

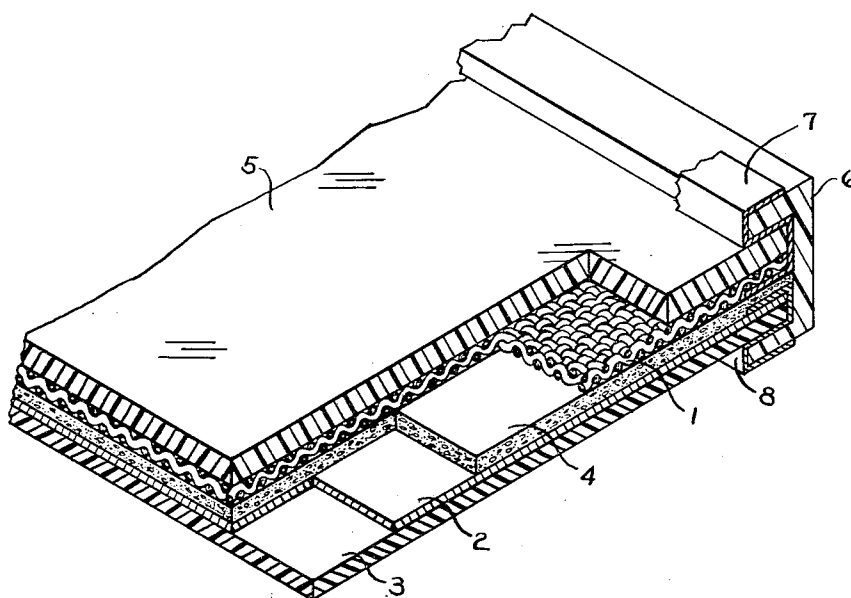
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FLEXIBLE ELECTROLUMINESCENT LAMINATED PANEL

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1

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FLEXIBLE ELECTROLUMINESCENT LAMINATED PANEL

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2 Claims. (Cl. 313—108)

This invention relates in general to electroluminescent devices and more particularly to a laminated electroluminescent panel of a flexible nature and suitable for working or forming into complex shapes.

In the production of light by electroluminescence, a suitable phosphor is subjected to an electric field and the light is generated directly, apparently by the effects of moving electric charges within the crystals of the phosphor. A form of electroluminescent device which holds forth considerable promise comprises a phosphor dispersed throughout a thin layer of dielectric material sandwiched between two conducting plates or surfaces between which a voltage is applied to excite the phosphor. In order to make use of the light generated in the phosphor, one of the conductive plates must be transparent or at least light-transmitting and the material which has been commonly used for this purpose up to the present time is so-called conducting glass.

Conducting glass as presently made is glass having on one surface thereof an electrically conducting iridized metal oxide film integrally united with the surface, suitable metals being tin, indium, and cadmium, either alone or in combination. Such electroluminescent panels however suffer from all the mechanical disadvantages inherent in the use of sheet glass, namely excessive weight, fragility, and difficulty of forming into odd shapes and patterns. It will thus readily be appreciated that such electroluminescent panels are not suitable for large electroluminescent devices such as architectural lamps, or for complexly shaped devices such as switch plates, illuminated symbols, and instrument panels.

An object of the present invention is to provide a new and improved form of electroluminescent panel having the advantages of lightness and flexibility.

Another object of the invention is to provide an electroluminescent panel which can readily be formed or bent into various shapes and designs during the installation thereof.

In accordance with the invention, I have found that it is possible to construct an electroluminescent panel wherein the transparent conductive plate which, up to the present, has generally been conducting glass, is a flexible conductive sheet of compacted glass fibers in the form of conducting glass cloth or paper. The glass cloth or paper is made conductive by subjecting it at a high temperature to the action of chemicals including in salt form one of the metals earlier mentioned which decomposes to form a conductive film integrally united with the surface of the glass fibers.

For a better understanding of the invention and of the advantages which may be realized through it, attention is now directed to the following description of a preferred embodiment thereof taken in conjunction with the accompanying drawing. The features of the invention believed to be novel will be more particularly pointed out in the appended claims.

The single figure of the drawing is a perspective view,

2

partly fragmented along one edge, of an electroluminescent panel embodying the invention, the thickness of the various layers comprised in it being exaggerated for ease of visualizing.

A factor which has, up until the present time, limited electroluminescent devices to rigid panels is the fact that the metal oxide films which provide electrical conductivity combined with optical transparency or translucency, require high temperatures of formation. For instance, glass may be iridized with coatings of tin, indium, cadmium, and zinc base oxides, but in order to obtain appreciable conductivity with any of these formulations, the temperature of the glass must be raised to at least 400° C. In fact, optimum conductivity is generally found in the range of 600° C. or higher. To the best of my knowledge, there is no organic transparent plastic sheet which can be exposed to such temperatures without destruction or at least greater damage than can be tolerated, so that transparent plastic sheets offer of themselves no solution to the problem.

In accordance with my invention, I use glass in a flexible fibrous form and make it conductive by coating the fibers with an appropriate salt of tin, indium, cadmium, zinc or other semi-conducting base. For instance the glass fibers may be drawn at a temperature of approximately 600° C. through an atmosphere of anhydrous stannic tetrachloride (SnCl_4) vaporized in the usual manner by a stream of air passed through it. Other suitable salts may be mixtures of cadmium nitrate ($\text{Cd}(\text{NO}_3)_2$) and indium trichloride (InCl_3) dissolved in water and sprayed in atomized form on the glass fibers. The fibers may then be made into cloth or paper. It will be appreciated that glass paper is made through a process involving pressing the fibers disposed at random into sheets, whereas cloth is made by first forming the fibers or strands into yarn which yarn is subsequently woven in the usual fashion into cloth. It will be appreciated that it is also possible to first make the fiber into the finished paper or cloth as the case may be, and to subsequently spray the paper or cloth in order to render it conductive.

