Aug. 1, 1967 R. C. L'HEUREUX 3,334,269

CHARACTER DISPLAY PANEL HAVING A PLURALITY OF GLOW DISCHARGE CAVITIES INCLUDING RESISTIVE BALLAST MEANS EXPOSED TO THE GLOW DISCHARGE THEREIN

Filed July 28, 1964 3 Sheets-Sheet 1

Fig. 1

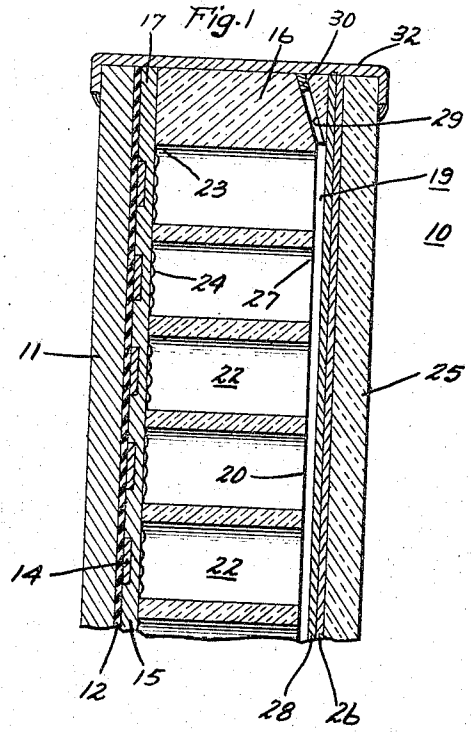
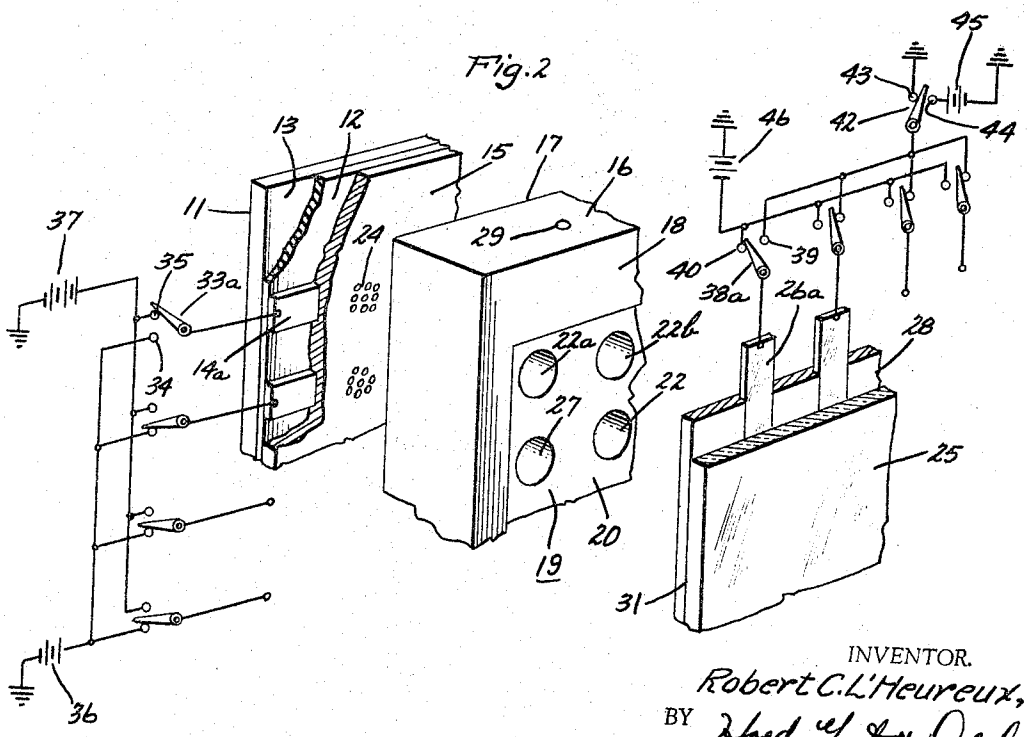


