

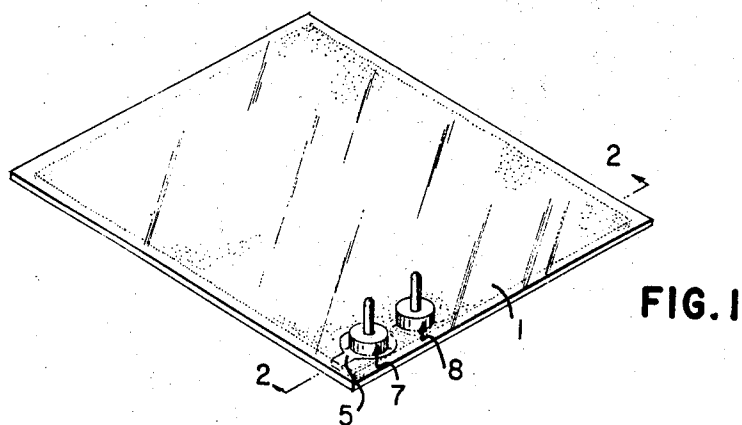
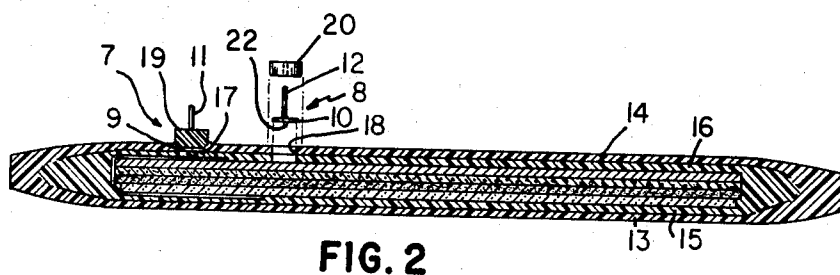
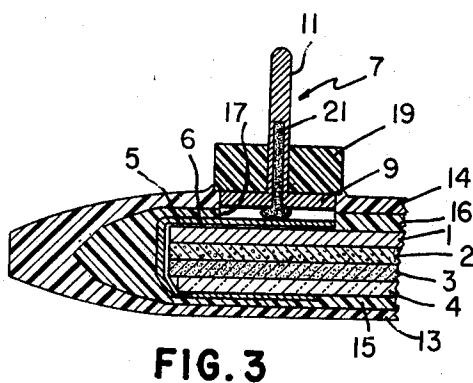
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ENCAPSULATED ELECTROLUMINESCENT DEVICE

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3,509,401 ENCAPSULATED ELECTROLUMINESCENT DEVICE

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5 Claims

ABSTRACT OF THE DISCLOSURE

Electrical connection between an electrode and a lead-in conductor of an encapsulated electroluminescent lamp is established through an electrically conductive rubber insert maintained in compression between the electrode and conductor. The resiliency of the rubber provides uninterrupted electrical continuity when the lamp is subjected to shock and vibration or when the lead-in conductor is flexed.

BACKGROUND OF THE INVENTION

Field of the invention

This invention pertains to electroluminescent devices wherein a phosphor is disposed between two electrodes and emits light when a suitable difference of potential, generally of a varying nature, is applied between the electrodes. The invention particularly relates to improvements in the electrical connection and hermetic encapsulation of flexible electroluminescent lamps.

Description of the prior art

Electroluminescent lamps are generally classified as either rigid or flexible. The rigid lamps usually have at least one electrode made of sheet metal thicker than about 0.020 inch and have the phosphor generally embedded in a dielectric of glass and ceramic. An example of such a lamp is shown in U.S. Patent 3,153,167, issued Oct. 13, 1964 to Rulon et al. In flexible lamps, the dielectric is usually a resin or plastic and, when one of the electrodes is fabricated from sheet metal, the metal is less than about 0.020 inch thick, for flexibility. An example is shown in U.S. Patent 3,161,797, issued Dec. 15, 1964 to Butler et al.

