

May 31, 1966

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3,254,254

CONTACT STRUCTURE FOR AN ELECTROLUMINESCENT DEVICE

Filed May 17, 1963

2 Sheets-Sheet 1

FIG. 1.

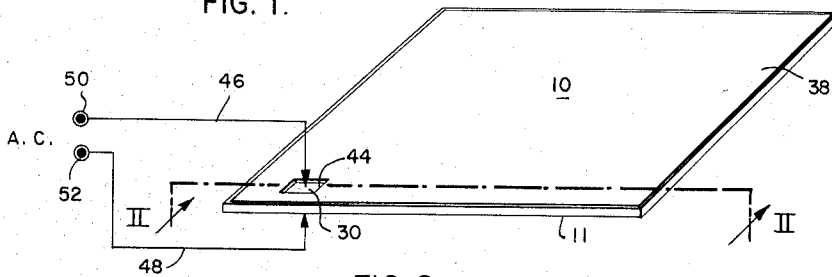


FIG. 2.

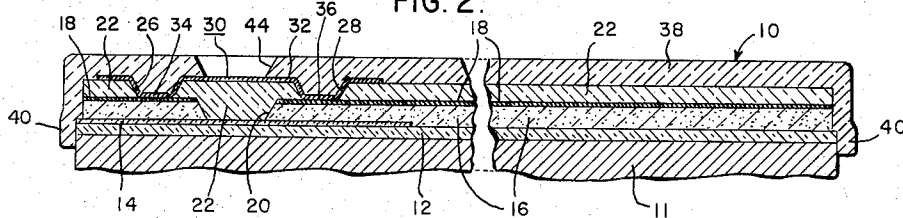


FIG. 3.

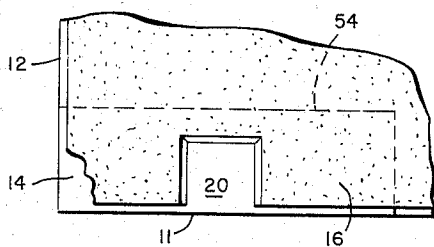


FIG. 4.

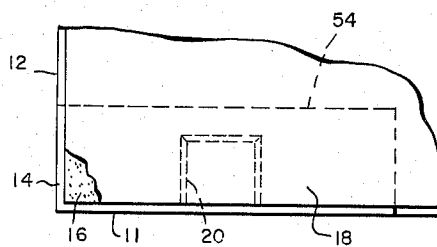


FIG. 5.

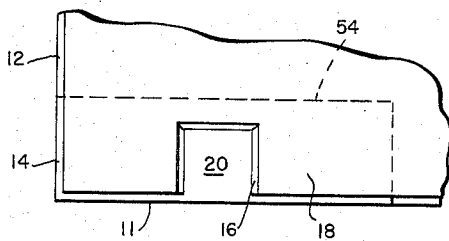


FIG. 6.

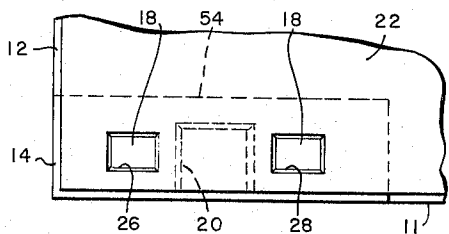
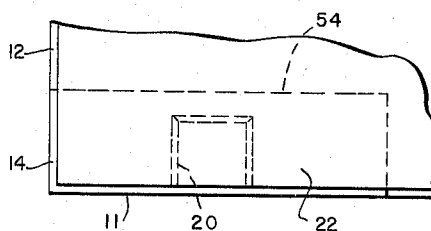


FIG. 7.

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FIG. 8.

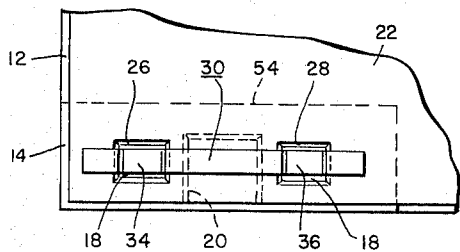


FIG. 9.

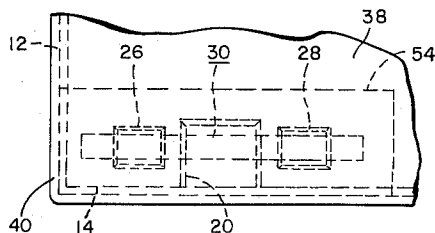


FIG. 10.