Fig. 2



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Fig. 3

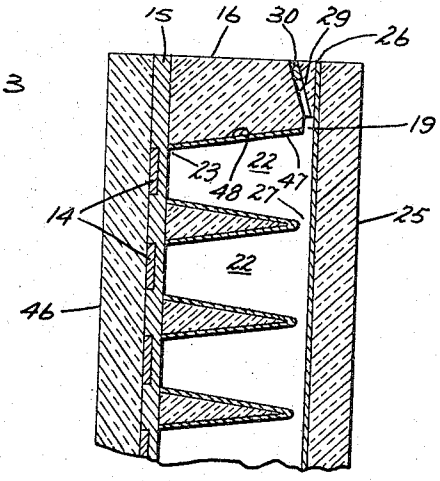
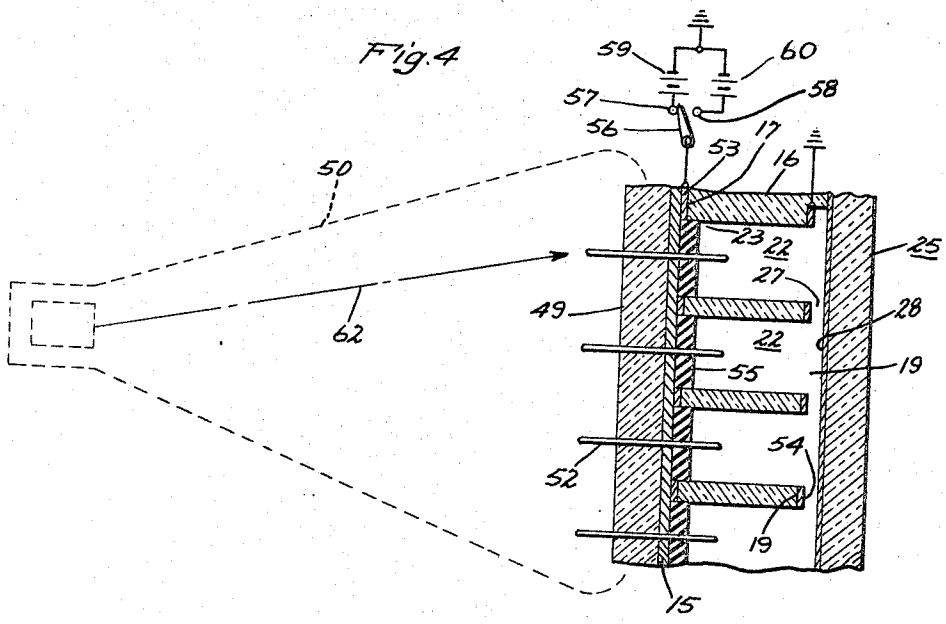


