June 20, 1967 W. W. BICKMIRE ET AL 3,327,153

COMPACT GLOW DISCHARGE DEVICE HAVING IMPROVED CONNECTION MEANS FOR SUPPLYING ELECTRICAL ENERGY

Filed March 30, 1964 3 Sheets-Sheet 1

Fig. 1

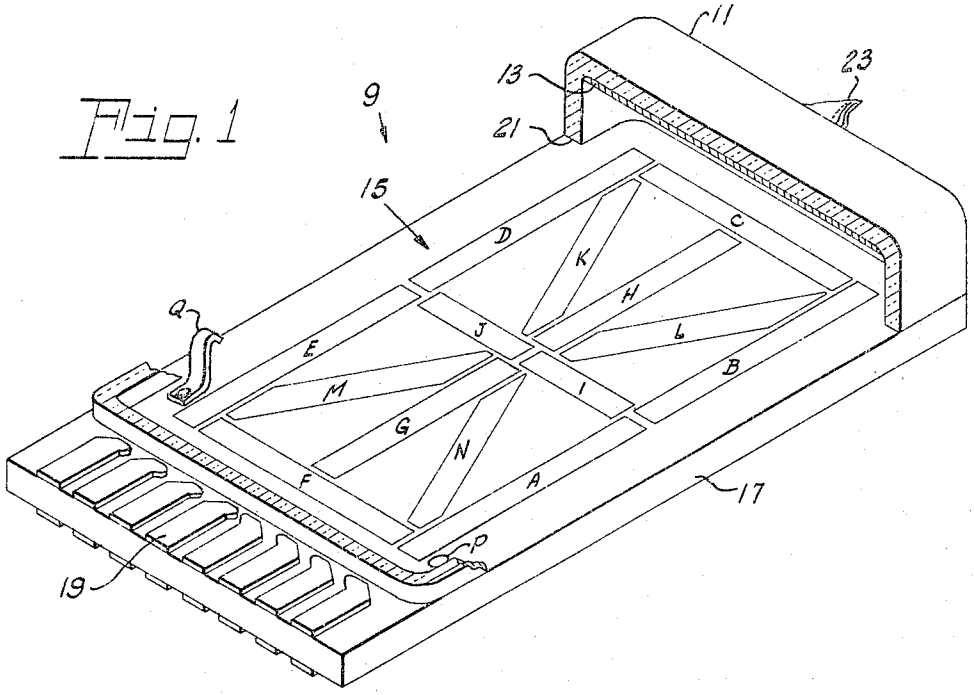
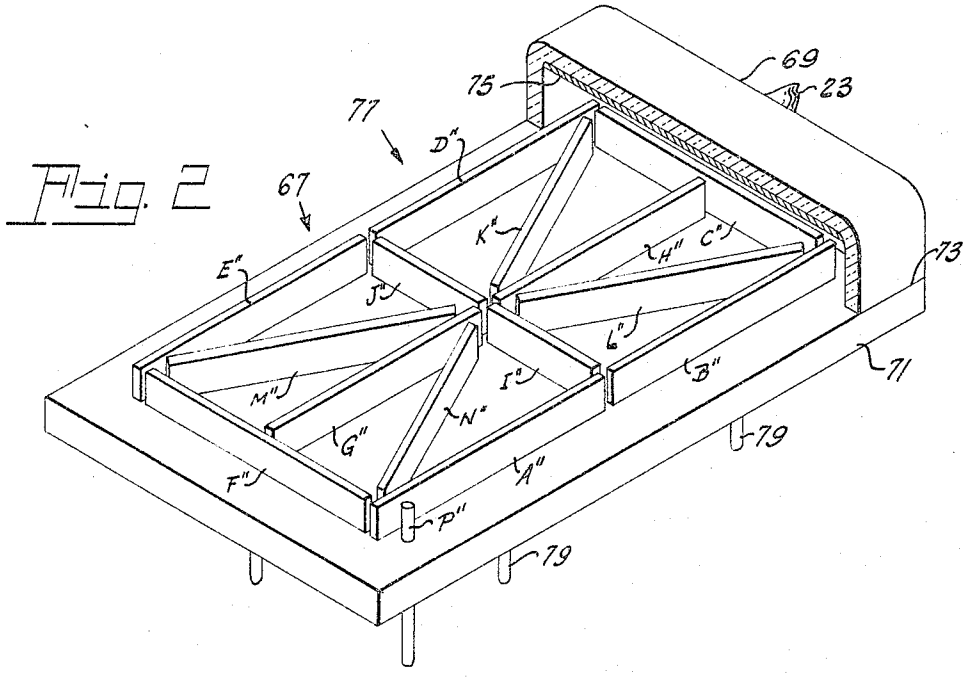


