United States Patent

Caras

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[54] **DISPLAY PANEL HAVING PARTICLE SOURCE**

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[52] **U.S. Cl.** **313/54,** 313/198, 313/220, 313/221

[51] **Int. Cl.**.....**H01j 17/16,** H01j 17/18, H01j 17/32

[58] **Field of Search**.....313/220, 221, 54, 109.5, 198; 315/169 R, 169 TV, 84.6

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[57] **ABSTRACT**

A gas-filled display panel includes a plurality of rows and columns of display cells and associated electrodes. The panel also includes a trigger means, known as a keep-alive cell, to facilitate the turn-on of the display cells. The keep-alive cell is heat-sensitive, and it is secured in the panel by techniques which operate at room temperature.

17 Claims, 10 Drawing Figures

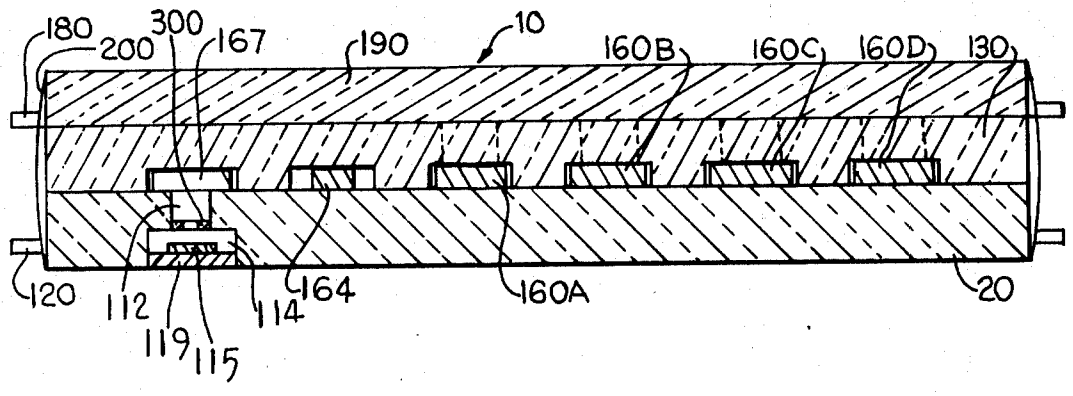
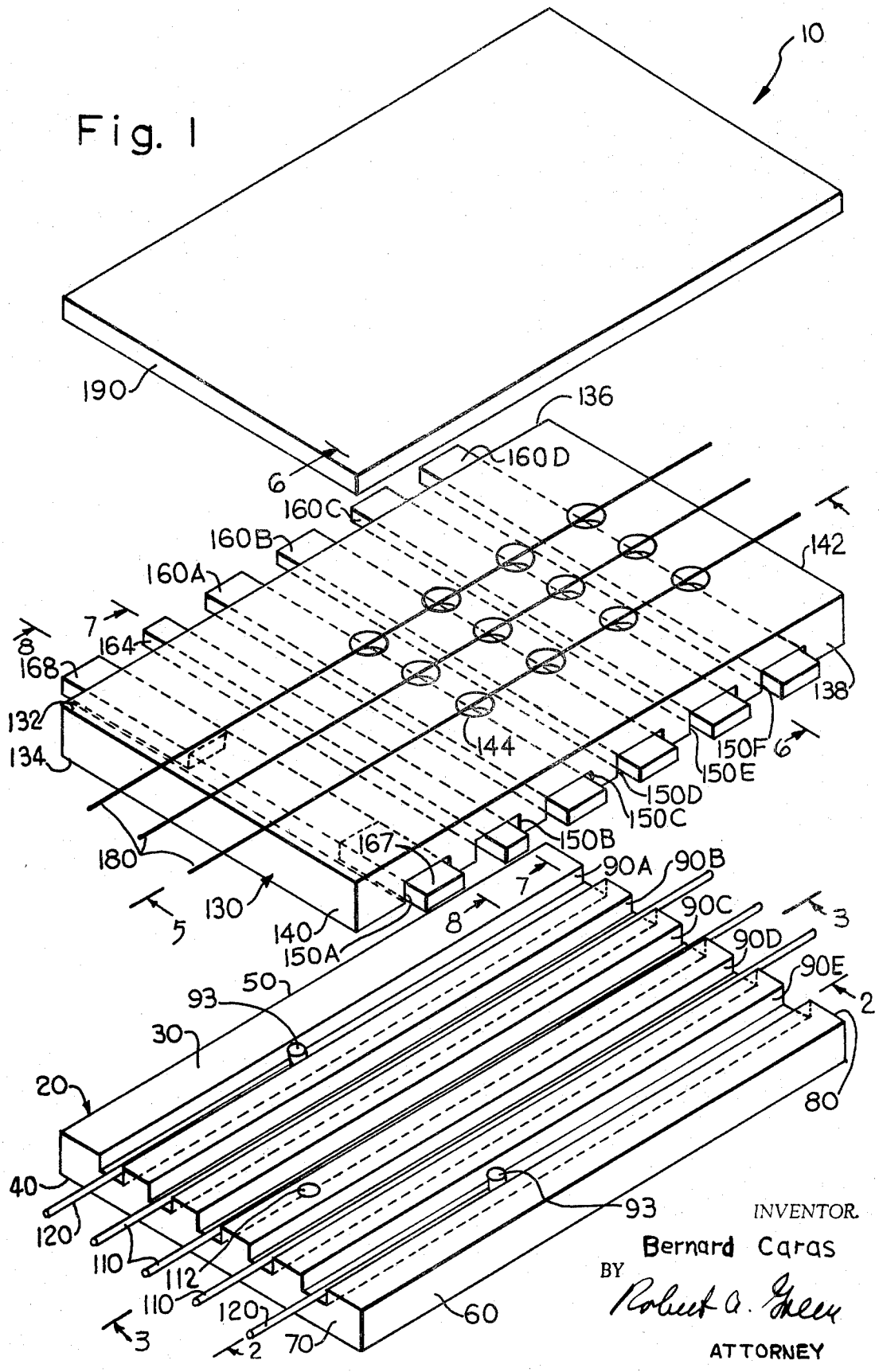