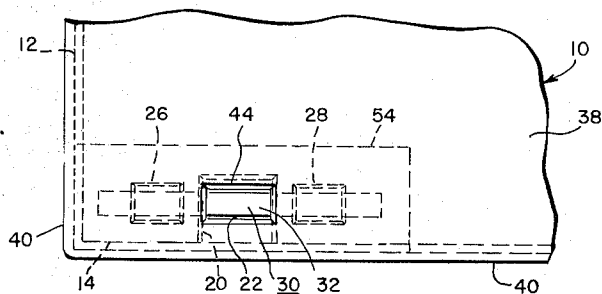


FIG. 11.

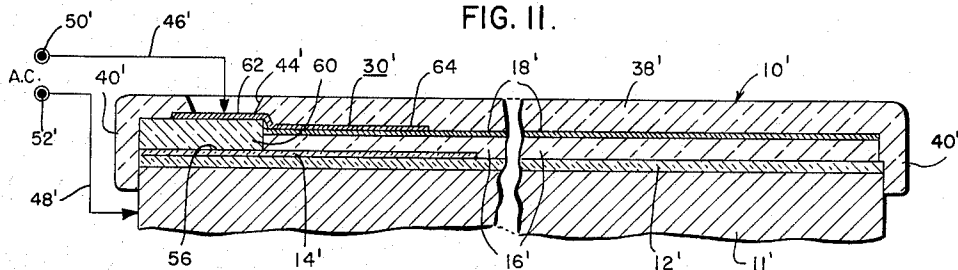
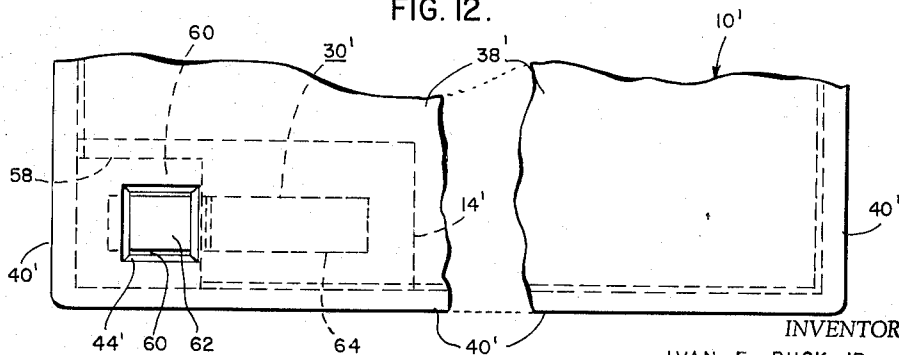


FIG. 12.



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3,254,254 CONTACT STRUCTURE FOR AN ELECTRO- LUMINESCENT DEVICE

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9 Claims. (Cl. 313-108)

This invention relates to electroluminescent lamps and, more particularly, to improved contact assemblies for such lamps and the manufacture thereof.

As is known, an electroluminescent lamp comprises a layer of dielectric material containing an electroluminescent phosphor sandwiched between a pair of electrodes. In the usual case, one electrode is opaque and covered with a light-colored enamel or the like, while the other electrode is light-transmitting. Covering the light-transmitting electrode is a layer of glass or other similar protective material. Upon the establishment of a suitable electrical potential across the electrodes, the phosphor will luminesce and give off light through the light-transmitting electrode and the protective layer.

One of the problems encountered in making such lamps resides in the difficulty of providing a suitable electrical contact for the light-transmitting electrode which overlies the phosphor-bearing dielectric layer. The generally accepted procedure for establishment of contact to this electrode is to have a small area of the electrode uncovered by the protective layer of glass. At most, a layer of burnish silver may be fired in place in this open area to establish a better surface for pressure or soldered leads.

The phosphor-dielectric layer is the most easily attacked layer in the lamp and, since it is adjacent the contact area in prior art assemblies, this location is weak, makes the connection of a lead to the upper electrode difficult without damaging the phosphor layer, and causes most of the lamp failures. This is especially true in the case of high humidity where lamp failure generally occurs rapidly.

As an overall object, the present invention provides an improved electroluminescent lamp structure which overcomes the above and other disadvantages of prior art lamps.

Another and more specific object of the invention is to provide an improved contact assembly for the light-transmitting electrode of an electroluminescent lamp, which assembly will prevent damage and failure of the lamp at the contact area due to humidity and other factors.