Fig. 2



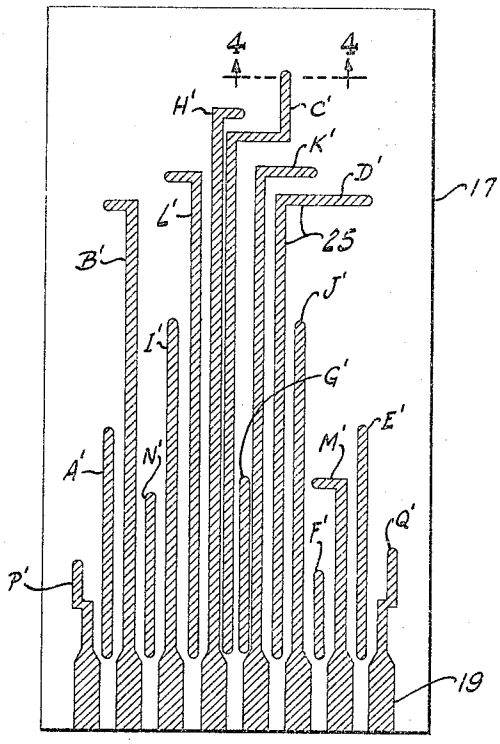
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Fig. 3



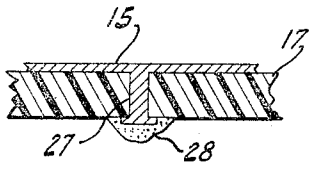


Fig. 4

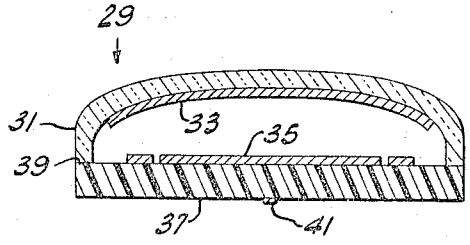


Fig. 5

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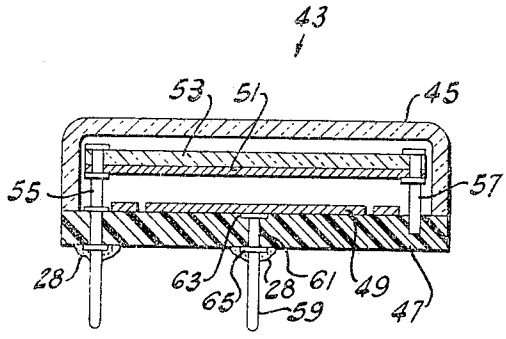


Fig. 6

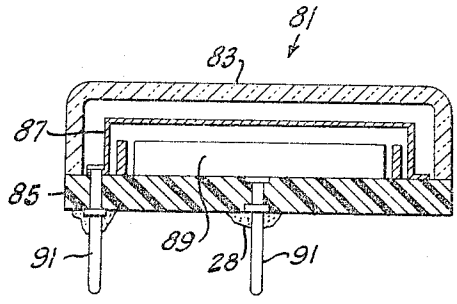


Fig. 7

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COMPACT GLOW DISCHARGE DEVICE HAVING IMPROVED CONNECTION MEANS FOR SUPPLYING ELECTRICAL ENERGY

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8 Claims. (Cl. 313—109.5)

This invention relates to glow discharge devices and more particularly to a segmented glow discharge "readout" device for visually displaying symbols including alphabetical letters, numerals, and letters and numerals.

