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I. E. BUCK, JR., ET AL
 ELECTROLUMINESCENT DISPLAY DEVICE WITH IMPROVED SEGMENTED
 ELECTRODE AND TERMINAL STRUCTURE
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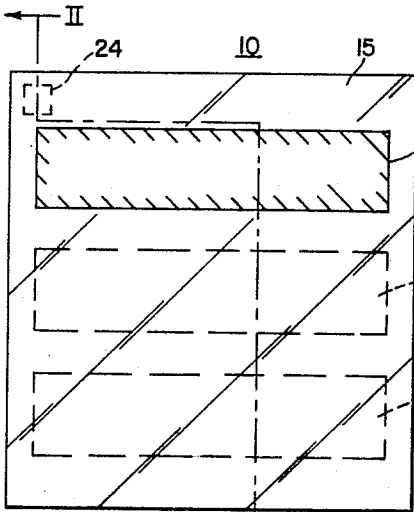


FIG. 1.

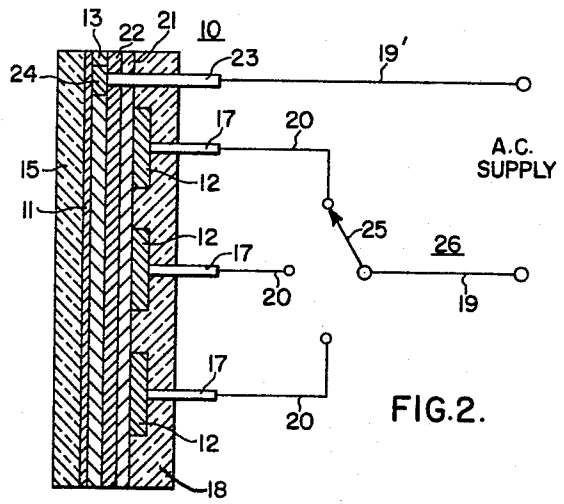


FIG. 2.

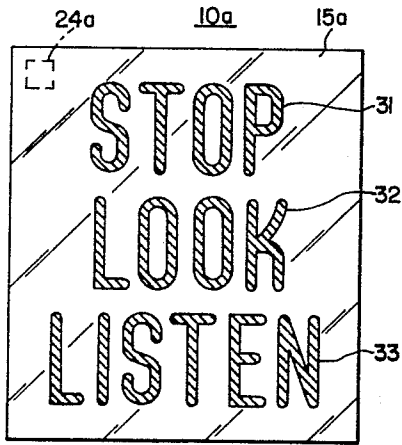


FIG. 3.

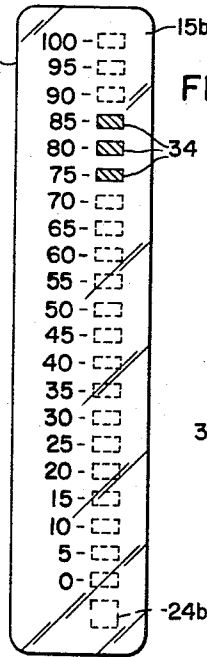


FIG. 4.

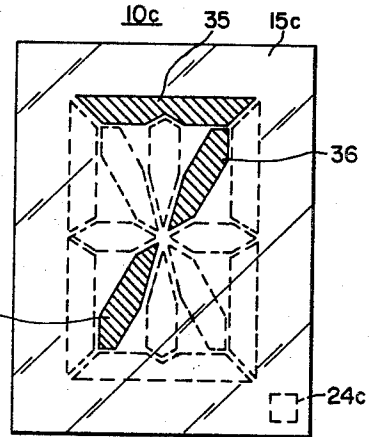


FIG. 5.

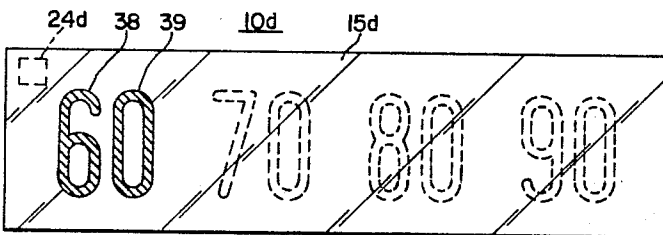


FIG. 6.