Fig. 4



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Fig. 5

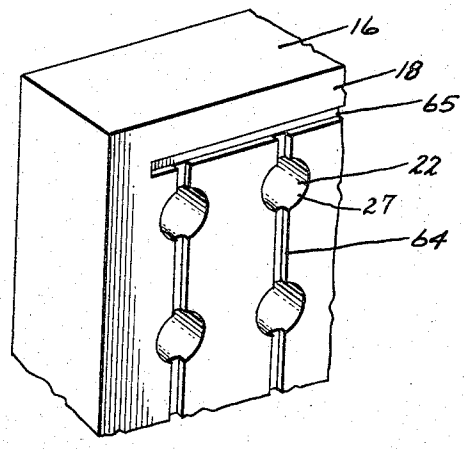


Fig. 6

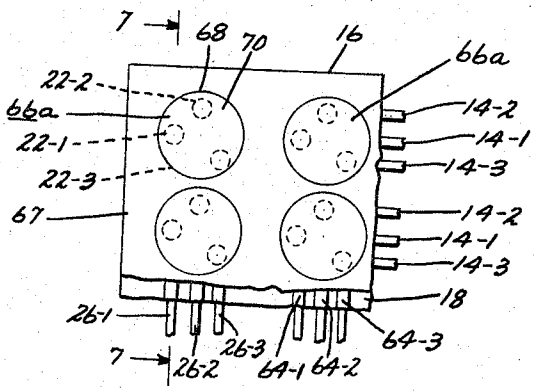
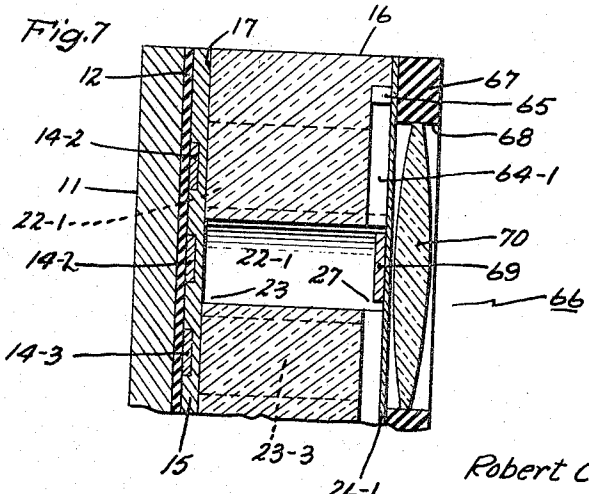


Fig. 7



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3,334,269

CHARACTER DISPLAY PANEL HAVING A PLURALITY OF GLOW DISCHARGE CAVITIES INCLUDING RESISTIVE BALLAST MEANS EXPOSED TO THE GLOW DISCHARGE THEREIN

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4 Claims. (Cl. 315—58)

This invention relates generally to devices for selectively forming and displaying a plurality of characters, such as letters and numerals, and more particularly to a character display panel employing an array of fluorescent lamp elements.

In the computer and instrumentation technologies, it is frequently desirable to provide a read-out device for visually displaying different characters; in airborne applications in which size and weight factors are critical, it is desirable that such read-out devices be highly miniaturized. A common form of character display device employs a plurality of individual incandescent lamps arranged in a predetermined pattern or array so that selective illumination of the lamps forms and displays the desired characters. While miniature incandescent lamps are commercially available, employment of a large number of such lamps in an array nevertheless provides a device of objectionable size. Furthermore, employment of a large number of incandescent lamps in an array necessitates accommodation of a large number of electrical leads extending from the lamps and provision must be made for disassembling the device in order to replace burned-out lamps. In addition, any device employing incandescent lamps inherently is subject to damage due to shock.

It is therefore desirable to provide a character display panel which lends itself to miniaturization and which does not employ incandescent lamps for the light sources.

It is accordingly an object of the invention to provide an improved character display panel.

Another object of the invention is to provide an improved character display panel capable of being highly miniaturized.

The invention in its broader aspects provides a character display panel comprising a self-contained array of individual fluorescent lamp elements. Each of these elements may have a very small internal diameter and the elements may be closely packed in a planar array for viewing from their ends thus permitting the provision of an extremely miniaturized device in which the electrical connections are simplified and importantly in which filaments are eliminated thus eliminating the necessity for disassembling the device for lamp replacement.

The above-mentioned and other features and objects of this invention and the manner of attaining them will become more apparent and the invention itself will be best understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a fragmentary cross-sectional view of one embodiment of the invention;

FIG. 2 is a fragmentary exploded view, partly in cross-section and partly broken away, further illustrating the embodiment of FIG. 1;

FIG. 3 is a fragmentary cross-sectional view illustrating another embodiment of the invention;

FIG. 4 is a fragmentary cross-sectional view illustrating yet another embodiment of the invention;

FIG. 5 is a fragmentary view in perspective illustrating a modification of the embodiment of FIG. 1;

FIG. 6 is a fragmentary end view illustrating a still further embodiment of the invention; and

FIG. 7 is a cross-sectional view taken along line 7—7 of FIG. 6.