For many applications, such as outdoor use, it is desirable to encapsulate or hermetically seal the lamp in an envelope to prevent humidity penetration, which can deteriorate the luminescent appearance and emission. When a flexible lamp is hermetically sealed in a plastic envelope, the lead-in conductors generally protrude from the edges of the device, as shown in 3,161,797, supra, or in U.S. Patent 3,197,664, issued July 27, 1965 to Sentementes et al. The reason for this type of construction is that a reliable electrical connection between the flat lead-in conductor and the flat electrode can be readily established. Also, the flat lead-in conductors, which protrude through the edge of the plastic envelope, are eminently suitable for satisfactory hermetic encapsulation.

However, in an increasing number of applications of flexible hermetically-sealed electroluminescent lamps, it is desirable to have the lead-in conductors substantially perpendicular to the surface of the lamp. This type of construction reduces the amount of space necessary to mount the lamp and simplifies the electrical connection to an external power source; for example, the lead-in conductors can be short rigid terminals which can be plugged into a socket.

SUMMARY OF THE INVENTION

We have invented a flexible electroluminescent lamp which has improved electrical contacts for better reliability and has improved hermetic encapsulation for increased resistance to the effects of humidity. A feature of the invention is that electrical terminals protruding perpendicularly from one surface of the lamp permit the lamp to be plugged into a suitable socket. The terminals are held securely by plastic flanges which are fused to the encapsulating envelope, thereby effectively hermetically sealing the terminals and preventing humidity penetration into the lamp. Electrical contact from the electrode to the terminal is improved by the use of a resilient electrically conductive rubber insert, maintained under compression by the encapsulating plastic. Thus, flexing or slight bending of the terminals does not interrupt the electrical connection from the terminal to the electrode.

BRIEF DESCRIPTION OF THE DRAWING

FIGURE 1 is a perspective view, partly in section, of a lamp in accordance with this invention.

FIGURE 2 is a cross-sectional view, along the line 2-2, of the lamp of FIGURE 1, showing one terminal and flange prior to insertion.

FIGURE 3 is an enlarged elevational view of an electrical terminal of the lamp.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, electrode 1 is made of an electrically conductive material, usually sheet metal less than about 0.020 inch thick for flexibility, and preferably of aluminum. Aluminum provides a good base for the subsequent layers to be applied, is readily available in rolls for semi-continuous production and can be obtained in various thicknesses and widths with electrically clean surfaces. Dielectric 2 is an insulating layer on electrode 1 and is usually a high dielectric constant material, about 1 or 2 mils thick, which provides a good base for the light-emitting phosphor layer 3. Dielectric 2 and phosphor 3 can be the materials such as shown in previously mentioned Patent 3,197,664, that is, barium-strontium titanate dispersed in cyanoethylcellulose and copper-activated, zinc sulfide phosphor dispersed in cyanoethylcellulose, respectively. Light transmitting electrode 4 is usually made of electrically conductive glass paper or fibers, about 1 or 2 mils thick, and is disposed on phosphor layer 3. To prevent the possibility of electrode 4 short circuiting to electrode 1, a small margin is left around the periphery of electrode 4, as shown in FIGURE 3.

In order for terminals 7 and 8 to protrude from the same surface of the lamp, that is, from the surface of electrode 1 as shown in FIGURE 1, it is necessary for a conductor to contact electrode 4, extend to the surface of electrode 1 and be insulated from the latter. A partially insulated flat metal ribbon 5, preferably of copper, is used for this purpose. One side of ribbon 5, excepting that portion which is in electrical contact with electrode 4, is electrically insulated by bonding a thin plastic film 6, such as cellulose acetate or Mylar, to the ribbon. The uninsulated portion is then placed on electrode 4, or on a flat conductor thereon, and taped in place to establish electrical contact between ribbon 5 and electrode 4. The remainder of ribbon 5 is then bent around the edges of electrode 4, phosphor 3, dielectric 2 and electrode 1 and onto the surface of electrode 1 so that insulation 6 prevents ribbon 5 from short circuiting to electrode 1. Preferably, insulation 6 also overlaps slightly on electrode 4 to further provide against a short circuit. To insure good electrical contact between ribbon 5 and electrode 4, the

uninsulated portion of ribbon 5 can extend almost the entire length of electrode 4 in contact therewith. To insure satisfactory contact between ribbon 5 and terminal 7, that portion of ribbon 5 which can contact disk portion 9 of terminal 7 has an increased area, substantially circular and slightly greater than the diameter of disk 9. The greater diameter of the insulated circular portion of ribbon 5 also prevents any possibility of disk 9, when properly positioned against ribbon 5, from overlapping and short circuiting to electrode 1.

