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Rogers

[11] **3,840,770**

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[54] **GASEOUS DISCHARGE DISPLAY DEVICE WITH EMBEDDED ELECTRODE SEGMENTS**

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[52] **U.S. Cl.** **313/517**

[51] **Int. Cl.** **H01j 61/66**

[58] **Field of Search** 313/109.5, 210, 217

[56] **References Cited**

UNITED STATES PATENTS

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3,617,793	11/1971	Matsushita et al.	313/109.5
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Primary Examiner—Palmer C. Demeo

[57] **ABSTRACT**

A gas discharge display device for displaying one of a plurality of alpha-numeric characters, including a substrate having a glass layer upon its upper surface; a plurality of flat metal segment elements embedded in the glass layer and arranged laterally in the general shape of the necessary segments of all the alpha-numeric characters to be displayed by the device; a plurality of metal leads, one for each segment, each electrically connected to its respective segment and extending outside the periphery of the substrate; a second metal layer electrically insulated from the segments lying in a plane parallel to that of the segments and having apertures therein arranged laterally in correspondence with the segments, the second metal layer being mechanically supported by the substrate; a metal lead electrically connected to the second metal layer also extending outside the periphery of the substrate; and a cover, at least partially translucent, so that the segments, when energized, are visible therethrough, the cover enclosing and sealing the segments and the second metal layer, thereby providing a sealed enclosure with the necessary electrical leads from the cathode segments and the anode extending outside the sealed enclosure so that, when the cathode segments are selectively electrically activated, a display of the selected alpha-numeric character is provided through the cover.

