Nov. 5, 1963 R. P. DELACHAPELLE ETAL 3,109,959

ELECTROLUMINESCENT DEVICE WITH A FUSIBLE ELEMENT

Filed June 21, 1961

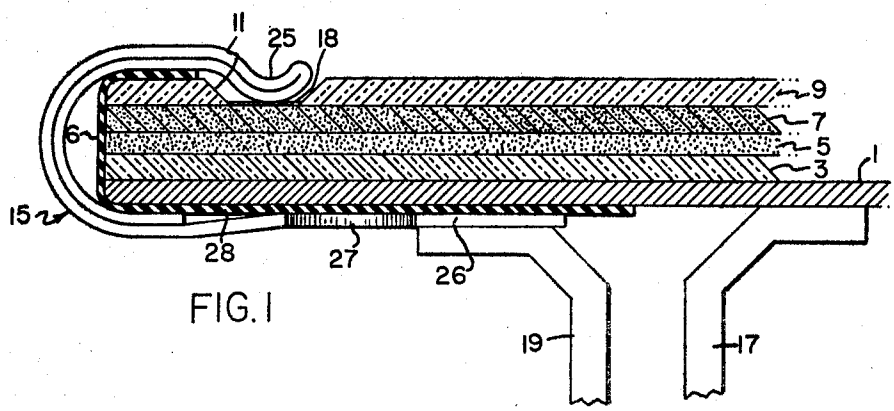

FIG. 1

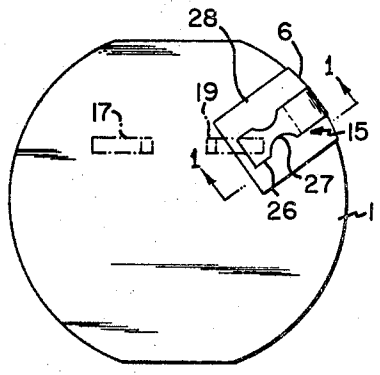

FIG. 2

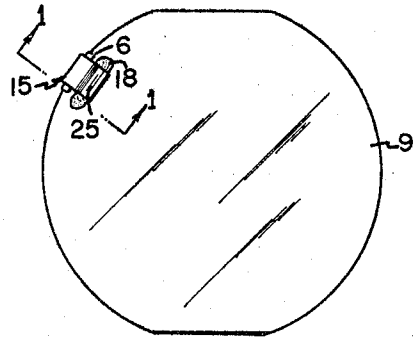

FIG. 3

RICHARD P. DELACHAPELLE
HENRY T. HIDLER
INVENTORS

BY

ATTORNEY

United States Patent Office 3,109,959 Patented Nov. 5, 1963

3,109,959
ELECTROLUMINESCENT DEVICE WITH A FUSIBLE ELEMENT

Richard P. Delachapelle, Gloucester, and Henry T. Hidler, Peabody, Mass., assignors to Sylvania Electric Products Inc., a corporation of Delaware

Filed June 21, 1961, Ser. No. 126,416
2 Claims. (Cl. 315—74)

This invention relates to electroluminescent devices. Most electroluminescent devices have two superposed electrodes, at least one of which is light transmitting, with a layer of an electroluminescent photophor, usually disposed in a light-transmitting dielectric material, positioned between them. When a voltage, generally varying or alternating, is applied, light is emitted from the phosphor and passes through the light-transmitting electrode. In most devices having commercial application, electrical contact with the light-transmitting electrode is rather difficult to establish since the material is usually prepared of a very thin, fragile coating of electrically conducting material, such as tin oxide. Conventional means for establishing electrical contact, such as soldering or welding, are unsatisfactory, since the attaching material will not readily adhere to the coating.

Because of such difficulties, prior means of establishing electrical contact with the electrodes have been rather large and bulky. Since one advantage of an electroluminescent device is that it may be formed in a compact, planar shape, electrical contact elements which protrude from the flat surface are often undesirable.