Known types of glow discharge devices have a hermetically sealed transparent tubular envelope with electrical conductors sealed into one end thereof and contain a visual display which is disposed either normal or parallel to the longitudinal axis of the envelope. The display includes cathode segments which may be shaped in the form of numerals, alphabetical letters, or arrayed as a symbol wherein each segment forms a portion of a numeral, an alphabetical letter, or both. Also, each cathode segment is connected to a conductor whereby energy is applied to and activates the cathode segment.

In addition to the visual display, the envelope contains a gas at glow discharge pressure and an electrically conductive anode. Thus, by applying a specific voltage difference to the conductor attached to the anode and one or more of the conductors attached to the segments, there is provided a means for causing a glow discharge to appear immediately adjacent the activated segment or segments whereby a visual display viewable through the envelope is provided.

While such devices have provided a great impetus to the adoption of "readout" devices, it has been found that numerous conditions exist which tend to deter the use of such devices in some applications. For example, the ratio of space used to space available within a tubular envelope in the known display devices leaves much to be desired. Also, tubular configurations are not particularly well suited for a panel-type display. Moreover, the known connecting means for applying external energy to the display are not particularly adapted to the printed circuit art and panel-type displays wherein such devices are frequently used.

Therefore, it is an object of this invention to provide an improved glow discharge visual display device.

Another object of the invention is to enhance the ratio of used to available space within a glow discharge visual display device.

Still another object of the invention is to improve the means for energizing the visual display of a glow discharge device.

A further object of the invention is to provide a glow discharge device having an enhanced resistance to vibration and shock.

These and other objects are achieved in one aspect of the invention by a vacuum-tight envelope which includes a transparent portion and is hermetically sealed to a rigid planar vacuum-tight insulating support to provide an enclosure containing a gas at glow discharge pressure, at least one visual display of cathode segments wherein each segment is insulated from the other and all are attached to the surface of the support facing the envelope transparent portion, and a transparent anode having an electrically conductive surface and disposed intermediate the cathode segments and the envelope transparent portion. Each of the cathode segments and the anode have an electrical connection to an electrical conductor external to the envelope and attached to the support.

For a better understanding of the present invention, together with other and further objects, advantages, and capabilities thereof, reference is made to the following disclosure and appended claims in connection with the accompanying drawings in which:

FIG. 1 is a plan view in section of one embodiment of the invention;

FIG. 2 is a plan view in section of another embodiment of the invention;

FIG. 3 is a plan view from the bottom, showing the electrical connections of the embodiment of FIG. 1;

FIG. 4 is a cross-sectional view taken along line 4—4 of FIG. 3 illustrating the interconnection between the segments of FIG. 1 and the electrical connections of FIG. 3;

FIG. 5 is a cross-sectional view of still another embodiment of the invention;

FIG. 6 is a cross-sectional view directed to the placement of an anode within the envelope; and

FIG. 7 is another cross-sectional view directed to an alternate anode placement in the embodiment of FIG. 2.

Referring to the drawings, FIG. 1 illustrates one embodiment of a glow discharge device **9** having a transparent envelope **11**, an anode **13**, a cathode segment display **15**, an insulator support **17**, and a plurality of spaced contact fingers **19**.

The envelope **11** is a substantially rectangular box-like configuration of a transparent and vacuum-tight material such as ordinary lead or lime glass and is hermetically sealed to the support **17** at a jointure **21** by any one of numerous well-known methods of making such seals. Also, the envelope **11** includes an exhaust and sealing means **23** which permits the replacement of the atmosphere within the hermetically sealed envelope **11** and support **17** with a gas at glow discharge pressure.

Adhered to the inner surface of the envelope **11** is a transparent anode **13** of an electrically conductive material such as, for example, a layer of stannous oxide. This anode **13** is disposed in a plane substantially parallel to the cathode segments of the display **15** and spaced substantially equi-distant from each of the segments. A contacting means Q is provided intermediate the anode **13** and the support **17** which electrically connects the anode to an electrical conductor disposed on the surface of the support **17** opposite to the surface thereof whereon is disposed the display **15**, as will be explained hereinafter.