The entire device is then encapsulated between two overlapping sheets 13 and 14 of thermoplastic material which flow under heat and pressure and fuse together along the margins. The material selected must be reasonably tough and stable, in addition to being light-transmitting and fairly flexible. Examples of such materials are polyethylene, polycarbonate, chlorotrifluoroethylene and polystyrene. A preferred material is polycarbonate film about 20 or 30 mils thick. The encapsulation inhibits the penetration of water vapor into the device, which, as previously mentioned, deteriorates the lamp. It also physically protects the lamp from, for example, abrasion or accidental scratching, which might remove parts of the various layers. Additionally, in our invention, the encapsulation holds and secures flanges 19 and 20, in addition to terminals 7 and 8, and aids in making electrical contact, as will be explained later, to disks 9 and 10. For even greater protection, the device may be encapsulated in two different materials, selected for their particular superior properties. As illustrated in FIGURES 2 and 3, the device can be first encapsulated in two sheets 15 and 16 of a thermoplastic material having superior moisture vapor transmission properties, such as chlorotrifluoroethylene, and then in two sheets 13 and 14 of a thermoplastic material such as the previously-mentioned polycarbonate, selected for its toughness and fusibility, the latter in order to provide for the subsequent hermetic seal to flanges 19 and 20.

Two holes 17 and 18 are then drilled through plastic sheets 14 and 16 to expose the metallic surface of ribbon 5 and electrode 1. The holes must be drilled with care in order not to damage or drill through the metal substrates and, preferably, a flat ended drill, such as an end mill, is used. Alternatively, holes 17 and 18 may be pre-punched in sheets 14 and 16 prior to the encapsulation, but suitable removable inserts must then be positioned in the holes during the heat-sealing operation to prevent holes 17 and 18 from distorting. Holes 17 and 18 are of the proper diameter to accommodate disks 9 and 10 of terminals 7 and 8. Also, hole 17 is centrally located on, and is of smaller diameter than, the circular end of ribbon 5.

Metal terminals 7 and 8 comprise cylindrical hollow pins 11 and 12, which are closed at one end and centrally fastened at the opposite end to disks 9 and 10. Holes through the centers of disks 9 and 10 are in communication with the bore of pins 11 and 12. Resilient cylindrical inserts 21 and 22, preferably made of electrically conductive rubber, are inserted through the holes of disks 9 and 10 completely into the bore of pins 11 and 12 up to the closed ends, with a short length protruding beyond disks 9 and 10. Circular flanges 19 and 20, made of the same material as sheets 13 and 14, are then positioned on terminals 7 and 8. Axial holes through flanges 19 and 20 are of the proper size to provide a tight fit when the pins 11 and 12 are inserted therethrough. The length of flanges 19 and 20 is shorter than the length of the pins 11 and 12 so that the latter protrude when flanges 19 and 20 are flush against disks 9 and 10. Flanges 19 and 20 are of greater diameter than holes 17 and 18 in order to overlap sheet 14 and to provide a satisfactory hermetic seal when subsequently fused therewith.

Terminals 7 and 8 with flanges 11 and 12 thereon, are then centrally positioned in holes 17 and 18 and the entire device is placed into a suitable press, which is de-

signed to exert heat and pressure on pins 11 and 12, flanges 19 and 20 and the underlying and immediately adjacent area of sheet 14. During sealing, the protruding ends of rubber inserts 21 and 22 are compressed between ribbon 5 and disk 9 and between electrode 1 and disk 10, respectively. After the flanges 19 and 20 have completely fused to sheet 14 to form a hermetic seal, the finished lamp is removed from the press. The jointure of the flanges with sheet 14 maintains compression on rubber inserts 21 and 22 for substantially the life of the lamp, which provides improved electrical continuity between the terminals and electrodes when the terminals are flexed or when the lamp undergoes vibration or shock. The design and construction of terminals 7 and 8 also permit simple electrical connection of the lamp to an external power source merely by plugging it into a suitable socket.

