheet **15** of conductive glass paper is applied over it. This sheet may consist of commercially available micro-fiber glass paper 0.001 inch thick made conducting by dipping in a solution of indium basic trifluoroacetate and stannic chloride and then drying and baking at an elevated temperature. Alternatively a wire mesh may be used to apply voltage to the conductive lacquer instead of the conductive glass paper; the mesh should be open enough to avoid excessive obstruction of light. A thin sheet **16** of low density polyethylene is placed over the conducting glass paper and serves to bind the glass paper sheet together and to the conductive lacquer layer **13** when the cell assembly is heat laminated together as shown in Fig. 1. A flattened flexible copper braid or ribbon **17** is laid between the glass paper sheet **15** and low density polyethylene sheet **16** and has attached to it a copper screen tab **18** projecting beyond the edge of the plastic envelope to serve as a common terminal for the lamp. Similar copper ribbons **19, 20** and **21** are connected in a repeating pattern to every third phosphor coated wire in a manner to be more particularly described hereafter and corresponding to the connections schematically indicated in Fig. 2. These may also be provided with screen tab terminals (not shown) similar to tab **18**. Ribbon **19** connected to phosphor coated wires **5** is energized along with common terminal **18** to light the lamp red; similarly ribbon **20** connected to wires **6** lights the lamp green and ribbon **21** connected to wires **7** lights the lamp blue. Of course more than one color phosphor may be energized to produce color blends.

To fabricate the phosphor coated wire assembly of the lamp, coated wire of one color, for instance blue phosphor coated wire **7**, is first wound triple pitch on a cylinder **22** of appropriate size which has been pre-wrapped with heat sensitive flexible plastic sheet **12**, as illustrated in Fig. 3 wherein the wire size is much exaggerated. Flexible copper braid or ribbon **21** is placed along the length of the cylinder over spots laid bare on each turn of wire and is then covered with an insulating strip **23**. Green phosphor coated wire **6** is then wound triple-pitch on the cylinder in the same fashion and copper ribbon **20** placed over the spots laid bare on each turn of wire and then covered over by insulating strip **24**. Finally red phosphor coated wire **5** is wound on the cylinder and fills the gaps between the wires already laid in place. Copper ribbon **19** is placed over the spots laid bare and in this way all the turns of one color are electrically joined in parallel by the copper ribbons **19, 20** and **21**. The thin film of slightly conducting transparent lacquer may then be sprayed over the cylinder which is then heat treated to secure the windings on backing sheet **12**. The assembly is then slit along its length, removed from the cylinder and developed into a plane.

In laminating the various components of the electroluminiscent lamp together, the vacuum plate technique with hydrostatic pressure applied to the electroluminiscent lay-up over a conformable diaphragm described in copending application Serial No. 701,906, filed December 10, 1957, of Elmer G. Fridrich and Paul A. Dell, entitled "Electroluminiscent Lamp and Manufacture Thereof," and assigned to the same assignee as the present invention, may be used.

The specific example of an embodiment of the invention given herein is intended as illustrative and not as limitative of the invention whose scope is to be determined by the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A variable color electroluminescent lamp comprising an assembly of conductors laid alongside one another, said conductors being alternately coated with different color producing electroluminescent phosphors, and means including terminals for applying voltage to the conductors corresponding to said different colors in order to energize selectively said different color producing the phosphors.

2. A variable color electroluminescent lamp comprising an assembly of conductors laid alongside one another, said conductors being alternately coated with different color producing electroluminescent phosphors, terminals for selectively energizing conductors coated with one color of phosphor to produce a given color of light, and a transparent conductive coating applied over said coated conductors.

3. A variable color electroluminescent lamp comprising an assembly of conductors laid alongside one another in a plane, said conductors being alternately coated with different color producing electroluminescent phosphors, terminals connecting the conductors of one color coating in parallel for selectively energizing the lamp to produce a given color of light, and a transparent conductive coating applied over said coated conductors and having a conductive terminals connected thereto to serve in common for all colors.

4. A variable color electroluminescent lamp comprising a plurality of fine conductors laid alongside one another in a plane, said conductors being alternately coated with different color producing electroluminescent phosphors, conductive terminals connecting the conductors of one color coating in parallel for selectively energizing the lamp to produce a given color of light, a coating of a transparent lacquer which is at least slightly conducting applied on one side of said coated conductors, and a sheet thereover of conductive glass fibers having a conductive terminal connected thereto to serve in common for all colors.

5. A variable color electroluminescent lamp comprising a plurality of fine wires coated with a high dielectric constant insulating material laid alongside one another in a plane, said wires being alternately overcoated with different color producing electroluminescent phosphors, conductive terminals connecting the wires of one color coating in parallel for selectively energizing the lamp to produce a given color of light, a coating of a transparent lacquer which is at least slightly conducting applied on one side of said coated wires, and means for applying a voltage to said lacquer coating.

6. A laminated variable color electroluminescent lamp assembly comprising an outer envelope of thermoplastic sheets enclosing an electrically active assembly including a plurality of wires coated with a high dielectric constant insulating material laid alongside one another in a plane, said wires being alternately overcoated with different color producing electroluminescent phosphors, conductive terminals connecting the wires of one color coating in parallel for selectively energizing the lamp to produce a given color of light, a coating of a transparent lacquer which is at least slightly conducting applied on one side of said coated wires, and a sheet thereover of conductive glass fibers having a conductive terminal connected thereto to serve in common for all colors.

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