In accordance with the invention, the improved contact assembly comprises a bus bar having a first portion which contacts the upper light-transmitting electrode and which is sealed into the lamp structure during the manufacture thereof, and a second portion which is exposed by means of an opening in the glass protective cover. Preferably, an insulating layer of glass is placed under the phosphor glass layer in the area covered by the bus bar to reinforce it and thus prevent breakage of the seal when a lead is attached to the contact.

In the manufacture of the lamp assembly, a reinforcing layer of glass or the like is initially deposited on the lower or base electrode in the area of the contact. Thereafter, the phosphor-bearing layer and light-transmitting front electrode are formed and an opening is provided therein above the aforementioned glass-reinforcing layer. This opening is then filled with a body of glass or other insulating and reinforcing material which projects above the upper surface of the front electrode, and a bus bar of burnish silver or the like is then applied over a region such that it has a first portion which covers the afore-

said body of insulating material and a second portion which contacts the front electrode. Finally, a protective layer of glass or other similar material is applied to the entirety of the lamp structure except for the portion of the bus bar which is above the opening in the upper electrode and the dielectric phosphor layer. In one embodiment of the invention, the final protective glass layer is applied in one coat; whereas in another embodiment it is applied in two coats. In both cases, however, the result is the same, namely, a contact assembly which is sealed into and comprises an integral part of the lamp and is also reinforced against mechanical and electrical breakdown.

The foregoing and other objects and features of the invention will become apparent from the following detailed description taken in connection with the accompanying drawings which form a part of this specification, and in which:

FIGURE 1 is a perspective view of an electro-luminescent device incorporating the improved contact assembly of the invention;

FIG. 2 is an enlarged sectional view taken along line II-II of FIG. 1;

FIG. 3 is a fragmentary top view of the left-hand corner of the lamp of FIG. 1, showing the lower electrode with a base coat of reinforcing glass over it at the contact area and a phosphor glass layer applied thereover as the first step in the manufacture of the electroluminescent lamp of the invention;

FIGS. 4-10 show successive phase or steps in the manufacture of the lamp of FIGS. 1 and 2;

FIG. 11 is a cross-sectional view, similar to that of FIG. 2, of an alternative embodiment of the invention; and

FIG. 12 is a fragmentary top view of the alternative embodiment shown in FIG. 11.

EMBODIMENT I

Referring now to the drawings, and particularly to FIGS. 1 and 2, the lamp shown is designated generally by the reference numeral 10 and includes a lower or base electrode 11 comprising a substrate of stainless steel or the like coated with a white porcelain enamel base layer 12. At one corner of the electrode 11, over which the contact is positioned, is a reinforcing localized layer 14 of an insulating glass which fires at the same temperature as the white porcelain enamel 12. Deposited over the enameled electrode 11 as well as the glass reinforcing layer 14 is a phosphor-containing layer 16 of glass, while above the layer 16 is a layer of light-transmitting conductive material such as tin oxide that serves as the upper or front electrode 18. The arrangement of these components is such that when a suitable electrical potential is established between electrodes 11 and 18, the phosphor embedded in layer 16 will luminesce to give off light which passes through the front electrode 18.

Provided in the phosphor-dielectric layer 16 and the front electrode 18 is an uncoated area or opening 20 (see FIG. 2) which lies above the reinforcing layer 14. After the layer 16 and electrode 18 are applied and the opening 20 formed, a first layer 22 of a suitable glass protective enamel is applied over the entire surface of the electrode 18 and extends down into the opening 20 where it engages the glass reinforcing layer 14.

As will also be noted in FIG. 2, two smaller apertures 26 and 28 are provided in the protective glass layer 22 on either side of the opening 20 to expose the light-transmitting electrode 18. An elongated bus-bar 30 having a raised portion 32 that overlies the reinforcing glass layer in opening 20, and depressed portions 34 and 36 which extend into the apertures 26 and 28 is provided in this region and connects with the front electrode 18. Above

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the first glass protective layer 22 is a second glass protective layer 38 which extends down over the edges of the assembly to provide an overlapping lip 40 that is bonded to the base electrode 11 and seals off the laminated cell structure from the atmosphere. An opening 44 is provided in the final glass coat 38 directly above the raised portion 32 of the bus-bar 30. This raised portion is thus exposed and serves as one of the lamp contacts.