In a specific example of a lamp about 3 inches square, designed for 110 volt A.C. operation, electrode 1 was made of 5 mil thick aluminum. Dielectric 2 was 1 mil thick and was deposited on electrode 1 from a solvent dispersion of cyanoethylcellulose and powdered barium titanate. After drying, phosphor layer 3 was next deposited from a solvent dispersion of cyanoethylcellulose and powdered copper-activated zinc sulphide to a dry film thickness of 2 mils. Electrode 4 comprised a commercially available micro-fiber glass paper 1 mil thick, made conductive by dipping into a solution of indium basic trifluoroacetate and stannic chloride dissolved in ethylene propyl monoethyl ether acetate, drying and then baking at an elevated temperature. It was fused to phosphor 3 by heat sealing with a thin film of nylon and, in order to prevent short circuiting to electrode 1, a small margin was left around the periphery of electrode 4.

Ribbon 5 was made of 5 mil thick copper $\frac{3}{32}$ inch wide, with an overall length of $\frac{5}{8}$ inch and a diameter at its circular end of $\frac{5}{16}$ inch. Except for $\frac{1}{8}$ inch at its narrow end, all of one side was insulated by adhesively bonding 2 mil Mylar to the ribbon. A self-sticking adhesive coating was then applied to the Mylar. Ribbon 5 was then bent, as previously mentioned, around one end near a corner of the device, with the $\frac{1}{8}$ inch bare end in electrical contact with a strip of 5 mil copper, about $2\frac{1}{2}$ inches long and $\frac{1}{32}$ inch wide, which was taped to the surface of, and in electrical contact with, electrode 4 near an edge.

The device was then heat sealed under pressure between sheets 15 and 16, which were made of chlorotrifluoroethylene film, 9 mils thick, the edges of which extended $\frac{1}{16}$ inch beyond the periphery of electrode 1. In the same manner, the device was then encapsulated between sheets 13 and 14, made of polycarbonate film, 30 mils thick, and which extended beyond sheets 13 and 14 about $\frac{1}{16}$ inch. The polycarbonate film fused at a lower temperature than the chlorotrifluoroethylene, about 350° F. versus 425° F. respectively, and thus sheets 15 and 16 were not distorted by the subsequent fusion of sheets 13 and 14.

Holes 17 and 18, $\frac{7}{32}$ inch in diameter, were carefully drilled through sheets 14 and 16 with an end mill, to expose electrode 1 and the central part of the circular end ribbon 5. Metal terminals 7 and 8 comprised disk portions 9 and 10, 0.210 inch diameter by $\frac{1}{32}$ inch thick, centrally fastened to partially hollow pins 11 and 12 as previously described, which were $\frac{1}{4}$ inch long by 0.050 inch in diameter. Conductive rubber inserts, 21 and 22, $\frac{3}{16}$ inch long by $\frac{1}{32}$ inch diameter, were inserted into the bore of the pins through holes at the center of disks 9 and 10 so that $\frac{1}{32}$ inch of the rubber inserts protruded beyond the face of the disks at complete insertion. Circular flanges 19 and 20 were made of polycarbonate plastic and had a 0.050 inch diameter hole through the center which resulted in a tight fit around pins 11 and 12 when terminals 7 and 8 were inserted on flanges 19 and 20. The face of flanges 19 and 20, which were flush against disks 9 and 10, had a diameter of $\frac{7}{16}$ inch, thereby overlapping the disks

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by about $\frac{7}{64}$ inch. Flanges 19 and 20 were $\frac{3}{32}$ inch long, so that $\frac{5}{32}$ inch of pins 11 and 12 protruded in order to provide for subsequent external power connection.

Terminals 7 and 8, with flanges 19 and 20 thereon, were positioned in holes 17 and 18 and the entire device placed in a heat sealing press. During heat sealing, the $\frac{1}{32}$ inch protruding portions of rubber inserts 21 and 22 were compressed and the $\frac{7}{64}$ inch overlapping portions of flanges 9 and 10 were fused to the underlying and immediately adjacent area of sheet 14. After fusion, pressure was maintained on the terminals and flanges until the polycarbonate had cooled below its working temperature. On removal from the press, the rubber inserts are maintained in compression by the jointure of the flanges to encapsulating sheet 14 which is firmly sealed around the entire device. The finished lamp was then energized by plugging pins 11 and 12 into a suitable 110 volt A.C. receptacle.