2 Claims, 3 Drawing Figures

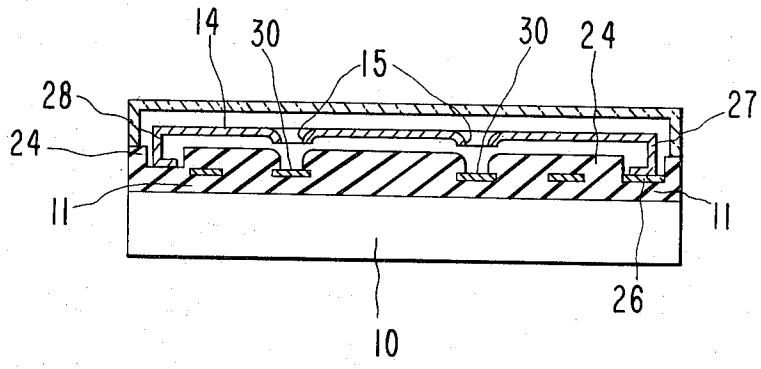


FIG. 1

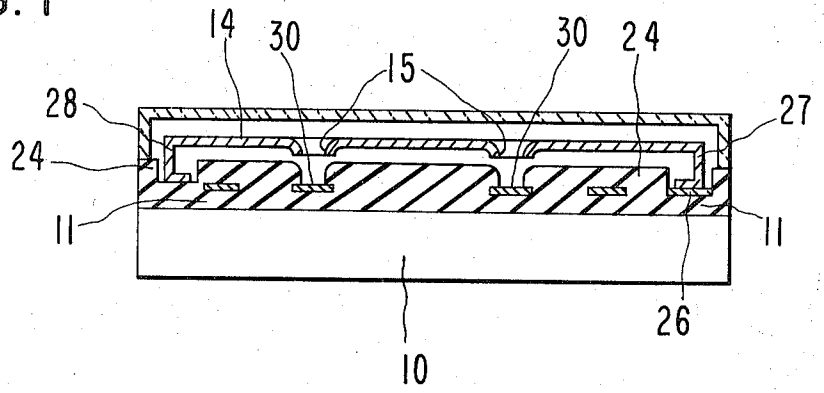


FIG. 2

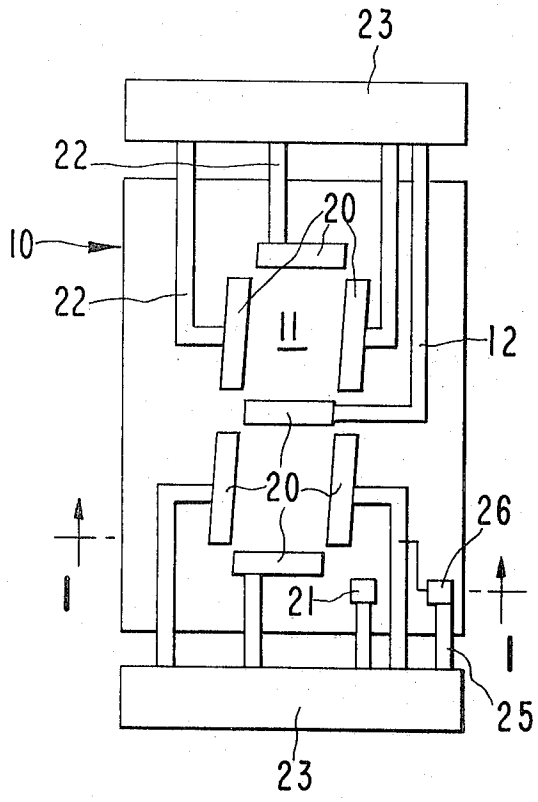
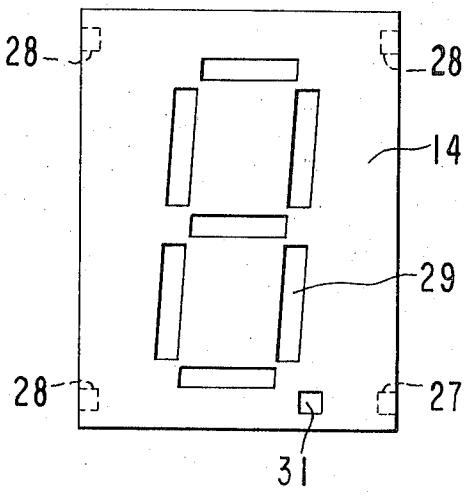


FIG. 3



GASEOUS DISCHARGE DISPLAY DEVICE WITH EMBEDDED ELECTRODE SEGMENTS

FIELD OF THE INVENTION

This invention is in the field of gas discharge display devices. Such display devices are commonly used in the industry for digital displays and have an anode and a plurality of cathodes which are selectively energized to cause the gas within the enclosure to glow in a pattern selected by the selective energization of one or a plurality of the cathode elements.

PRIOR ART

Gas discharge display devices are well known. For example, U.S. Pat. No. 3,418,509 shows a device which has the basic configuration of the device of the invention. The enclosures of such prior art devices includes a substrate, a cap, a plurality of cathode and lead element combinations, and a counter electrode or anode which is customarily formed by a perforated metal layer applied to the inner side of the cover plate. These enclosures of the prior art, however, have been tricky to assemble and test and thus costly to manufacture. The principal reason for this has been the inability to test the device until it had been totally completed and sealed. At that time, if an improper connection or a lack of a connection was found by testing, the entire unit had to be scrapped. It was impossible to test the units until the cap, containing the anode layer, was sealed to the base. At that stage, unsealing was no longer practical as a means to make repairs.

Furthermore, in the prior art devices, a complicated sealing procedure is necessitated. The sealing of the package of the prior art, leaving a glass tube extending outside the package for evacuation purposes, is called "tubulation." The unit is exhausted through a tube and filled with the desired gas or gas mixture, at which time the tube is closed. The stub of this tube still extends outside the package after sealing and is an inconvenience in circuit board insertion of the device.

BRIEF DESCRIPTION OF THE INVENTION

The gas discharge display device of this invention is similar to the packages of the prior art, but has the advantage that it can be fully assembled and tested prior to attachment of the cover. In the package of this invention, both the anode element and the cathode elements are mechanically affixed to the substrate before the cover is attached. All of the electrical connections necessary to test the unit are thereby completed prior to placing on the cap. After testing, the cap is placed on the unit simultaneously with the evacuation of the air and the introduction of the necessary gas or gas mixture for the completed device. Any defect in the electrical connection of the cathode segments or the anode can be corrected prior to sealing and completing the unit. Accordingly, the manufacturing yields of the alpha-numeric character display devices of this invention are substantially improved.