As shown in FIG. 1, electrical leads 46 and 48 connect the base electrode 11 and the bus-bar 30 to an energizing voltage source through input terminals 50 and 52. The leads may be connected to the aforesaid base electrode and bus-bar by soldering or pressure techniques. Since the front electrode 18 is completely covered or encased, it is not exposed and vulnerable to attack by water vapor or other impurities. Furthermore, the support provided by the glass layer 22 and the lower reinforcing glass layer 14 in the contact area assures that the bus-bar 30 will not break away from the glass protective seals when connection is made with the front contact by soldering or pressure techniques. This construction also provides additional protection against electrical break-down in this critical area.

FABRICATION

The manufacture of the lamp 10 is illustrated in step-by-step fashion in FIGS. 3-10. With reference, first, to FIG. 3, the metal base electrode 11 coated with porcelain enamel 12 is initially coated at one corner with the glass reinforcing layer 14 over a predetermined rectangular region, the outline of which is defined by the broken line 54. Such porcelain enamels are well known and it is deposited by spraying the upper face of the electrode 11 to form a layer about 4 to 12 mils thick. Thereafter, the area which will be under the bus-bar 30 is reinforced by the localized application of a suitable insulating glass 14 which fires at the same temperature as the white porcelain enamel. After drying, the electrode 11 is fired at a temperature to fuse the coatings. As an example, the enamel may be a material commercially available as "Pemco Neowhite #44," in which case the assembly is fired at 800° C. for five minutes.

After the application of the reinforcing glass layer 14 and firing in the manner described above, a layer 16 of admixed phosphor and glass frit is deposited over the entire face of the metal base 11. The layer 16 is the top layer as viewed in FIG. 3 and has its lower left-hand corner broken away to expose the glass reinforcing layer 14 and facilitate the illustration of the invention. Then a rectangular area is cleared of the glass-phosphor layer 16 to provide an opening 20 and expose the glass reinforcing layer 14. The layer 16 may be deposited by settling, spraying or screen processing techniques in a manner such that a margin of about one-eighth inch remains around its edges to expose the underlying edges of the enamel layer 12 and reinforcing glass layer 14. After drying, the assembly is again fired.

As a specific example of a suitable glass-phosphor mixture, about 70 parts by weight of a glass frit having a lower firing temperature than that of the enamel layer 12 is mixed with 30 parts by weight of ZnS:CU electroluminescent phosphor and a suitable vehicle such as 30 parts by weight of Du Pont "K-595 Squeegee Oil." This mixture is then screened through a 163 mesh nylon onto the substrate and fired at 620° C. for five minutes. The glass frit may be of the type disclosed in U.S. Patent No. 3,005,722 to N. F. Cerulli. The thickness of this layer may vary from one-half mil to several mils.

At the conclusion of the firing operation of the glass-phosphor layer 16, it is sprayed with tin chloride (SnCl₄) while at a temperature of about 550° C. to provide the conductive light-transmitting or front electrode 18 (FIG. 4). This front electrode is then isolated from the base electrode 11 by a light sandblasting operation to provide a clear margin along the edges.

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As shown in FIG. 5, the rectangular opening 20 is then cleared of front electrode 18 to again expose the lower glass reinforcing layer 14. The first layer 22 of powdered glass protective enamel is then applied over the entire face of the assembly, as shown in FIG. 6, by the methods described in connection with the application of the phosphor-bearing glass layer 16. After the protective glass layer 22 has dried, two relatively small areas are cleared to form the rectangular apertures 26 and 28 and expose the electrode 18, as shown in FIG. 7. This layer is then fired to form a fused coating. Any suitable glass having a lower firing temperature than that of the glass frit employed in making the glass-phosphor layer 16 can be used as this cover coat.

The bus-bar 30 (FIG. 8) of burnish silver is then applied by screening or painting over an area such that it spans the apertures 26 and 28 in layer 22 and the opening 20 which has been filled by a plug of glass that comprises part of the layer 22. As will be noted in FIG. 2, the bus-bar 30 thus formed has two depressed portions 34 and 36 which make contact with the front electrode 18.

After the bus-bar 30 has dried, the second protective layer 38 of glass is applied (FIG. 9) over the assembly by the same method and from the same material as described in connection with the layer 22. However, this layer 38 extends around the underlying layers and forms an overlapping lip 40 that is bonded to edges of the base electrode 11 (see FIG. 2) and thus seals off the lamp from the atmosphere. When the second cover coat 38 has dried, an opening 44 (FIG. 10) is provided therein that is aligned with the opening 20 and thus exposes a predetermined area of the raised portion 32 of the bus-bar 30. The completed assembly is then fired at about 650° C. for five minutes to fuse the second cover coat and anchor it in place. The top contact can be made by pressure techniques or soldering as described above.

