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IONIZABLE GAS DISPLAY DEVICE WITH SEGMENTED ELECTRODE PATTERN

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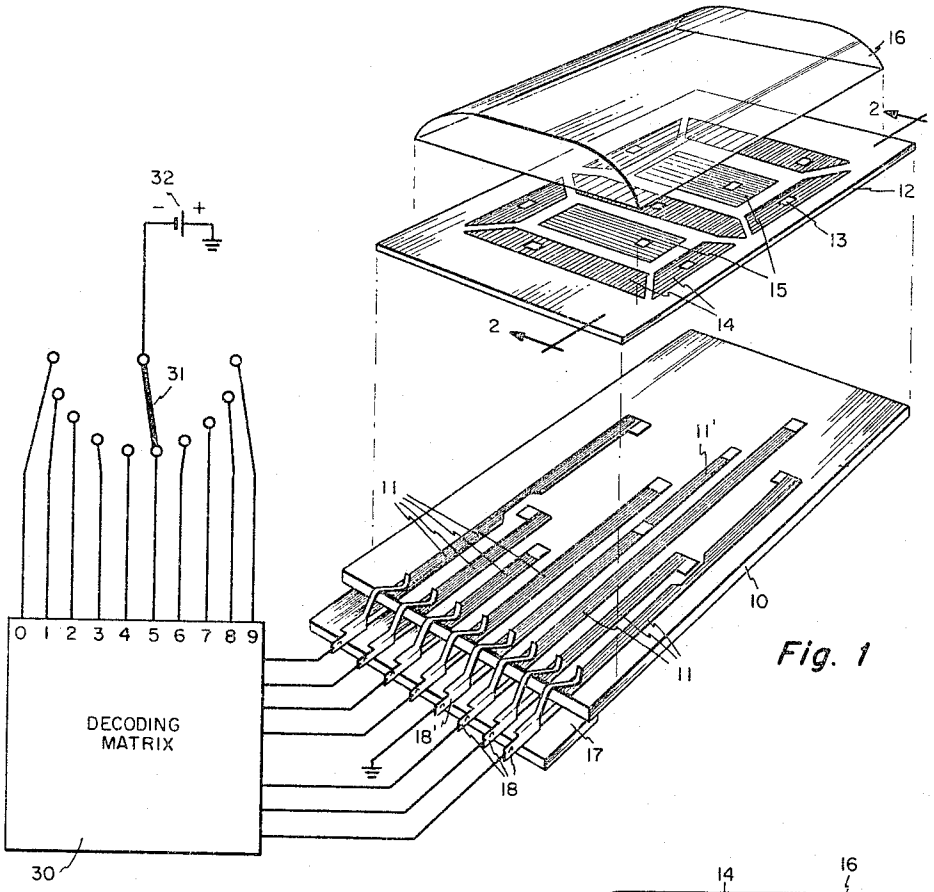


Fig. 1

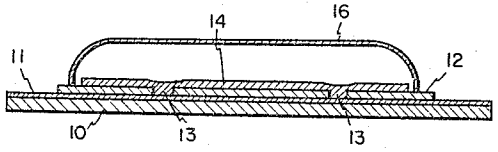


Fig. 2.

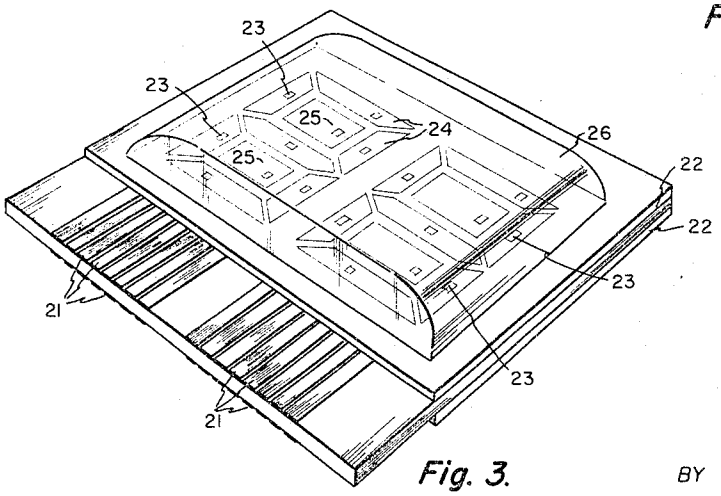


Fig. 3.