Referring now to FIGS. 1 and 2, there is shown a miniature character display panel, generally indicated at **10**, comprising a flat cathode plate **11** in order to provide support for the other elements of the device and to impart the requisite rigidity. Cathode plate **11** is preferably formed of suitable metal having good thermal conductivity, such as aluminum, in order to conduct away heat generated in the individual fluorescent lamp elements due to the arc discharge therein, as will be hereinafter more fully described. Cathode plate **11** may also be formed of electrical insulation material having good thermal conductive properties, such as beryllium oxide or aluminum oxide. In the case of a cathode plate **11** formed of electrically conductive material, a thin layer **12** of insulating material is deposited or otherwise formed on the inner surface **13**, as by anodizing in the case of aluminum. A plurality of elongated, spaced, parallel conductive strips **14** are formed or adhered to the surface of the insulating layer **12**, as shown.

A layer **15** of suitable resistive material is deposited over the insulating layer **12** and the conductive strips **14**. Resistive layer **15** serves to limit or ballast the glow discharge current, as will be hereinafter more fully described.

A member **16** is provided having flat opposite sides **17**, **18** and with its side **17** abutting the resistive layer **15**, as shown. A recess **19** is formed in side **18** of member **16** and has a flat bottom surface **20** parallel with the side **17**. A plurality of closely spaced cylindrical cavities or openings **22** are formed in member **16** extending transversely between sides **17** and surface **20**; in the preferred embodiment shown, the axes of openings **22** are parallel and respectively perpendicular to the planes of sides **17** and surface **20**. Each of the openings **22** has its end **23** which communicates with side **17** of member **16** in registry with a conductive strip **14**. In the preferred embodiment of the invention, areas **24** of material, such as nickel, nichrome, etc. having secondary electron emission characteristics are deposited on the surface on the resistive layer **15** and are respectively disposed to the ends **23** of the openings **22**.

Another flat plate member **25** is provided formed of light-transmitting material, such as glass. A plurality of elongated, spaced, parallel, conductive strips **26**, also having light-transmitting characteristics, are secured or deposited on the inner surface **27** of plate **25**. As best seen in FIG. 2, the conductive strips **26**, which are preferably formed of transparent conductive material, extend transversely with respect to the conductive strips **14**, and each of the openings **22** in member **16** has its other end **27** in registry with a conductive strip **26**.

In the embodiment of FIGS. 1 and 2, a layer **28** of suitable phosphor material, such as Sylvania #5702 which emits visible light when stimulated by ultra-violet light, is deposited over the inner surface **31** of plate **25** and over the conductive strips **26**. Plate member **25** with conductive strips **26** and phosphor layer **28** thereon is arranged with the phosphor layer **28** abutting side **18** of member **16**, the phosphor layer **28** thus being exposed to cavity **19** and ends **27** of the openings **22**.

The openings or cells **22** and the channel formed by recess **19** which, it will be seen, interconnects ends **27** of the openings **22**, is filled with the proper mixture of mercury and argon gas at the proper pressure to provide a glow discharge having the desired spectral characteristic at the operating voltage employed; in the preferred

embodiment, the mercury-argon mixture and pressure is selected to generate ultra-violet light of 2537 A. at an operating or holding voltage of the order of 260 volts. The gas pressures employed are similar to those employed in conventional fluorescent lamps adjusted in accordance with the geometry of the openings **22** and the operating voltages employed, is well known to those skilled in the art. The channel defined by the recess **19** which interconnects the cells or openings **22** equalizes the pressures and gas mixtures in each of the cells.