A preferred method of making conductive a fibrous glassy material, be it cloth or paper, consists in dipping the material in a solution of a metal salt, which upon subsequent drying and baking, forms a conducting coating. A suitable solution may consist of indium basic trifluoroacetate $\text{In}(\text{OH})(\text{CF}_3\text{CO}_2)_2$ with stannic chloride (SnCl_4) dissolved in an organic solvent such as ethylene glycol monoethyl ether acetate ("Cellosolve acetate" of Carbide and Carbon Chemicals Corporation). Reference may be made to my copending application No. 347,617, filed April 8, 1953, entitled Conductive Coating on Glass, and assigned to the same assignee as the present invention, for a more complete description of this process and composition. The dipping process has the advantage that the metal salt solution is drawn by capillary action into the spaces between the fibers, so that the conducting coating envelopes the individual fibers of the cloth or paper, resulting in a higher conductivity or lower resistance per square.

Using a fibrous glassy material which has been rendered conductive by iridizing, an electroluminescent panel may be constructed as illustrated in the drawing. The light-transmitting conducting surface of the cell is provided by the iridized glass cloth 1. The cloth may be iridized substantially on the lower side only when a spraying process is used, or it may be iridized on both sides and throughout the body of the fibers or strands when a liquid dipping process is used, a higher conductivity per square being obtained with the latter process. The other conductive plate of the panel is provided by a thin layer of metal 2 which may be adherent to a backing panel 3 of plastic, for

3

instance aluminum deposited by the usual vacuum evaporation process. It will be appreciated that since transparency or translucency is not a requirement for the lower plate of the panel, a variety of materials may be utilized for it, such as metallized or metal-clad plastics or plywood, or a thin metal sheet. Alternately of course, the lower plate may be a second sheet of conducting fibrous glassy material such as the glass cloth 1, where it is desired that the panel radiate light from both sides.

The phosphor is comprised in a layer 4 sandwiched between the glass cloth 1 and the metallized layer 2 and it may take the form of a zinc oxide-zinc sulfide phosphor with suitable activators such as copper, manganese, lead or silver, fired at a temperature in the range from 700° C. to 1200° C. A number of electroluminescent phosphors are at present known to the art and any of these may be utilized in a cell construction within the purview of my invention. Reference may be made to copending application, Serial No. 266,241, filed January 12, 1952, of Herman C. Froelich, entitled "Preparation of Electroluminescent Phosphors," and assigned to the same assignee as the present invention, for a description of a suitable electroluminescent phosphor and a detailed disclosure of the method of its preparation. The phosphor material may be dispersed throughout a suitable solid dielectric to constitute the layer 4, the dielectric material serving at the same time as a cement making the phosphor adherent to the glass cloth 1 and to the metallized layer 2, whereby these electrically active layers of the panel are tightly bound together as a laminate. Where it is necessary to protect the panel from the effects of the atmosphere such as moisture or dust, the glass cloth 1 may be faced with a layer 5 of transparent plastic. Suitable transparent plastics for this purpose may for instance be methyl-methacrylate, cellulose esters and ethers, urea formaldehyde, and phenol condensation products. The edge of the panel may be sealed by a molding 6 of similar material glued on either side to the outer plastic plates 5 and 3 of the panel. Metal tabs 7 and 8 may be provided to serve as terminals for the application of voltage to the cell, the former being extended around the inside of the moulding into an area of contact with the conductive glass cloth 1, and the latter being likewise extended into an area of contact with the metal or metallized layer 2.

While the illustrated embodiment of the invention has

4

been shown as comprising a conductive glass cloth, it will be appreciated that conductive glass paper may likewise be used.

My invention thus provides an electroluminescent panel which has the advantages of flexibility, light weight, mechanical strength, and the ability to be punched, drilled, sawed and bent as desired. While the reticular nature of the conductive glass cloth 1 may result in a somewhat lower electric field on the phosphor lying opposite a hole in the mesh with corresponding loss of luminous output, the loss is not serious and is small in amount, particularly in the case of fine woven cloth or in the case of glass paper where the fibers are laid very close together.

While a certain specific embodiment of the invention has been shown and described, it is intended as exemplary and not as limitative of the invention. The scope of the invention is to be determined by the appended claims which are intended to cover any modifications coming within its true scope and spirit.

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

1. A flexible electroluminescent panel comprising a flexible fibrous glass sheet made of glass fibers individually enveloped in a light-transmitting electrically conductive coating formed thereon, a layer thereover of an electroluminescent phosphor dispersed in a dielectric material adherent to said sheet, and a layer thereover of a conductive material adherent to said dielectric material.

2. An electroluminescent panel comprising a fibrous glass sheet made of glass fibers individually enveloped in formed thereon, a layer thereover of an electroluminescent light-transmitting electrically conductive coating cent phosphor dispersed in a dielectric material adherent to said sheet, a layer thereover of a conductive material adherent to said dielectric material, and a protective light-transmitting sheet of plastic material on the reverse side of said glass sheet from the aforesaid layers.

References Cited in the file of this patent

UNITED STATES PATENTS

2,566,349	Mager	Sept. 4, 1951
2,624,857	Mager	Jan. 6, 1953
2,644,113	Etzkorn	June 30, 1953