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IONIZABLE GAS DISPLAY DEVICE WITH SEGMENTED ELECTRODE PATTERN

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This invention relates to display devices and more particularly to a glow discharge display device.

A glow discharge display device is generally comprised of a transparent envelope which contains an anode electrode, a number of cathode electrodes, and an ionizable gas capable of supporting a glow discharge. The application of a suitable D.C. voltage between the anode electrode and a selected cathode electrode results in the breakdown of the gas and current flow through the gas from the cathode to the anode. This breakdown of the gas is characterized by a glow at the surface of the selected cathode.

The shape of the cathode elements determines the pattern of the glow discharge of the gas and many different alpha-numeric cathode configurations have been employed. One particularly useful configuration is a segmented cathode having a figure-eight shape and comprising seven substantially equal segments. The anode electrode may be formed in the two central portions of the figure-eight or a wire mesh screen may be spaced from the entire pattern. By applying the D.C. voltage between the anode and selected cathode segments, the glow discharge depicts any numeral from 1 to 0. In addition, other configurations have been employed to permit the representation of any desired letter and/or numeral.

In the construction of display devices of this type the segments of the cathode electrode are generally formed by engraving or other graphic arts techniques and are mounted on a mica insulator. The cathode segments are provided with lugs which extend through the insulator and serve to position and lock the segments in place.

A common anode may be provided by a wire mesh screen which is assembled over the cathode segments and is locked in place to the mica insulator. The assembly is then provided with a supporting base and gas-containing envelope. The electrical connections within the display device are provided by wiring each cathode electrode segment to an external pin connector. The wire used must be insulated to prevent any glow discharge from occurring thereat.

The display device construction is found to have certain disadvantages. These disadvantages arise from the fact that each cathode segment must be supported on the insulator by mounting lugs and then individually wired to an external pin connector on the envelope base. Since the number of cathode segments may be thirteen or greater for alpha-numeric cathode electrodes, the mounting and wiring steps performed during assembly have resulted in an increase in cost, complexity and size of the manufactured display device.

Accordingly, an object of the present invention is the provision of a glow discharge display device wherein the segmented cathode electrode and the electrical connections thereto are formed on one side of a suitable substrate.

Another object is to provide a glow discharge display device wherein the cathode electrode and the electrical connections to the segments thereof may be formed by graphic arts techniques on a glass substrate.

A further object is to provide a glow discharge display device in which a cathode pattern and corresponding glow discharge may be formed on more than one surface of the substrate.

In accordance with the present invention, a display device of the glow discharge type is provided in which a plurality of conducting paths are formed on one surface of a substrate. Overlying a portion of the conducting paths is an insulating layer, which may be a glass frit suitably glazed. The insulating layer is provided with a plurality of apertures extending therethrough. Each of the apertures in the insulating layer is positioned to register with one of the conducting paths formed on the glass substrate.

A segmented electrode pattern is then formed on the insulating layer with each segment being formed about at least one of the apertures in the insulating layer. Each segment is electrically connected through an aperture to a conducting path. The connections may be readily attained through the use of evaporation or metal spray techniques in forming the electrode pattern.

The electrode pattern is then covered by an envelope containing an ionizable gas having a pressure capable of sustaining a glow discharge. The envelope is hermetically bonded to the insulating layer. By applying a suitable D.C. voltage between conducting paths connected to selected segments in the electrode pattern and at least one conducting path coupled to an unselected segment of said electrode pattern which renders the selected segments cathodic, a glow discharge is provided along the surface of the selected cathode segments.

The display device is formed entirely on one side of the substrate so that no connecting holes need be formed in the substrate. As a result, inexpensive substrate materials, such as sheet glass, wherein it is generally difficult to form holes, may be readily employed.

A further advantage is realized in the afore-discussed construction in that restricting the graphic arts techniques to one surface of the substrate permits similar operations to be concurrently performed on more than one surface of the substrate. Thus, a display device may be formed on each of the opposing broad-area surfaces of a relatively thin substrate. In addition, a plurality of display devices may be formed on each surface of a large-area substrate with a single gas-filled envelope provided on each surface.