Bonded to the support **17** and disposed intermediate thereto and facing the transparent anode **13** and envelope **11** is a cathode segment display **15**. This display **15** includes a plurality of cathode segments designated by the letters A, B, C, D, E, F, G, H, I, J, K, L, M, N, and P and is arrayed in a substantially rectangular configuration in a plane substantially parallel to the anode **13** and the support **17**. Also the rectangular configuration has therein pairs of segments substantially normal to the opposing sides and diagonal to the corners thereof and may include as few as 12 cathode segments, depending upon the visual qualities desired. Moreover, the segments A through N and P of the display **15** are arrayed such that numerals 0 through 9 and all of the letters of the alphabet, along with a decimal point, are provided in an economical and restricted area. Thus, the display provides a symbol which may be in the form of a numeral, an alphabetical letter, or both.

The segments A through N and P of the display **15** are of a nickel material, although steel, iron, molybdenum, and tungsten are equally applicable and appropriate and are insulatingly spaced from one another to provide individual electrical identities. Also, the segments A through N and P are bonded to the surface of the support **17** by any one of numerous well-known processes. For instance, the surface of the support **17** may be metallized

and the undesired metal portions removed by etching or sand-blasting, or the segments may be prefabricated and glued or adhered to the support. Obviously, numerous well-known and often used techniques for forming and attaching the segments to the support are equally applicable and appropriate. Regardless of the technique used, the segments A through N and P are attached to the support **17** to provide a substantially planar display **15** facing the anode **13**.

The support **17** is a rigid planar insulator having a substantially rectangular configuration which extends longitudinally beyond the confines of the hermetically sealed envelope **11**. Preferably, the support **17** is of a material such as "Photoceram" produced by Corning Glass Works, of Corning, N.Y., which has a good electrical and mechanical properties and may be converted from a transparent to an opaque condition during the processing thereof. However, any one of a number of ceramic materials are equally applicable so long as they are rigid, hermetically sealable to the envelope, and are/or can be made to be vacuum tight.

At one end of the support **17** and extending inwardly therefrom is a plurality of spaced contact fingers **19**. These fingers **19** are disposed on opposite surfaces of the support **17** external to the envelope **11** and provide a convenient and commonly used means for applying energy from an external source to the segments A through N and P and to the anode **13** within the envelope **11**. Essentially, the contact fingers **19** are adapted for use with the ordinary printed circuit type of contact.

In order to provide an electrical connection between the fingers **19** and the segments A through N and P, as well as the contacting means Q of the anode **13**, a plurality of conductors **25** are bonded to the opposite surface of the support **17** as illustrated in FIG. 3. Herein, the conductors **25** are designated by the same alphabetical letters as the segments A′ through N′ and P′ and the anode Q of FIG. 1 and are directly connected thereto as illustrated in the cross-sectional view of FIG. 4 taken along the line **4—4** of FIG. 3.

As can be readily understood, the cathode segment display **15**, as well as the conductors **25** and the contact fingers **19**, are preferably of the same conductive material and bonded to the support **17** in a similar manner. Moreover, the process for providing and bonding the display **15**, conductors **25**, and contact fingers **19** is carried out in substantially the same manner and essentially in the same sequence in the interest of minimum cost per unit.

Referring to FIG. 4, the support **17** has an aperture **27** therethrough which is filled with the same electrical conducting material as is provided for the cathode segment display **15** and the conductors **25**. Additionally, the aperture **27** is hermetically sealed with a "glob" **28** of glass frit of which any number are available and commonly used in the sealing art. Thus, each cathode segment A through N and P of the the display **15**, as well as the anode conecting means Q, is electrically connected to one of the conductors **25** which is directly connected to a contact finger **19** adapted for external application of energy thereto.

In an alternate embodiment as illustrated in FIG. 5, a discharge device **29** includes a substantially semicylindrical transparent glass enevelope **31** having an electrically conductive transparent anode **33** bonded to the inner surface thereof and facing a planar cathode segment display **35** attached to a rigid planar insulator support **37**.