Solvent fusion may be substituted for the heat sealing of the flanges to the other encapsulating layer 14 by, for example, softening the areas to be joined by the application of a suitable solvent such as methylene chloride, in the case of polycarbonate film. A similar pressure, as was applied during heat sealing, is applied and maintained until all traces of the solvent have evaporated, and the plastic has hardened again.

In the specific example mentioned, rubber inserts 21 and 22 had an electrical resistivity of 7 ohm-centimeters. However since electroluminescent lamps commonly draw a current of only a few milliamperes, the resistivity of the rubber inserts was very small compared to the resistivity of the lamp itself. Therefore, resistivities of the inserts in the order of a hundred or a thousand ohm-centimeters would still be satisfactory in our invention. The inserts must also be resilient enough that they will not overcome the compressive force maintained by the jointure of flanges 9 and 10 to sheet 14. Rubber having a Shore A Hardness of 65 had sufficient resiliency for our invention. Although it is possible for the insert to be compressed sufficiently to permit contact between, say, ribbon 5 and substantially the entire face of disk 9, there can be a relaxation of the encapsulating plastic upon removal from the press, which will permit a gap of several mils to develop therebetween. If the inserts were not present in such a case, the contact might be intermittent and unreliable. In addition, if the terminal deviated slightly from the perpendicular, only one point at the periphery of disk 9 or 10 would be in contact, which might also cause an intermittent connection whenever the terminal was slightly flexed, as could occur during insertion of the lamp into a socket. It is also possible that a particle of dirt or plastic at this one point of the peripheral contact could prevent electrical continuity.

It is also within the contemplation of this invention that the conductive rubber insert need not be cylindrical nor inserted into the bore of the terminal pin, but could be flat or any other convenient shape, and positioned entirely between the flat portions of the terminals and the adjacent electrode or conductor. In such a case, its resiliency must still be such as to not completely overcome its compression from the pressure sealing operation.

As used in this specification, the term "rubber" is not confined only to the commonly accepted natural and synthetic rubbers, but has a broader definition as in Webster's Dictionary: "something made of or resembling rubber." This includes, for example, elastomeric resins and plastics or other materials having rubber-like properties of flexibility, resiliency and elasticity.

It is apparent that modifications and changes can be

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made within the spirit and scope of the instant invention, but it is our intention to be limited only by the appended claims.

We claim:

1. An electroluminescent lamp comprising:
 - a two superposed electrodes, at least one of which is light transmitting;
 - a layer of electroluminescent phosphor interposed between said electrodes;
 - a flat U-shaped electrical connector insulatively disposed on the first of said electrodes, extending beyond and around the edges of said electrodes and said phosphor layer, and in electrical contact with the second of said electrodes;
 - two spaced apart metal terminals disposed on one surface of said lamp, each of said terminals comprising a cylindrical hollow pin closed at one end and a disc centrally attached to said pin at the other end thereof;
 - and an electrically conductive rubber insert disposed within each of said hollow pins, the insert in the first of said terminals being in compressive electrical engagement with the first of said electrodes, and the insert in the second of said terminals being in compressive electrical engagement with said metal connector.
2. The lamp of claim 1 comprising, in addition, a transparent plastic envelope hermetically encapsulating said lamp, said terminals protruding through said envelope.
3. The lamp of claim 2 wherein said rubber inserts are maintained in compression by said encapsulating envelope.
4. An electroluminescent lamp comprising:
 - two superposed electrodes, at least one of which is light transmitting;
 - a layer of electroluminescent phosphor interposed between said electrodes;
 - two spaced apart metal terminals disposed on one surface of said lamp, each of said terminals comprising a hollow cylindrical pin and a disc centrally attached thereto;
 - means electrically connecting one of said terminals with one of said electrodes and the other of said terminals with the other said electrodes, said means including an electrically conductive rubber insert disposed within each of said hollow pins;
 - a plastic flange sealably disposed about each of said pins and abutting the corresponding disc;
 - and a transparent plastic envelope hermetically encapsulating said lamp, said envelope being sealed to said plastic flanges.
5. The lamp of claim 4 wherein said plastic envelope comprises an inner layer and an outer layer of transparent thermoplastic materials, the material of said outer layer having a lower sealing temperature than that of said inner layer, and said plastic flanges are sealed to said outer layer.

References Cited

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