EMBODIMENT II

In FIGS. 11 and 12 there is shown another embodiment of the invention wherein elements corresponding to those shown in FIGS. 1-10 are identified by like, primed reference numerals. It will be noted that the lamp 10' again includes a metal base electrode 11' of stainless steel or the like which is coated with a white porcelain enamel layer 12'. Over the enamel layer 12' in a localized area is an insulating and reinforcing glass layer 14'. Over this reinforcing layer and the remainder of the porcelain enamel layer 12' is a phosphor-glass layer 16' which, in turn, is coated with a light-transmitting electrode 18'.

In the manufacture of the lamp 10' shown in FIGS. 11 and 12, the glass reinforcing layer 14' is initially applied, followed by the application of the glass-phosphor layer 16' in the manner described in connection with the embodiment of FIGS. 1-10. In the glass-phosphor layer 16' there is provided an opening 56 which exposes a rectangular corner-portion of the reinforcing glass layer 14', the outline of which is indicated by the broken line 58 in FIG. 12. This portion is then painted with an oil paste of clear glass frit which may, for example, be of the same material as the cover coats 22 and 38 described in connection with the embodiment of FIG. 2 as well as the cover coat of the present embodiment, hereinafter described. The clear glass coating in this region is applied thicker than the glass-phosphor layer 16' to provide a glass insulating block 60 (FIG. 11). With this construction, it will be noted that a stepped effect is produced between the block 60 and the glass-phosphor layer 16'.

After drying of the glass material forming the block 60, the coated substrate is fired at 620° C. for five minutes. The front light-transmitting electrode 18' is applied as the laminated substrate is withdrawn from the furnace. When cool, the electrode 18' is removed from the edges of the substrate and also from the area above the block 60.

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An elongated bus-bar 30' of burnish silver is then applied over the top of the block 60 and onto the adjacent portion of the front electrode. The bus-bar 30' thus has a raised portion 62 that overlies the block 60, and a depressed portion 64 which makes contact with the transparent electrode 18', as shown in FIG. 11. After the bus-bar 30' has dried, a cover coat 38' of the same material as cover coats 22 and 38 in FIG. 2, is applied over the entire assembly and provided with an overlapping lip 40' which seals the entire assembly off from the atmosphere. When the cover coat 38' dries, a small rectangular area is removed to form an aperture 44' and thus provide access to the bus-bar 30'. The lamp is fired at 650° C. for five minutes to fuse the cover coat 38' and complete the fabrication.

The present invention thus provides new and improved electroluminescent lamp structures wherein the difficulties previously encountered in providing suitable contact assemblies are eliminated by effectively sealing a portion of the contact bus-bar into the lamp structure and by reinforcing the area beneath the bus-bar. Although the invention has been shown in connection with certain specific embodiments, it will be readily apparent to those skilled in the art that various changes in form and arrangement of parts may be made to suit requirements without departing from the spirit and scope of the invention.

I claim as my invention:

1. In an electroluminescent device of the type having a base electrode and a superposed light-transmitting front electrode, a layer of dielectric material containing an electroluminescent phosphor sandwiched between said electrodes and a protective layer of insulating light-transmitting material covering said light-transmitting electrode; an improved contact assembly for the light-transmitting electrode comprising an opening in said light-transmitting electrode and said dielectric layer containing the electroluminescent material, a body of electrical insulating material in said opening, an elongated contact strip of conductive material having a portion which overlies said body of insulating material and another portion which connects with said light-transmitting electrode, and an opening in said protective layer exposing a predetermined area of the portion of said contact strip which overlies the body of insulating material, the portion of said strip that connects with said light-transmitting electrode being covered by and hermetically united to said protective layer so that the strip constitutes a sealed-in contact for said device.

2. In an electroluminescent device of the type having a base electrode and a superposed light-transmitting front electrode, a layer of dielectric material containing an electroluminescent phosphor sandwiched between the electrodes and a protective layer of insulating light-transmitting material covering said light-transmitting electrode; an improved contact assembly for the light-transmitting electrode comprising an opening in said light-transmitting electrode and said dielectric layer containing the electroluminescent material, a first layer of electrical insulating material beneath said opening and projecting above said base electrode, a second layer of electrical insulating material in said opening and projecting above said light-transmitting electrode, an elongated contact strip of conductive material having a first portion which overlies said second layer of insulating material and a second portion which connects with said light-transmitting electrode and is located beneath and is bonded to said protective layer, and an opening in said protective layer exposing at least a part of said first portion of the contact strip.