Accordingly, an object of our invention is the attainment of a compact electroluminescent device having an easily assembled, generally flat electrical contact.

Another object of our invention is the inclusion of a fuse in the electrical contact, thereby increasing the compactness of the device and minimizing parts.

An advantage of our invention is the reliable and positive nature of the electrical connection with the light-transmitting electrode of the device and a further advantage is that such contact is obtained with a minimum of parts.

A feature of the electroluminescent device of our invention is a resilient, U-shaped cross-over connector embodying a fuse in a unitary construction.

These and other objects, features and advantages will become apparent to those skilled in the art upon reading the following specification when taken in conjunction with the accompanying drawing in which:

FIGURE 1 is a cross-sectional view of an electroluminescent device taken along the lines 1—1 of either FIGURES 2 and 3 and showing an electroluminescent device having a U-shaped cross-over connector positioned about the side thereof, one end of which is in contact with lead-in prongs and the other end of which is in contact with the light-transmitting electrode.

FIGURE 2 is a rear view of an electroluminescent device showing a cross-over connector including a fuse attached to and insulated from the device.

FIGURE 3 is a view of the light-emitting face of an electroluminescent device showing the cross-over connector in electrical contact with a metallized surface on the light-transmitting electrode.

In each of the figures of the drawing, similar numerical designations are indicative of similar elements.

Referring to FIGURE 1, a cross section of an electroluminescent device is shown together with a resilient, U-shaped cross-over connector for conducting electricity from lead-in prongs to the light-transmitting electrode. Base electrode **1** of the device is preferably prepared of a steel plate, since this material is relatively economical and structurally is quite stable. However, it is apparent that many other materials also have applicability, for example, base electrode **1** may be prepared of metal foil or of materials, such as plastic or glass, which have been rendered electrically conductive. When using these latter examples, the device has the added features that it may have two light-emitting faces or may be flexible or both.

When desired, a ground coat **3**, generally prepared of a layer of low melting, ceramic dielectric material of known and suitable composition, is coated over the base electrode **1**, to provide a bonding surface for light-producing layer **5**. It has been found that when using a metal plate for the base electrode **1**, permanent adherence of a glass dielectric, light-producing layer **5** is rather difficult to establish, unless a ground coat is used. However, the ground coat **3** may be omitted if the light-producing layer **5** readily adheres to the base electrode **1**, such as would be the case if the base electrode **1** is prepared of electrically conductive glass or if the phosphor suspending dielectric is plastic.

Superimposed on the ground coat **3** or on the base electrode **1**, as desired, is a light-producing layer **5**, which is generally prepared of an electroluminescent phosphor suspended in a light-transmitting dielectric material. The electroluminescent phosphor may be for example, a copper-activated zinc sulfide such as described in the copending application of Goldberg et al. entitled Electroluminescent Device, Serial No. 714,481, filed February 11, 1958, now Patent No. 3,050,655, issued August 21, 1962. The light-transmitting dielectric material may be for example, a glass frit such as described in the application of Richard M. Rulon, Serial No. 365,617, filed July 2, 1953, now abandoned, although a suitable plastic dielectric may also be used, such as described in the copending application of Sentementes et al. entitled Electroluminescent Devices and an Improved Dielectric Material for Such Electroluminescent Devices, Serial No. 94,536, filed March 9, 1961.

Superimposed on the light-emitting layer **5** is a coating which forms a light-transmitting electrode **7**. The coating may be applied by spraying the light-emitting layer **5** with a solution of metal compounds, for example chlorides, oxides, sulfates or organic complexes of tin, antimony or indium; however other available methods of applying such compounds or the metals to form an electrically conductive coating are for example, dipping and vapor deposition. If the light-emitting layer **5** is hot when the solution of metal compounds is applied, the metal oxide of the metal compound will be formed; however such metal oxides may also be formed by subsequently heating a light-emitting layer which was coated while cold.