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ELECTROLUMINESCENT DISPLAY DEVICE WITH IMPROVED SEGMENTED ELECTRODE AND TERMINAL STRUCTURE

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This invention relates, generally, to electroluminescent devices and, more particularly, to electroluminescent display devices of a segmented or digital type.

Electroluminescent devices normally comprise a metallic backing plate which acts as one electrode, a layer of phosphor impregnated in a dielectric coated thereover, and a light transmitting electrode over the phosphor-dielectric layer. The light-transmitting electrode normally comprises a layer of tin oxide on a glass foundation although other light-transmitting, electrically continuous materials may be substituted therefor, such as a layer of copper iodide deposited directly onto the phosphor-dielectric layer. If desired the phosphor material and the dielectric material may be applied as separate layers. In the conventional electroluminescent device, a metallic backing plate, which may be composed of steel or aluminum, mechanically supports the other layers of the device which are quite thin and have little mechanical strength.

The usual construction of a segmented metal-ceramic lamp, such as a digit display device, requires intricate and difficult configuration on the front transparent electrode. In addition, the problems of mounting and insulating contact members and sealing are considerably increased. A certain amount of masking is also required to conceal the leads to the electrode segments.

An object of this invention is to simplify and improve the structure of a metal-ceramic segmented electroluminescent device.

A more specific object of the invention is to eliminate the foregoing undesirable characteristics of prior electroluminescent devices by segmenting the rear electrodes instead of the front electrodes.

Another object of the invention is to provide means for supporting and insulating the segmented rear electrodes of such a device.

A further object of the invention is to provide contact members for the front and the rear electrodes to which electrical connections may be readily made at the rear of the electroluminescent device.

Other objects of the invention will be explained fully hereinafter or will be apparent to those skilled in the art.

In accordance with one embodiment of the invention, the rear metal electrode of an electroluminescent device is constructed of preformed individual segments embedded in a ceramic insulating material capable of supporting the other laminations or layers of the device. A contact pin which is joined to or constitutes an integral part of the metal electrode segments extends through the ceramic material to the rear of the device where it is accessible for making electrical connections thereto. An additional contact pin which is connected to the front electrode also protrudes through the ceramic material to the rear of the device. The electrode segments may be of a variety of shapes such as words, letters of the alphabet, numerals, geometrical figures or digital display members which are preformed from enameling steel, aluminum or other sheet metal. They can also comprise preshaped metal forms or castings. The embedding

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ceramic is capable of being fired with the metal without fracturing or softening.

For a better understanding of the nature and objects of the invention, reference may be had to the following detailed description, taken in conjunction with the accompanying drawing, in which:

FIGURE 1 is a view, in front elevation, of an electroluminescent device embodying principal features of the invention;

FIG. 2 is a view, in section, taken along the line II-II in FIG. 1, and

FIGS. 3 to 6, inclusive, are views, in front elevation, of different modifications of the invention illustrated in FIGS. 1 and 2.

Referring to the drawing, and particularly to FIGS. 1 and 2, the electroluminescent device 10 shown therein comprises a light-transmitting front electrode 11, a composite rear electrode consisting of a plurality of metal segments 12, and a layer 13 of electroluminescent phosphor disposed between the front and rear electrodes. The front electrode 11 consists of a thin, light-transmitting, electrically-conducting layer of tin oxide, or other suitable material, and has a transparent cover coating 15 thereover. The cover coating 15 may be fused glass or a suitable transparent plastic material. Other materials such as, for example, indium oxide, bismuth oxide or aluminum oxide may be utilized in place of the tin oxide.

The phosphor layer 13 may comprise any electroluminescent phosphor material which can be energized by an electric field to produce visible light. As a specific example, the electroluminescent material may comprise zinc sulfide activated by copper and coactivated by chlorine, or others which are well known to the art.

The rear composite electrode comprises a plurality of preformed planar metal segments 12 of preselected configuration each one of which has a conducting member or pin 17 extending from its rear surface. The planar electrode segments may be formed from a suitable metal such as, for example, enameling steel or aluminum.