The envelope **31** is hermetically sealed to the support **37** at a jointure **39** and includes therein a gas at glow discharge pressure and the anode **33** and display **35** which are electrically connected through the support **37** to a plurality of electrical conductors **41**. Thus, a wider angle for viewing the display is provided without a sacrifice in the ratio of used space to available space within the envelope **31**.

In another embodiment, FIG. 6 illustrates a glow discharge device **43** having a transparent glass envelope **45** hermetically sealed to a rigid planar insulator support **47** whereon is atached a cathode segment display **49**. However, in this embodiment the anode **51** is an electrically conductive transparent layer, such as stannous oxide, adhered to a transparent substrate **53** which is spaced from the envelope **45** and the display **49** by a pair of support members **55** and **57** attached to the support **47**.

Also, each member of the cathode segment display **49**, as well as the anode **51**, is directly connected electrically to a connecting pin **59** affixed to the support **47**. The connecting pin **59** is slid through an aperture **61** in the support **47** and brought into contact with a member of the display **49** at a jointure **63**. Moreover, the pin **59** has a platform **65** which limits the advance thereof through the support **47** and which serves to hermetically seal the aperture **61** and hold the pin upon application of a glob **28** of glass frit to the platform **65** and the support **47** immediately adjacent thereto.

Alternately, FIG. 2 illustrates a glow discharge device **67** which includes a transparent box-like glass envelope **69** hermetically sealed to a substantially rectangular planar insulator support **71** at a jointure **73** and including therebetween a gas at glow discharge pressure, a transparent electrically conductive anode **75** adhered to the envelope **69**, and a cathode segment display **77** attached to the support **71** and in a plane substantially parallel to and facing the anode **75** and the envelope **69**.

The display **77** includes a plurality of individual segments A″ through N″ and P″ electrically isolated from each other and arrayed in a substantially rectangular configuration as previously described in FIG. 1. Each segment A″ through N″ and P″ is essentially a rectangular strip of nickel, iron, tungsten, or similar applicable metals and is affixed to the support **71** and electrically connected therethrough to a connecting pin **79**.

Additionally, FIG. 7 illustrates still another embodiment of a glow discharge device **81** wherein a transparent box-like glass envelope **83** is hermetically sealed to a rigid planar insulator support **85** and includes therebetween a gas at glow discharge pressure, an electrically conductive and transparent anode **87**, such as a wire mesh, spaced from the envelope **83** and surrounding a cathode segment display **89**. Moreover, each member of the display **89**, as well as the anode **87**, is affixed to the support **85** and electrically connected through the support **85** to an external connecting pin **91**.

In a specific structure, a photoceram support having a length of about 2.25 inches, a width of 1.25 inches, and a thickness of 0.06 inch was nickel plated and a portion of the nickel removed to provide a display substantially as illustrated in FIG. 1. The display had a width of about 1 inch and a length of approximately 1.5 inches, while each cathode segment had a thickness of about 0.005 inch and a width of about 0.06 inch. The display was hermetically sealed within a box-like glass envelope having a layer of stannous oxide on the inner surface thereof and the atmosphere therein replaced with a neon-argon gas mixture at a pressure of approximately 12 mm. of mercury.

After the usual processing and stabilization period, a voltage difference of about 170 v. D.C. was applied between the anode and the cathode segments with the anode positive with respect to the cathode. Thereupon, the resultant glow discharge was rated at approximately 200 foot-lamberts and clearly readable even under adverse ambient lighting conditions.

Thus, there has been provided a glow discharge device having a unique and unexpected resistance to shock and vibration. The device is especially applicable to panel-type displays as well as the frequently encountered block-type printed circuit electrical connecting means. Moreover, the ratio of used to available space within the envelope far

surpasses any of the known types of glow discharge devices while the readability and appearance of the panel-type display, as well as the compactness thereof, is enhanced by the device.

While there have been shown and described what are at present considered the preferred embodiments of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention as defined by the appended claims.