The openings **22** and channel **19** are initially filled with gas by means of passageway **29** communicating with channel **19**, passageway **29** being sealed as at **30** when the proper pressure has been obtained. The elements forming the panel **10** are held in assembled relation and sealed by means of a clamping element **32**, as shown.

It will now be seen that each of the cells or openings **22** is filled with gas, has one conductive strip **14** at its one end **23** and another conductive strip **26** at its other end **27**, and has the phosphor material **28** exposed to its end **27**. Each of the cells or openings **22** thus forms an individual fluorescent lamp. Thus, upon application of a suitable breakdown or sparking potential to the two conductive strips **14, 26** with which the two ends **23, 27** of one cell **22** are in registry, break-down of the gas in which the two conductive strips or electrodes are immersed occurs and a self-sustained arc discharge will be initiated between the two conductive strips **14, 26**. It is well known that such an arc discharge has a negative resistance characteristic, i.e., as the current increases the resistance decreases. Thus, unless the voltage which was required initially to produce the discharge is rapidly reduced to a lower level, the current will very rapidly increase to a destructive level. This reduction in operating voltage may be provided by the current-limiting resistance layer **12** and/or the immediate application of a lower operating or holding potential across the two effective conductive strips **14, 26**. It will further be seen that so long as the operating or holding potential is maintained across the two effective conductive strips **14, 26** the arc discharge in the respective cell **22** will be maintained; removal of the holding potential or pulsing of the applied voltage to a lower level will extinguish the arc. As indicated, the arc or glow discharge generates ultra-violet light which in turn activates or stimulates the phosphor layer **28** exposed to the respective cell **22** causing it to emit visible light, in the same manner as a conventional fluorescent lamp.

It will now be seen that the transversely disposed conductive strips **14, 26** form a matrix arrangement with the result that selective application of a potential across one of the strips **14** and one of the strips **26** will cause illumination of the respective cell **22**. In this manner, different characters, such as letters or numerals, may be formed and displayed by selective application of potential to predetermined strips **14, 26** thus illuminating predetermined ones of the cells **22**.

Referring particularly to FIG. 2, one possible switching arrangement is shown, it being understood that the switching arrangement by which potentials are applied to the respective conductive strips **14, 26** does not form a part of the invention and is shown for illustrative purposes only. Here, each of the conductive strips **14** is coupled to a switch **33** having first and second positions **34** and **35**, the position **34** being coupled to source **36** of holding potential, such as 260 volts, and position **35** being coupled to another source of potential **37**. The other conductive strips **26** are coupled to switches **38** respectively having first and second positions **39, 40**. Switch positions **39** are coupled to switch **42** having a first and second position **43, 44**. Switch position **43** is coupled to the other side of potential sources **36, 37** while switch position **44** is coupled to source **45** which reduces the holding potential source **36** to a lower arc extinguishing level. Switch positions **40** are coupled to potential source **46** which, together with source **37**, provides a higher sparking or breakdown potential for initiating the arc discharge. In operation, if it is desired to illuminate cell **22*a***, the switches **33*a*** and **38*a*** are momentarily and simultaneously moved to their positions **35, 40** thus applying the sum of the potentials of sources **37, 46** across conductive strips **14*a*, 26*a***, and thereby to initiate the arc discharge in the cell **22*a***. Switches **33*a*, 38*a*** are then immediately moved to their positions **34, 39** thereby to impress the lower holding potential of source **36** across conductive strips **14*a*, 26*a*** thereby to maintain the arc discharge in cell **22*a***, switch **42** remaining in this position **43**. When it is desired to extinguish the glow discharge in cell **22*a***, switch **42** is moved to position **44** thus reducing the potential applied across conductors **14*a*, 26*a*** to a lower arc extinguishing level.

It will be readily understood that in actual practice, the switching of the potentials applied to the conductive strips **14*a*, 26*a*** may be accomplished by conventional static and/or pulsed switching arrangements well known to those skilled in the art.