In order to insulate and support the metal electrode segments 12 and also to support the other layers of the device, the aforesaid electrode segments are embedded in and thus hermetically united to front face of an insulating glass or ceramic member 18. As shown in FIG. 2, the electrode segments 12 are so embedded that their exposed surfaces are flush with the front face of the supporting member 18 thereby providing a substantially flat supporting surface for the other layers of the device. The pins 17 protrude through the glass or ceramic member 18 to the rear of the device and thus provide an exposed terminal for electrical contact to each, or simultaneously to a multiplicity, of the metal electrode segments 12. The embedding ceramic or glass must be capable of being fired with the metal electrode segments without fracturing or softening. A ceramic or porcelain enameling frit having a high softening point (900° C.-1050° C. for example) and a suitable coefficient of expansion may be utilized to form the supporting member 18.

As shown most clearly in FIG. 2, a ground coat layer 21 of suitable insulating material, such as a titania precipitating glass of the type disclosed in U.S. Patent No. 3,073,982, may be provided over the metal electrodes 12 or over the entire surface of the sub-assembly. Also, a dielectric breakdown layer 22 of 65% to 95% barium titanate embedded in glass may be provided between the ground coat layer 21 and the phosphor layer 13. As a specific example, the aforesaid ground coat layer may comprise a glass having the following composition (percent by wt.): 10.5% Na₂O, 35% K₂O, 14.0% B₂O₃, 45% SiO₂, 20.0% TiO₂, 2.0% P₂O₅ and 5.0% F₂. Any TiO₂

recipitating glass which can be enameled can be used and from 0.001 to 30.0% of BaTiO₃ may also be added.

The glass constituting the dielectric breakdown layer 2 must have a relatively low firing temperature to avoid damaging the phosphor. A suitable glass is as follows percent by wt.): 15.4% ZnO, 31.7% BaO; 19.1% B₂O₃, % SiO₂, 7.7% K₂O, 3.8% Na₂O, 1.3% Li₂O, 3.9% Al₂O₃, 11.2% TiO₂ and 1.9% Sb₂O₃.

As is also shown in FIG. 2, one terminal of an alternating current supply source is connected by a conductor 9' to a conducting member or pin 23 which extends through the ceramic member 18, the ground coat layer 11, the dielectric layer 22 and the phosphor layer 13 and is in electrical contact with the front transparent electrode 1 at an area 24. The pin 23 may be attached to the electrode 11 as by soldering. The other terminal of the alternating current supply is connected by another conductor 19 to the arm 25 of a switch 26 that is adapted to selectively energize the rear electrode through a series of contacts and conductors 20 that connect with the terminal pins 17 attached to the respective metal electrode segments 12.

Thus, in a manner well known in the art, any one of the electrode segments 12 may be energized to illuminate a preselected portion of the device 10. When the arm 25 of the switch 26 is in the position shown in FIG. 2, the uppermost electrode segment 12 is energized and the corresponding portion of the device (the shaded area 27 of FIG. 1) is illuminated. The other areas 28 and 29 may be illuminated by rotating the switch arm 25 to energize the corresponding rear electrode segments.

As a variation of the construction shown in FIG. 2, the metal electrode segments 12 may be disposed on and be hermetically bonded to the front surface of the ceramic supporting member 18 with the pins 17 inserted through holes in the ceramic member. In this case the electrode segments 12 would be insulated from each other by the ground coat layer 21 instead of the ceramic member 18.

It is apparent that an electroluminescent device of the type herein described has numerous applications. Thus, as shown in FIG. 3, a device 10a may be fabricated wherein the rear electrode means comprise a plurality of segments preformed into letters of the alphabet which are arranged to convey desired information. In the illustrated example, all of the electrode segments 31, 32 and 33 are energized simultaneously to illuminate the areas for the letters of the three words constituting the sign. Each letter of the rear electrode means has a conductor pin secured to its rear surface, which pin is connected to one terminal of the alternating current supply. The other terminal of the supply is connected to the light-transmitting electrically common front electrode means at the contact area 24a.

The embodiment 10b of the invention illustrated in FIG. 4 may be utilized in connection with a temperature indicator or other device to convey and display certain information. In this case, one or more of the areas 34 corresponding to the rear electrode segments is illuminated in accordance with the information received from the transmitting device.