After the application of the light-transmitting electrode **7** on the face of the light-emitting layer **5**, it is good practice to protect the various layers of the electroluminescent device from the effects of humidity and the possibility of scratching. Such protection is conveniently afforded by forming a glass or plastic protective layer **9** over the light-transmitting electrode **7**. In some cases, however, the protective layer may be eliminated and the light-transmitting electrode **7** will then serve as the face of the device. Since protective layer **9** is an insulator and since electricity must be conducted to the light-emitting electrode **7** to illuminate the device, a cavity **11** is provided in the protective layer **9** to expose the conductive material for an electrical connection. Conveniently, the cavity **11** may be prepared by masking the light-transmitting electrode **7** before the protective layer **9** is applied, and afterward removing the mask so that the light-transmitting electrode **7** is exposed.

Because of the fragility of the light-transmitting electrode **7** and to inhibit the effect of the humidity upon the phosphor, a small dab of finely divided metal dispersed in a resin, such as silver dispersed in epoxy, is placed in the cavity **11**. The preferred method of preparing the cavity **11**, however is to spray-paint a small silver area on the light-transmitting electrode **7**, before the protective layer **9** is applied and afterwards remove the protective layer over the silver to expose a silver area. After hardening, the metal will fill the bottom of cavity **11** and form a solid, electrically conducting, metallized surface **18** on light-transmitting electrode **7**, thus providing a durable foundation for resilient, U-shaped cross-over connector **15**. We have found that metals which are not readily oxidized, such as the noble metals, are most appropriate for the metallized surface **18** although other metals, such as aluminum or copper may also be used.

For many applications of electroluminescence, such as room illumination, it is desirable to plug the device directly into convention wall sockets. Therefore, lead-in prongs **17** and **19**, having outer ends of well known and suitable design for use with such sockets are placed in a supporting holder (not shown) and the inner ends are placed in electrical contact with the electroluminescent device. Lead-in prong **19** biases against lead-in contact portion **26** of cross-over connector **15** and lead-in prong **17** biases against back electrode **1**. Current will be conducted from a power source (not shown) through lead-in prong **19** and lead-in contact **26**, through fuse **27** and thence to light-transmitting electrode **7** through metallized surface **18**.

Insulator **28** is disposed beneath the device and between cross-over connector **15** and base electrode **1**, thereby insulating the cross-over connector **15** from base electrode **1**. A side insulator **6** is wrapped about the side of the electroluminescent device to insulate cross-over connector **15** from the sides of the various layers of the device. To insure adequate insulation, save materials and eliminate inordinate bulk, the side insulator **6**, which wraps about the side of the electroluminescent device, is formed of a unitary prolongation of the insulator **26**. The side insulator **6** is at least sufficiently long to wrap over the side of the electroluminescent device and preferably long enough to cover a small area of the protective layer **9**. It is at least as wide as the cross-over connector **15** and preferably a little wider to insure electrical insulation. Insulator **28** and side insulator **6** may be prepared of any suitable and well-known pliant insulating material, for example a plastic such as Mylar or vinyl, although other flexible insulators, such as rubber, may also be used. In addition to insulation, when using the preferred dimensions for side insulator **6**, the possibility that a cross-over connector **15** might scratch the protective layer **9** is reduced.

The cross-over connector **15** not only is the electrical connection between the light-transmitting electrode **7** and the lead-in prong **19**, but it also secures and retains the insulator **28** on the electroluminescent device. Greater retention and permanence of electrical contact is produced by increasing the resiliency of the cross-over connector and such increased resiliency can be obtained by doubling the light-transmitting electrode contact end of the connector **15** back over itself, so that there are two layers of resilient material biasing against the upper surface of the device. We have found that tempered steel is quite efficient for conducting electricity and retaining the insulator **26**, however many other materials such as aluminum, bronze, copper and nickel may also be used.