While cells **22** have been shown as being cylindrical and arranged in a regular geometric pattern with the conductive strips **14, 26** thus having a conventional cross-grid arrangement, it will be readily understood that the individual cells **22** may have other cross-sectional configurations and may be arranged in other patterns with the conductive strip electrodes being correspondingly rearranged.

Referring now to FIG. 3 in which like elements are indicated by like reference numerals, a modification is shown in which a flat plate **46** is employed formed of insulating material rather than the metal plate **11** of FIGS. 1 and 2 which thus permits elimination of the insulating coating **12**. Here, the walls of the openings or cells **22** are tapered or flared outwardly toward the transparent plate member **25** to have a frusto-conical configuration so that their ends **23** exposed to the resistive layer **15** are smaller in diameter than their ends **27** which face the plate **25**. In this embodiment, the phosphor layer **47** is deposited over the walls **48** of the cells **22** rather than on the transparent plate **25**, the frusto-conical configuration of the cells thus permitting better viewing of the light emitted by the phosphor layer **47**. This arrangement of the phosphor permits viewing of the light emitted by the surface of the phosphor which is excited by the ultra-violet radiation rather than the light attenuated by absorption in passing through the phosphor layer.

Referring now to FIG. 4 in which like elements are still indicated by like reference numerals, an embodiment is shown adapted for cathode ray switching. Here, plate **49** forms the faceplate of a cathode ray tube, shown in dashed lines at **50**. Resistive layer **15**, which acts as a current limiter, is deposited upon the outer surface of the faceplate **49** with the member **16** again positioned as shown. Faceplate **49** is provided with a plurality of discrete cathode wires or electrodes **52** extending therethrough and respectively into the openings or cells **22** as shown. Side **17** of member **16** and surface **20** defined by the recess **19** respectively have layers **53, 54** of conductive material coated thereon; layer **54** which surrounds end **27** of each cell **22** forms the anode whereas layer **54** which surrounds end **23** of each cell forms a holding electrode. A layer **55** of insulating material is preferably coated upon the resistive layer **15** within end **23** of each cell **22**. Phosphor layer **28** is again deposited upon the inner side of transparent plate member **25**, but in the alternative may be deposited upon the walls of the openings **22**, as in the embodiment of FIG. 3.

Conductive layer **53** is coupled to switch **56** having first and second positions **57, 58** position **57** being coupled to source **59** of holding potential and position **58** being connected to source **60** of arc-extinguishing potential.

Conductive coating **54** is coupled to the other side of sources **59**, **60**, as shown.

It will readily be seen that the individual cells **22** are triggered "on" by impingement of the electron beam **62** upon the respective electrode **52** which instantaneously raises the cell potential to the firing level. When the beam **62** moves on to another electrode **52** under the influence of conventional beam-deflection means (not shown), the glow discharge previously initiated in the respective cell **22** is maintained by virtue of the holding potential applied across conductive layers **53**, **54** by switch **56** in its position **57**. When it is desired to extinguish the display thus formed, switch **56** may be moved to position **58** thus applying the arc-extinguishing potential to the conductive layers **53**, **54**.

Referring now to FIG. 5 in which a modification of the embodiment of FIGS. 1 and 2 is shown, in order to minimize any cross-talk between adjacent cells **22** during operation, parallel channels **64** are provided in side **18** of member **16** interconnecting ends **27** of the openings **22** in lieu of the large-area recess **19** of FIGS. 1 and 2. Channels **22** may in turn communicate with a common header channel **65**. Header channel **65** may thus serve as a reservoir for the gas, or may in turn be connected to a separate gas reservoir (not shown).