As shown in FIG. 5, the rear metal electrode segments may also be symmetrically arranged to provide a device 10c wherein preselected ones of the segments may be energized to illuminate a numerical digit. Thus, areas 35, 36 and 37 may be illuminated to produce the numeral 7. Other digits from zero to nine may be produced by energizing the proper segments to illuminate the corresponding areas. The device 10c shown in FIG. 5 may also be utilized to produce numerous letters of the alphabet.

In the modification shown in FIG. 6, the rear metal electrode segments of the display device 10d are preformed into numerical digits which may be arranged horizontally in a desired manner. These segments are selectively energized to convey information by illuminating the corresponding areas. As illustrated, the areas 38

and 39 are illuminated to produce the numeral 60. Other areas may be illuminated to produce other numerals. It is obvious that other applications of the electroluminescent device may be made.

From the foregoing description it will be apparent that the invention provides a simplified and economical construction for a metal-ceramic segmented electroluminescent device. The ceramic member is utilized as a support for both the metal electrode segments and the overlying laminations or layers that comprise the electroluminescent cell. In this manner the device is provided with sufficient rigidity to withstand the abuse sustained in commercial use. Moreover, since the metal electrode rather than the light-transmitting front electrode is segmented to form the desired indicia, electrical connection with the various segments can be readily accomplished by pins or the like that extend directly through the back of the device. The sealing and masking problems associated with the prior art practice of segmenting the front light-transmitting electrode are thus eliminated.

Since numerous changes may be made in the above desired construction and different embodiments of the invention may be made without departing from the spirit and scope thereof, it is intended that all subject matter contained in the foregoing description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

We claim as our invention:

1. An electroluminescent display device comprising, front and rear electrode means having a continuous layer of electroluminescent phosphor disposed therebetween, said front electrode means comprising a continuous layer of light-transmitting material, said rear electrode means including a plurality of individual preformed planar metal segments each having an elongated conducting member secured thereto, an insulating member of glass or ceramic material supporting the metal segments and phosphor layer in operative relationship with the front electrode means, said planar metal segments being embedded in and hermetically united to the front face of said insulating support member, said conducting members protruding through the insulating-support member to the rear of the device and thereby providing exposed terminals for the respective metal electrode segments, and an additional elongated conducting member connected to the front electrode means and extending through the phosphor layer and insulating-support member to the rear of the device.
2. An electroluminescent display device as set forth in claim 1 wherein said elongated conducting members comprise metal pins that are joined to the rear surfaces of said first and second electrode means and are also embedded in the insulating-support member.
3. The electroluminescent display device set forth in claim 1 wherein; said insulating-support member is of substantially planar configuration, and the exposed surfaces of the embedded planar metal segments together with the intervening portions of said insulating-support member define a substantially flat supporting surface for the overlying layers of the device.
4. The electroluminescent display device set forth in claim 1 wherein said insulating-support member has a softening point of at least 900° C. and is thus adapted to be fired with the metal electrode segments without fracturing or softening.
5. The electroluminescent display device set forth in claim 1 wherein; the front face of said insulating-support member is of substantially planar configuration, the planar metal electrode segments are disposed on the front face of said member, and a continuous layer of fused glass covers said metal electrode segments and hermetically secures them to the front face of said member.
6. The electroluminescent display device set forth in claim 5 wherein said elongated conducting members comprise rigid metal pins that extend through holes in the insulating-support member.

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7. In an electroluminescent display device having a plurality of separately energizable segments, the improvement which comprises the combination of a like number of preformed sheet metal electrode segments, a ceramic insulating member that is hermetically bonded to and holds the metal electrode segments in their assembled relationship, and a pin terminal joined to the rear surfaces of each of the metal electrode segments and extending through said ceramic insulating member to the rear of said device, said terminals and electrode segments being supported in the aforesaid relationship by said ceramic member.

8. An integral electrode-and-supporting assembly adapted for use in a segmented electroluminescent display device comprising, a rigid insulator body of glass or ceramic having a softening point of about 900° C., a plurality of spaced thin metal electrode segments her-

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metically bonded to one side of said body, and a corresponding number of rigid conductor members joined to the bonded side of the respective electrode segments and extending through and beyond said body, said electrode segments and joined conductor members being held in predetermined array solely by said insulator body.

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