3. An electroluminescent device comprising a base electrode and a superposed light-transmitting front electrode, a layer of dielectric material containing an electroluminescent phosphor sandwiched between said electrodes, an opening in said light-transmitting electrode and said dielectric layer, a body of electrical insulating material in

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said opening and projecting above said light-transmitting electrode, a contact strip of conductive material having a portion which overlies said body of insulating material and a depressed portion which is connected to said light-transmitting electrode, and a protective layer of light-transmitting insulating material covering the entirety of said light-transmitting electrode and said contact strip except for a predetermined area of the portion of said strip which overlies said body of insulating material and is thus exposed and serves as a contact for said device.

4. An electroluminescent device comprising, a base electrode and a superposed front electrode, said base electrode comprising a metal substrate coated on its upper surface with porcelain enamel and said front electrode being light-transmitting, a layer of glass containing an electroluminescent phosphor sandwiched between said electrodes, an opening in said front electrode and said glass-phosphor layer, a body of electrical insulating material in said opening and projecting above said front electrode, a contact strip of conductive material having a portion which overlies said body of insulating material and a depressed portion which is connected to said front electrode, and a protective light-transmitting layer of glass covering the entirety of said front electrode and said contact strip except for a predetermined area of the portion of said strip which overlies said body of insulating material and is left exposed to serve as a contact for said device.

5. The electroluminescent device of claim 4 wherein; the body of insulating material beneath the contact strip comprises glass, and the contact strip is formed from burnish silver.

6. An electroluminescent device comprising a base electrode and a superposed light-transmitting front electrode, a layer of dielectric material containing an electroluminescent phosphor sandwiched between said electrodes, an opening in said front electrode and said phosphor-dielectric layer, a first layer of electrical insulating material beneath said opening, a second layer of electrical insulating material within the opening and projecting above said front electrode, a contact strip of conductive material having a portion which overlies said second layer of insulating material and a depressed portion which is connected to said front electrode, and a protective layer of light-transmitting vitreous material covering the entirety of said front electrode and said contact strip except for a predetermined area of the portion of said strip which overlies said second layer of insulating material which thus remains exposed and serves as a contact for said device.

7. In an electroluminescent device comprising a base electrode and a superposed front electrode that is light-transmitting, a layer of dielectric material containing an electroluminescent phosphor sandwiched between said electrodes, an opening in said front electrode and said phosphor-dielectric layer, a first layer of transparent insulating material covering said front electrode and extending into said opening, a pair of apertures in said first layer of transparent insulating material disposed on either side of said opening and exposing said front electrode, a contact strip of conductive material extending over said opening and into said pair of apertures where they connect with said front electrode, and a second layer of transparent insulating material covering said first layer and said contact strip except for a predetermined portion of said strip between said pair of apertures, said predetermined portion being above the opening in said front electrode and said phosphor-dielectric layer and comprising an exposed contact for said device.

8. An electroluminescent device comprising a base electrode and a superposed front electrode that is light-transmitting, a layer of dielectric material containing an electroluminescent phosphor sandwiched between said electrodes, a first layer of glass between said base electrode and said phosphor-dielectric layer, said first layer covering only a localized area of said base electrode, an

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opening in said front electrode and said phosphor-dielectric layer above said first glass layer, a second layer of glass covering substantially the entirety of said front electrode and extending into said opening, a pair of apertures in the second layer of glass disposed on either side of said opening and exposing said front electrode, a contact strip of conductive material extending between and into said pair of apertures and connected to said front electrode, and a third layer of glass covering said second glass layer and said contact strip except for a predetermined portion of said strip that is located between said pair of apertures and above said opening and thus comprises an exposed contact for said device.

9. An electroluminescent device comprising a base electrode and a superposed front electrode that is light-transmitting, a layer of dielectric material containing an electroluminescent phosphor sandwiched between the conductive layers, an opening in said front electrode and said phosphor-dielectric layer, a block of electrical insulat-

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ing material in said opening projecting above the front electrode, a contact strip of conductive material having a first portion which overlies said insulating block and a second depressed portion which connects with said front electrode, and a protective layer of transparent insulating material covering said front electrode and said contact strip in their entirety except for a predetermined area of said first portion of the strip which overlies said insulating block and comprises an exposed contact for said device.

References Cited by the Examiner

UNITED STATES PATENTS

2,900,271	8/1959	Macintyre et al.	117—33.5
3,109,958	11/1963	Delachapelle et al.	313—108 X
3,153,167	10/1946	Rulon et al.	313—108

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