Referring now to FIGS. 6 and 7 in which like elements are still indicated by like reference numerals, another embodiment of the invention is shown adapted for providing a multi-color display with either mixed or unmixed colors. Here, a flat cathode plate **11** is again provided preferably formed of thermal conductive material and having a thin layer **12** of insulating material deposited thereon. A plurality of enlongated, spaced, parallel conductive strips **14** are again formed on the surface of the insulating layer **12** and a layer **15** of suitable resistive material is deposited over the insulating layer **12** and the conductive strips.

In this embodiment, member **16** has a plurality of clusters **66** of openings or cells **22** formed therethrough, each such cluster **66** including three such cells **22–1**, **22–2**, and **22–3**. Member **16** is again arranged with its flat side **17** abutting the resistive layer **15** and with end **23** of the openings **22–1**, **22–2** and **22–3** of each cluster **66** respectively in registry with conductive strips **14–1**, **14–2**, and **14–3**. Channels **64–1**, **64–2**, and **64–3** are formed in side **18** of member **16** respectively communicating with ends **27** of the openings **22–1**, **22–2**, and **22–3**, channels **64–1**, **64–2**, and **64–3** being connected by header or reservoir channel **65**, as shown.

Another flat plate member **67** is provided which may be formed of suitable opaque insulating material and which has a plurality of openings **68** formed therein. A plurality of elongated spaced, parallel, conductive strips **26** having light transmitting characteristics are formed on the inner surface of plate member **67**, conductive strips **26** extending transversely with respect to the conductive strips **14**.

A plurality of small areas **69** of suitable phosphor material which emit visible light when stimulated by ultraviolet light are deposited over the inner surface of plate member **67** and over the conductive strips **26**. Plate member **67** with the conductive strips **26** and the phosphor areas **69** thereon is arranged abutting side **18** of member **16**, conductive strips **26–1**, **26–2**, and **26–3** being respectively in registry with ends **27** of the openings **22–1**, **22–2** and **22–3**, and the phosphor areas **69** being respectively exposed to ends **27** of the openings. It will be seen that each of the openings **68** in the plate member **67** surrounds and defines a respective cluster **66**, the openings **22–1**, **22–2**, and **22–3** which form a respective cluster **66** being in registry with a respective opening **68**.

In this embodiment, each of the phosphor areas **69** for a respective cluster **66** emits visible light having a different color, such as the primary colors red, blue and yellow. Thus, the phosphor areas **69** respectively associated with openings **22–1**, **22–2** and **22–3** of each cluster

66 may respectively be formed of phosphor materials emitting red, blue and yellow visible light.

In order to provide for mixing or blending of the colored light emitted by the phosphor areas **69** respectively associated with the cells **22–1**, **22–2** and **22–3** forming each cluster **66**, a suitable optical lens **70** is positioned in each of the openings **68** in the member **67**.

It will now be seen that when a suitable potential, as above described, is applied to conductive strip **14–1** associated respectively with clusters **66***a* and **66***b* and to conductive strip **26–1** associated with cluster **66***a*, a discharge will be initiated in cell **22–1** of cluster **66***a* which will excite phosphor area **69** associated therewith to emit red light, which will be viewed through the lens **70**. It will further be seen that if a suitable potential is initially applied to conductive strip **14–2** associated with clusters **66***a* and **66***b* and to conductive strip **26–2** associated with cluster **66***a*, a discharge will be initiated in cell **22–2** which will excite the phosphor area **69** associated therewith to emit blue light, the blue light thereby emitted and the red light emitted by the phosphor areas **69** associated with the cell **22–1** of cluster **66***a* being mixed or blended by lens **70** to provide a resultant purple display.

It will now be seen that by the employment of a suitable switching arrangement, as is well known to those skilled in the art, any one of the three primary colors may be individually displayed in any one or more of the clusters **66***a*, or any mixture of the primary colors may be displayed in any one or more of the clusters **66***a*.