Briefly, the gas discharge display element of this invention, for displaying one of a plurality of alpha-numeric characters, includes a gas discharge display device for displaying one of a plurality of alpha-numeric characters including a substrate having a glass layer upon its upper surface; a plurality of flat metal segment elements embedded in the glass layer and arranged laterally in the general shape of the necessary segments of all the alpha-numeric characters to be displayed by the device; a plurality of metal leads, one for each segment, each electrically connected to its respective segment and extending outside the periphery of the substrate; a second metal layer electrically insulated from the segments lying in a plane parallel to that of the segments and having apertures therein arranged laterally in correspondence with the segments, the second metal layer being mechanically supported by the substrate; a metal lead electrically connected to the second metal layer also extending outside the periphery of the substrate; and a cover, at least partially translucent, so that the segments, when energized, are visible therethrough, the cover enclosing and sealing the segments and the second metal layer, thereby providing a sealed enclosure with the necessary electrical leads from the cathode segments and the anode extending outside the sealed enclosure so that, when the cathode segments are selectively electrically activated, a display of the selected alpha-numeric character is provided through the cover.

The device of the invention is sealed by attaching the cover in an evacuated atmosphere into which the desired gas or gas mixture is introduced. No tubulation process or tube extending outside the package is required.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross-sectional drawing of the gas discharge display device of the invention;

FIG. **2** is a top view of the substrate of this invention showing the cathode segments, the cathode connecting leads, and the anode connecting lead (prior to deposition of the final glass layer); and

FIG. **3** is a top view of the anode of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring to the drawings, particularly to FIG. **1**, the basic parts of the gas discharge display device of the invention all are formed on substrate **10.** Substrate **10** conventionally is ceramic. However, metal or other conductive materials could be used since the glass layer **11** provides the necessary insulation between the substrate **10** and the conductive cathode and lead elements, **12, 20, 21** and **22.** In the embodiment shown in the drawings, for example, the cathode is comprised of seven character display elements **20,** along with a decimal point element **21.** Cathode elements **20,** shown in FIG. **2,** are arranged in the segments of a "FIG. **8**". As is well known in the art, with a **7**-segment "FIG. **8**", the selective activation of two or more cathode elements is sufficient to display all of the digits **0** through **9.** Element **21** is used to display the decimal point. The segment arrangement is conventional in the art and needs no further explanation here.

Referring to FIG. **2,** the plurality of substantially flat metal segments **20,** making up the cathodes, are embedded in glass layers **11** and **24** (only lower layer **11** being shown in FIG. **2**) but are exposed and free from glass on their upper surfaces **30** shown in FIG. **1.** The leads **22** and **25,** shown in FIG. **2** are connected to the respective cathode elements and anode contact **26** and are normally embedded in the glass layers **11** and **24** as shown in FIG. **1,** to hold them tightly on the substrate. The glass layers **11** and **24** also insulate the metal cathode elements at portions of their surface which other-

wise might cause undesirable sputtering during device operation and thus decrease the useful life of the final device. These metal leads, one for each cathode segment **20** and **21** and one for anode contact **26** are electrically connected to the respective segment or contact as shown in FIG. **2**, and extend at least beyond the periphery of substrate **10**. For convenience of manufacture, all of the leads **22** and cathode elements **20** and **21** as well as lead **25** connected to anode terminal **26** can be stamped or etched simultaneously in a frame pattern held together by bars **23**. Bars **23** are removed after the leads have been mechanically attached to the substrate by the glass so that the individual parts **21, 22,** and **26** are separately available for electrical testing.

The fabrication of the substrate of the invention begins by assembling the cathode elements, leads, contact and frame assembly **20, 21, 22, 23, 25,** and **26** onto the substrate. Referring to FIG. **1**, first a layer of a slurry of devitrifiable glass material **11** is deposited upon the substrate **10** over the entire substrate. A devitrifiable glass is a type of glass which is capable of being devitrified. Devitrification is the growth of crystalline material in the glass. In normal glass-making procedures, steps are taken to prevent devitrification. However, in connection with the encapsulation of the devices of the invention, a seal is made by employing a deliberate devitrification step. The composition of the glass material **11** can be one of many glasses capable of devitrification. Representative compositions are described in U.S. Pat. No. 3,248,350. These devitrifiable glass compositions are devitrified at temperatures normally in excess of 400°C, as described in that patent.