Further features and advantages of the invention will become more readily apparent from the following description of specific embodiments when viewed in conjunction with the accompany drawings, in which

FIG. 1 is an exploded view of one embodiment of the invention;

FIG. 2 is a side view in section of the embodiment of FIG. 1 taken along lines 2—2; and

FIG. 3 is a perspective view of a second embodiment.

Referring to the display device of FIGS. 1 and 2, substrate **10** is shown having a network comprising a plurality of conducting paths **11** formed on one surface thereof. The substrate **10** may be of glass or other suitable vacuum tight ceramic.

The conducting paths **11** may be formed on the substrate by conventional graphic arts techniques. One suitable technique is to silk screen a metallic gold luster on to the substrate and then heat the substrate to bond the gold thereto. Also, transparent conducting paths may be formed by spraying a stannic chloride solution onto a hot glass substrate. The excess conductor is then removed by protecting the conducting paths with a stencil while sandblasting the exposed surface.

Apertured insulating layer **12** is formed on the substrate overlying the inner portion of the conducting paths. This layer may advantageously be applied by spraying a layer of glass frit on the substrate, removing the frit at selected locations to form apertures **13** and heating the assembly to glaze the frit. The apertures **13** are located

in registration with a corresponding conducting path. The insulating layer may be either opaque or transparent and in practice, the use of a black glass frit has been found to provide increased contrast between the glow discharge and the background. In addition, the insulating layer need not be uniform in thickness so that increasing the thickness of the central portion of the layer can be used to increase the angle at which the display device can be viewed.

The final segmented electrode pattern comprising segments **14** and **15**, herein termed the cathode and anode segments respectively, is then applied over the insulating layer **12**. The particular electrode pattern shown is a figure-eight containing segments **14** with segments **15** centrally located therein. One method of applying the electrode pattern is to first mask the surface and then deposit evaporated aluminum thereon. It will be noted that many other methods, such as metal spray or electroless plating, may be employed. The particular pattern applied depends on the application mask.

Each segment of the electrode pattern includes at least one aperture. During the application of these segments to the insulating layer, a portion of the metal deposited enters the apertures to provide the electrical connection between a segment and a corresponding conducting path. This is shown in FIG. 2 wherein the apertures **13** are filled with the metal deposited to form the electrode pattern.

An envelope **16** is hermetically mounted on insulating layer **12**. The envelope may be formed of glass and sealed to the layer **12** by a glass solder. The envelope is evacuated of air and filled with an ionizable gas suitable for supporting a glow discharge, for example, argon or neon at a pressure of about 30 mm. of Hg at room temperatures.

The conducting paths **11** are carried to the edge of substrate **10** and may be plugged into printed circuit board connector **17** having a number of spring clips **18** thereon. As shown in FIG. 1, anode segments **15** are coupled through their corresponding apertures to a common conducting path **11** and to spring clip **18'** while each cathode segment **14** is coupled to an individual conducting path and spring clip. The application of a voltage of the order of 150 volts D.C. between conducting paths connected to selected cathode segments and conducting path **11'**, having a polarity such that the selected segments are cathodic with respect to the ionizable gas, results in a glow discharge of the gas. This glow discharge occurs on the surface of the selected cathode segments so that selecting different segments permits different characters to be displayed. To this end, anode segments **15** are connected to ground at spring clip **18'** while the cathode segments are connected to one end of decoding matrix **30**. The other end of matrix **30** is connected through selector switch **31** to negative D.C. voltage source **32**. The decoding matrix is of conventional design with the position of the selector switch determining which of the outputs and the corresponding conducting paths are energized. Since the voltage required to sustain a glow discharge is less than the voltage required to initiate it, the decoding matrix should provide equal current limiting resistances for each output. Alternatively, a separate current limiting resistor may be connected in series with each spring clip **18**.

While the above description refers to an embodiment which displays one character, the present invention may be constructed so as to display several characters on each surface of the substrate. This is shown in the embodiment of FIG. 3 wherein a single substrate is utilized to form a display device for displaying two characters on each broad area surface of the substrate.

Conducting paths **21** are formed on each side of substrate **20** and comprise four networks of the conducting paths **11** shown in FIG. 1. The conducting paths **21** are covered by a pair of insulating layers **22** having apertures **23** therein. The apertures register with a corresponding conducting path.

A pair of segmented electrode patterns comprising cathode segments **24** and anode segments **25** is formed on each of the insulating layers **22**. Each segment is coupled to a conducting path through a corresponding aperture.