It will be readily understood that the embodiments of either FIG. 3 or FIG. 4 above may equally advantageously be modified to provide the multi-color display. It will also be readily understood that any desired combination of different colored phosphors may be employed in each of the clusters **66** and that each of the clusters **66** may comprise a greater number of cells **22** thus providing a greater range of individual colors and a greater range of color mixing.

While there have been described above the principles of this invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of the invention.

What is claimed is:

1. A character display panel comprising: means forming a plurality of cavities each having opposite ends respectively lying in spaced parallel planes; first electrically conductive means at one end of each of said cavities; fluorescent phosphor material exposed to each of said cavities; second electrically conductive means at the other end of each of said cavities; and means sealing said cavities; each of said cavities having glow discharge-inducing gas therein whereby selective application of electrical potential to said conductive means provides glow discharge in selected ones of said cavities and emission of light from the phosphor material respectively exposed thereto; at least a part of said sealing means having light-transmitting properties for transmitting the light emitted by said phosphor material for viewing; and current limiting resistance means connected to said first conductive means and exposed to said one end of each of said cavities for respectively ballasting the current of said glow discharge therein.

2. A character display panel comprising: a first member formed of insulating material and having flat opposite surfaces with a plurality of openings formed therethrough and respectively extending between said surfaces; a first flat plate member closely adjacent one of said surfaces; first electrically conductive means carried by said first plate member and positioned at one end of each of said openings; fluorescent phosphor material exposed to each of said openings; second electrically conductive means at the other end of each of said openings; a second flat plate member closely adjacent the other of said surfaces; and means sealing said plate members to said first member thereby sealing said openings therein; each of said open-

ings having glow discharge-inducing gas therein whereby selective application of electrical potential to said conductive means provides a glow discharge in selected ones of said openings and emission of light from the phosphor material respectively exposed thereto; said second plate member having light-transmitting properties for transmitting the light emitted by said phosphor material for viewing; said first conductive means having a plurality of first elongated spaced parallel conductors carried by said first plate member, each of said openings having one end thereof in registry with one of said first conductors; said second conductive means having a plurality of second elongated spaced parallel conductors carried by said second plate member, each of said openings having its other end in registery with one of said second conductors; said first and second conductors extending transversely with respect to each other whereby application of said electrical potential to one of said first conductors and one of said second conductors causes a glow discharge in one only of said openings; said second conductors having light-transmitting properties; said openings being frustoconical with their said other ends being larger than their said one ends, and said phosphor material being deposited on the walls of said openings.

3. A character display panel comprising: a first member formed of insulating material and having flat opposite surfaces with a plurality of openings formed therethrough and respectively extending between said surfaces; a first flat plate member closely adjacent one of said surfaces; first electrically conductive means carried by said first plate member and positioned at one end of each of said openings; fluorescent phosphor material exposed to each of said openings; second electrically conductive means at the other end of each of said openings; a second flat plate member closely adjacent the other of said surfaces; and means sealing said plate member to said first member thereby sealing said openings therein; each of said openings having glow discharge-inducing gas therein whereby selective application of electrical potential to said conductive means provides a glow discharge in selected ones of said openings and emission of light from the phosphor material respectively exposed thereto; said second plate member having light-transmitting properties for transmitting the light emitted by said phosphor material for viewing; said first conductive means having a plurality of first elongated spaced parallel conductors carried by said first plate member, each of said openings having one end thereof in registry with one of said first conductors; said second conductive means having a plurality of second elongated spaced parallel conductors carried by said second plate member, each of said openings having its other end in registry with one of said second conductors; said first and second conductors extending transversely with respect to each other whereby application of said electrical potential to one of said first conductors and one of said second conductors causes a glow discharge in one only of said openings; said second conductors having light-transmitting properties; and a layer of resistance material deposited on said first plate member and said first conductors, said resistance material being exposed to said one end of said openings for ballasting the current of said glow discharge therein.

4. The panel of claim 3 wherein areas of secondary electron emissive material are deposited on said layer of resistance material respectively in said one each of said openings.

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