The layer **11** of sealing glass is initially applied at a relatively low temperature, and subsequently converted by devitrification at a higher temperature to a material of crystalline character that will withstand subsequent high temperature environments without softening of flowing.

The lead frame assembly **20, 21, 22, 23, 25,** and **26** is placed onto the glass layer **11**. The assembly, including substrate **10**, glass layer **11**, cathodes **20, 21,** leads **22** and **25,** frame **23** and contact **26** with the leads, cathode elements, and contact resting in the glass, is placed into a conventional devitrification furnace. Devitrification can be carried out at temperatures ranging from 450°C to 550°C at times between 2 minutes and 1 hour. Using, for example, a glass composition called "CV-**98**" sold by Owens-Illinois, devitrification takes place satisfactorily at 500°C in about **5** minutes. After devitrification, the assembly including cathode elements **20** and **21,** and leads **22** and **25** (FIG. **2**) and contact **26** are embedded in layer **11,** leaving only cathode elements **20** and **21** and contact **26** free of glass.

After the assembly has been removed from the devitrification oven and cooled, a second glass layer **24** shown in FIG. **1** can be applied. The second layer **24** is also devitrifiable glass material, and must have thermal expansion characteristics compatible with the substrate, the previous glass layer and the metal lead frame. However, it is not necessary that it be the identical glass layer as the first layer as long as the above criteria are met. The second layer is laid down on top of the first devitrified layer, covering the leads **22** and **25** (FIG. **2**) but not the cathode elements **20** and **21** or contact **26.** Leads **22** and **25** extend beyond the glass layer and beyond to the perimeter of substrate **10.** It is important that the cathode elements **20** and **21** remain free of glass or else they will not glow when activated. It is equally important, however, that the corners of the metal be covered to prevent sputtering, as discussed above. Contact **26** must be free of glass so the anode may be electrically connected. The second glass layer **24** is deposited at temperatures and times which will not permit devitrification. The layer is, however, preferably sintered at temperatures ranging from about 425°C to 480°C, these temperatures being selected to be below the devitrification conditions (time and temperature) of the glass composition employed. The purpose of the sintering step is merely to solidify the glass layer, but to leave it non-devitrified so it can be later devitrified in the final sealing of the cap to the package.

Included in the lead configuration shown in FIG. **2** are one or more anode leads **25,** connected to an anode contact **26.** Anode contact **26** is to be connected to tab **27** (shown in FIGS. **1** and **3**), preferably formed as an integral part of anode element **14,** shown in FIG. **1.** The anode contact **26** and tab **27** together serve to rigidly hold the anode **14** onto the substrate **10** as shown in FIG. **1.** Anode contact **26** must make electrical contact with the anode element **14** through tab **27.** Tab **27** also holds the anode element **14** separated from the cathode segments **20** and **21** and their associated leads **22.** For structural rigidity, additional mechanical separating supports or tabs **28** can be provided integral with or connected to anode element **14,** but which need not necessarily also make electrical contact to anode lead **25.** One electrical connection is all that is required.

As shown in FIG. **3,** anode element **14** has apertures **29** and **31** which are arranged laterally in correspondence with the plurality of cathode segments **20** and **21** shown in FIG. **2** in the final assembly. The anode element **14** is stamped from a suitable sheet metal such as stainless steel. During the stamping, at least two opposing sides of the aperture, preferably the major or longer sides, are drawn to an angle of at least 45°, preferably approximately 90°, to the planar viewing surface, resulting in the drawn lips **15** shown in FIG. **1.** The apertures **29** and **31,** shown in FIG. **3** are punched out with the drawn lips **15,** shown in FIG. **1,** lying on the side of the anode layer facing the exposed cathode elements at apertures **30.** These lips **15,** extending below the plane of anode **14,** as shown in FIG. **1,** act as illumination multipliers by reflecting the gas discharge image of the cathode elements **20** and **21** (FIG. **2**). This effect provides a brighter image outline compared to the systems of the prior art where the outline of the image is of lower density than the central area of the design. Drawn lips **15** of anode **14** insure that the image density of the outline is at least as bright as the image density of the central area.