What is claimed is:

1. A glow discharge device comprising:
a rigid vacuum-tight planar insulating support having a plurality of cathode segments attached to one surface thereof and arranged to provide a display symbol, each one of said segments being electrically connected through the support to a conductor attached to the opposite surface thereof;
an envelope enclosing said segments and hermetically sealed to said support, said envelope having a transparent portion facing said segments and containing a gas at glow discharge pressure; and
a transparent electrically conductive anode disposed intermediate the envelope transparent portion and said segments and spaced substantially equidistantly from each of said segments, said anode being electrically connected to a conductor bonded to said support and external to said envelope.

2. A glow discharge device comprising:
a vacuum-tight planar ceramic support having a plurality of cathode segments bonded to one surface thereof and arranged to provide at least one visual display symbol, said segments being electrically insulated from each other and each segment electrically connected through the support to an electrical conductor attached to the opposite surface thereof; and
a transparent glass envelope enclosing said segments and hermetically sealed to said support, said envelope containing a gas at glow discharge pressure, and a transparent electrically conductive anode disposed within and intermediate said envelope and said segments and spaced substantially equidistantly from each of said segments, said anode having an electrical connection to a conductor external to said envelope.

3. A glow discharge device comprising:
a vacuum-tight planar ceramic support having a plurality of cathode segments insulated from each other and bonded to one surface of the support, said segments being arrayed in a substantially rectangular configuration having segment pairs extending in a direction substantially normal to the sides and intermediate diagonal corners of the configuration with each segment electrically connected through the support to an electrical conductor attached to the support surface opposite the bonded cathode segment surface;
a transparent glass envelope enclosing said segments and hermetically sealed to said support, said envelope containing a gas at glow discharge pressure; and
a transparent anode having at least an electrically conductive surface and disposed intermediate said envelope and said segments and spaced substantially equidistantly from each of said cathode segments, said anode having an electrical connection to an electrical conductor external to said envelope.

4. A glow discharge device comprising:
a substantially box-shaped transparent glass envelope hermetically sealed to a substantially rectangular vacuum-tight planar ceramic support and containing therebetween a gas at glow discharge pressure, a plurality of cathode segments attached to the surface of said support within said envelope and arrayed as a visual display facing said envelope, and a transparent anode having at least an electrical conductive surface and disposed intermediate said envelope and said segments and spaced substantially equidistantly from each of said cathode segments, each of said cathode segments and said anode being electrically connected to an electrical conductor bonded to the support surface external to the envelope and opposite to the attached cathode segment surface with each of said conductors directly connected to one of a plurality of electrical conducting fingers bonded to opposite surfaces at one end of said support and extending inwardly therefrom.

5. A glow discharge device comprising:
a rigid planar vacuum-tight insulating support having a plurality of cathode segments insulated from one another and attached to said support, said segments being arrayed in a plane substantially parallel to said support to provide at least one visual display symbol with each one of said segments having an electrical connection through said support to a conductor attached to the opposite surface thereof;
an envelope hermetically sealed to said support and enclosing said segments therebetween, said envelope having a transparent portion in a plane substantially parallel to said display and containing a gas at glow discharge pressure; and
a transparent electrically conductive anode bonded to the transparent portion of said envelope and disposed intermediate said envelope and said display, said anode having an electrical connection to a conductor attached to said support external to said envelope.

6. A glow discharge device comprising:
a semicylindrical transparent glass envelope hermetically sealed to a substantially rectangular vacuum-tight planar insulator support and containing a gas at glow discharge pressure, a plurality of cathode segments insulated from one another and attached to the surface of and in a plane substantially parallel to said support, and a wire mesh electrically conductive anode substantially parallel to said segments and intermediate said segments and said envelope with each of said segments and said anode having an electrical connection through the support to an external conductor attached thereto.

7. The glow discharge device of claim 5 wherein said support and said envelope are substantially rectangular in shape with said envelope having a substantially rectangular-shaped peripheral surface hermetically sealed to said support.

8. The glow discharge device of claim 5 wherein said support and envelope are substantially rectangular-shaped and said segments providing said visual display symbol are arrayed in a substantially rectangular configuration with segment pairs extending in a direction substantially normal to the sides and intermediate diagonal corners of the configuration.

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