Even when a metallized surface **18** is applied to the light-transmitting electrode **7**, care must be taken to avoid the possibility of scratching. Therefore, as an additional safeguard, a depression **25** is placed in the end of cross-over connector **15** which contacts the light-transmitting electrode and because of this construction, only smooth, rounded surfaces will touch the more easily scratched

portions of the device. Since the rounded surfaces yield more freely, the legs of the U of the cross-over connector **15** will spread more readily and thus, the connector **15** is easily slipped over the side of the electroluminescent device.

Referring jointly to FIGURES 2 and 3, the cross-over connector **15** is a unitary strip of metal in electrical contact with lead-in prong **19** and insulated from the back electrode **1** by insulator **28**. Lead-in contact portion **26** of the cross-over connector may be of any appropriate size and may be shaped as desired, however for efficient electrical contact we prefer a contact portion at least as large as the lead-in prong. Spring biased prongs are generally preferred for conducting current to the lead-in contact portion **26**, although many other suitable means for conducting current to the device may also be used, for example it is possible to weld or solder lead-in wires to the lead-in contact portion **26**. Although the peripheral shape and size of the lead-in contact portion **26** is not critical, we prefer a generally rectangular shape, since the entire cross-over connector **15**, including the fuse, is formed from a single strip of metal.

Insulator **28** must be of sufficient area to separate cross-over connector **15** and fuse **27** from the electroluminescent device. Any desired shape insulator may be used, but for convenience of manufacture we prefer one having a generally rectangular shape. Extending from the central portion of one edge of the insulator **28** is a side insulator **6** which wraps around the side of the device and insulates the cross-over connector **15** from the sides of the various layers. Because heat is generated if the fuse **27** burns out, the insulator **28** must be sufficiently thick to absorb such generated heat without burning through and we have found that for a 10 amp. circuit a Mylar insulator should be at least 0.005 inch thick. The thickness of the insulator, of course, will vary depending upon the characteristics of the circuit and may be determined by routine experimentation.

With regard to the construction of the fuse, we prefer to grind a recession on opposing sides of one end of the cross-over clip **15**, however other procedures may also be used, for example, it may be possible to stamp out or acid etch these recessions on one or both sides of the metal strip. The peripheral shape of the recession forming the fuse is of no particular significance, so long as the fuse breaks at the desired current value and although we have shown rounded neck, it is possible to use rectangular or other angular shapes with equal success. The width and thickness of the neck of the fuse is quite important however, and may be determined empirically to satisfy the characteristics of the circuit. For example, a 10 amp. steel fuse, which will be operated with a 110 volt circuit should have a neck which is $\frac{1}{16}$ inch wide at its narrowest point and should be 0.003 inch thick.

It is apparent that changes and modifications may be made within the spirit and scope of the instant invention, but it is our intention however, to be limited only by the scope of the appended claims.

As our invention we claim:

1. In combination, an electroluminescent device having a light-transmitting electrode superposed on a base electrode and a layer of light-emitting material including an electroluminescent phosphor positioned between said electrodes; a fuse disposed under said base electrode, said fuse being defined by a pair of opposed recesses disposed on either side of a resilient metal strip; means to conduct current from said fuse to said light-transmitting electrode, said means comprising a resilient, U-shaped cross-over connector positioned about the side of said device and disposed at one end in electrical contact with said light transmitting electrode and extending at the other end as a unitary prolongation of said fuse; an insulator positioned between said base electrode and said fuse adapted to insulate said fuse from said base electrode;

a side insulator extending as a prolongation of said insulator and positioned between said cross-over connector and the side of said device.

2. The device according to claim 1 wherein said U-shaped crossover connector is doubled on itself and clamped on the top and bottom of said device.

References Cited in the file of this patent

UNITED STATES PATENTS

2,704,341	Stacy et al.	Mar. 15, 1955
2,908,806	Cohen	Oct. 13, 1959
2,922,912	Miller	Jan. 26, 1960
2,934,627	Bristol et al.	Apr. 26, 1960