By virtue of drawn lips **15** extending below the main plane of the anode layer **14,** down to the immediate region of the cathode elements **20** and **21,** the device achieves an improved field focusing of the cathode-anode voltage. Furthermore, the cross-talk associated with conventional gas discharge devices is reduced and the ratio of the desired image to the image cross-talk is increased in the display device of the invention.

Anode layer **14** is rigidly attached, such as by brazing or soldering, to anode contact **26.** Alternatively, layer **14** and contact **26** may be formed integrally, such as by stamping the portion **26** being embedded in glass layer **24.** This feature elminates the prior art ohmic spring

type contacts which were considered necessary to electrically connect the transparent conductive coatings which were formed under the covers of the devices. Extra supports **28** are placed to rest at the same time on glass layer **11**, as shown in FIG. **1**, prior to the attachment of cap **17**. The preassembly of the anode and the cathode elements of the subject invention permits adjustment in the alignment of the cathode and anode or in the spacing between them to achieve optimum operating characteristics prior to final assembly and attachment of the cap.

Finally, after any adjustments, testing, and alignment is completed, cap **17** is attached to the glass layer **24**. Referring to FIG. **1**, preferably the bottom portion of cap **17**, adjacent to glass layer **24**, is glass-free. In the sealing technique of this invention, the cap **17** is heated to a temperature greater than the softening point of glass layer **24** on substrate **10**. Preferably the cap **17** is held in the heater block of a conventional assembly jig. The entire heater block and assembly jig are placed in a conventional evacuated chamber during the sealing process. If desired, substrate **10** can also be heated using an additional heating block beneath the substrate. The substrate is heated sufficiently so that the glass layer **11** and **24** reach an elevated temperature below their softening point. If the glass layers were heated to a temperature at or above their softening point, the cathode and lead elements may tend to shift, and premature devitrification of the sealing glass may occur which would cause unreliable sealing. Accordingly, it is essential that the glass layers **11** and **24** remain at a temperature below their softening point up to the time when they are contacted by the heated cap **17**.

After the heating of the parts has been completed in the vacuum chamber, the vacuum is replaced by the desired gas or gas mixture to be enclosed in the device. These gases are conventional in the art. During the sealing step, the entire atmosphere around the device will be the gas desired to be introduced into the package after final sealing. Once the gas has equilibrated in the chamber, the cap **17** is contacted with the glass layer **24** on substrate **10**. This may be accomplished by lowering the cap into position or raising the substrate while the cap remains in its heater block. The heat conducted from the heater block adjacent the cap during sealing processes passes through the cap **17** and serves to soften the glass layer **24**, thereby effecting a seal between the two parts of the package upon contact.

After the sealing operation has been completed, the vacuum and gas atmosphere in the chamber may be released, and the device removed from the chamber.

The above sealing operation completely avoids the tubulation procedures required in the prior art, wherein a tube extends from the package after sealing and is subsequently used for the introduction of the proper gas into the chamber. By elimination of this tubulation process, the user will not be hampered by the existence of a tube extending from the bottom side of the package which gets in the way during the assembly of the package onto a conventional printed circuit board.

I claim:

1. A gas discharge display device for displaying one of a plurality of alpha-numeric characters comprising:

a substrate having a glass layer on its upper surface;

a plurality of substantially flat metal segments embedded in said glass layer and arranged laterally in the general shape of the necessary segments of all of the alpha-numeric characters to be displayed by said device;

a plurality of metal leads, one for each segment, each electrically connected to its respective segment and extending outside the periphery of said substrate;

a second metal layer lying in a plane parallel to the plane of said segments and electrically insulated from said segments, said second metal layer having apertures therein arranged laterally in correspondence with said segments, said second metal layer being mechanically supported by said glass layer and said substrate, at least the major edges of the apertures of said second metal layer being inwardly bent on an angle exceeding 45° with the main plane of said second metal layer;

a metal lead electrically connected to said second metal layer and also extending outside the periphery of said substrate; and

a cover, at least partially translucent so that said segments, when energized, are visible therethrough, said cover enclosing and sealing said segments and said second metal layer, thereby providing a sealed gaseous atmosphere in the enclosure with the necessary electrical leads extending outside of said sealed enclosure which, when said leads are selectively electrically activated, provide a display of the selected alpha-numeric character through said cover.

2. The gas discharge display device of claim **1** further characterized by said angle being approximately 90°.

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