An envelope **26** is hermetically mounted on each insulating layer **22** and is filled with an ionizable gas having a pressure capable of sustaining a glow discharge therein. The application of a voltage between selected cathode segments of each pattern and their respective anode segments provides a display of two characters on each side of the substrate.

Although the substrate is shown relatively thin, other substrate geometries may be employed with different electrode patterns being formed on one or a plurality of the surfaces thereof. While the above description refers to specific embodiments, it is understood that many modifications and variations may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. A display device of the type wherein a glow discharge of a confined ionizable gas is used to display information which comprises

(a) a substrate,

(b) a plurality of conducting paths formed on at least one surface of said substrate,

(c) an insulating layer formed on said surface of the substrate and overlying a portion of said conducting paths, said insulating layer having a number of apertures therein in registration with said conducting paths, at least one aperture being in registration with each of said conducting paths,

(d) a segmented electrode pattern formed on said insulating layer and extending through said apertures to said conducting paths, and

(e) an envelope mounted on said insulating layer for containing said ionizable gas, the application of a voltage between conducting paths connected to selected segments and at least one conducting path connected to an unselected segment of said electrode pattern resulting in a glow discharge along the surface of the selected segments.

2. A display device of the type wherein a glow discharge of a confined ionizable gas is used to display information which comprises

(a) a substrate,

(b) a plurality of conducting path networks formed on at least one surface of said substrate,

(c) an insulating layer formed on said surface of the substrate and overlying a portion of said conducting paths, said insulating layer having a number of apertures therein in registration with said conducting paths, at least one aperture being in registration with each of said conducting paths,

(d) a plurality of segmented electrode patterns formed on said insulating layer and extending through said apertures to said conducting paths, and

(e) an envelope mounted on said insulating layer for containing said ionizable gas, the application of a voltage between conducting paths connected to selected segments and at least one conducting path connected to an unselected segment of said electrode patterns resulting in a glow discharge along the surface of the selected segments.

3. A display device of the type wherein a glow discharge of a confined ionizable gas is used to display information which comprises

(a) a substrate,

(b) a plurality of conducting path networks formed on the surfaces of said substrate,

(c) an insulating layer formed on said substrate and overlying a portion of said conducting paths, said insulating layer having a number of apertures there-

in in registration with said conducting paths, at least one aperture being in registration with each of said conducting paths,

(d) a plurality of segmented electrode patterns formed on said insulating layer and extending through said apertures to said conducting paths, and

(e) envelope means mounted on said insulating layer for containing said ionizable gas, the application of a voltage between conducting paths connected to selected segments and at least one conducting path connected to an unselected segment of said electrode patterns resulting in a glow discharge along the surface of the selected segments.

4. A display device of the type wherein a glow discharge of a confined ionizable gas is used to display information which comprises

(a) a substrate,

(b) a plurality of conducting paths formed on said substrate,

(c) an insulating layer formed on said substrate and overlying a portion of said conducting paths, said insulating layer having a number of apertures therein in registration with said conducting paths, at least one aperture being in registration with each of said conducting paths,

(d) a segmented cathode electrode pattern formed on said insulating layer and extending through said apertures to said conducting paths,

(e) anode electrode means formed on said insulating layer and extending through at least one aperture to said conducting paths, and

(f) an envelope mounted on said insulating layer for containing said ionizable gas, the application of a voltage between conducting paths connected to selected segments and at least one conducting path connected to said anode electrode means resulting in a glow discharge along the surface of the selected segments.

5. A display device of the type wherein a glow discharge of a confined ionizable gas is used to display information which comprises

(a) a substrate,

(b) a plurality of conducting paths formed on said substrate,

(c) an insulating layer formed on said substrate and overlying a portion of said conducting paths, said insulating layer having a number of apertures therein in registration with said conducting paths, at least one aperture being in registration with each of said conducting paths,

(d) a segmented electrode pattern formed on said insulating layer and extending through said apertures to said conducting paths,

(e) an envelope mounted on said insulating layer for containing said ionizable gas,

(f) connecting means for receiving said substrate therein and contacting said conducting paths on said substrate, and

(g) means connected to said connecting means for applying a voltage between conducting paths connected to selected segments and at least one conducting path connected to an unselected segment of said electrode pattern so that a glow discharge occurs along the surface of the selected segments.

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