Fig. 1



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Fig. 2

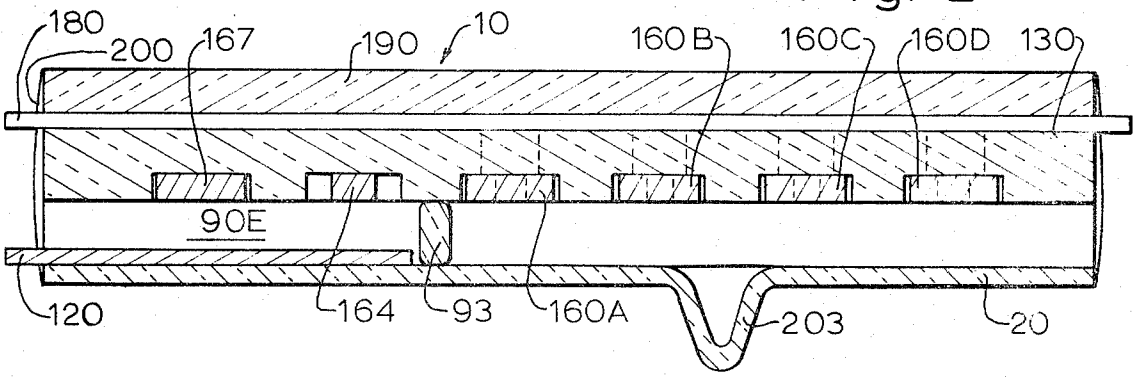


Fig. 5

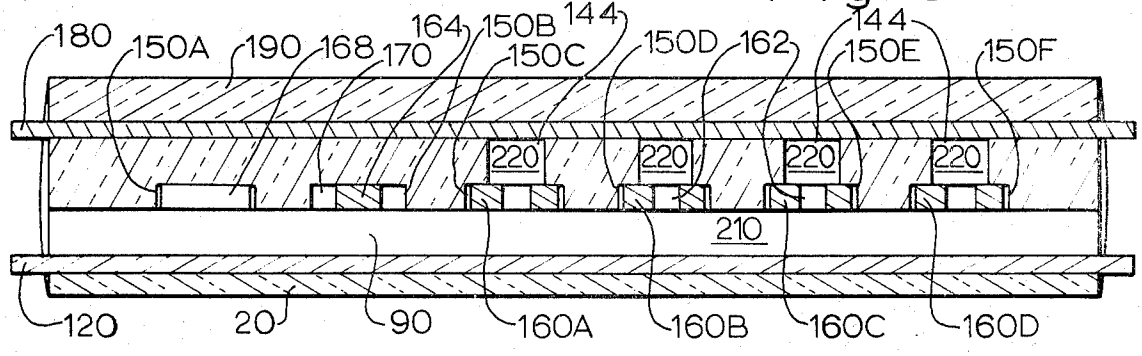
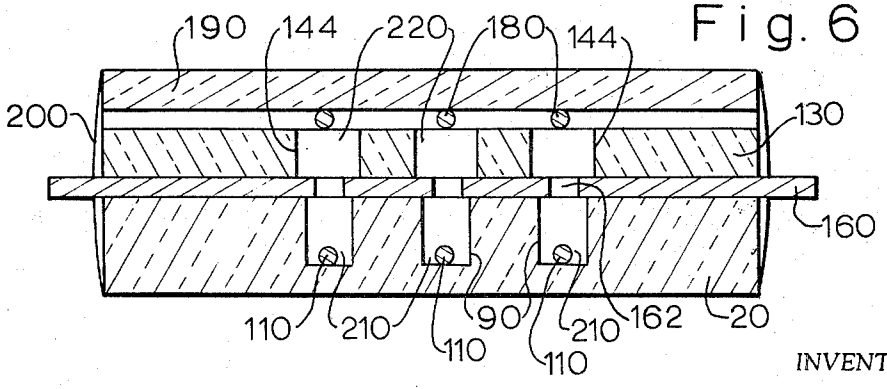


Fig. 6



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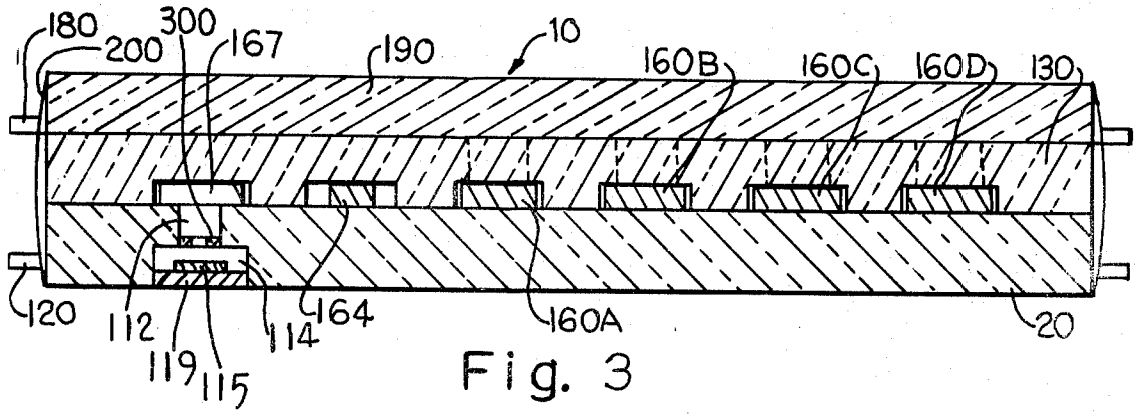


Fig. 3

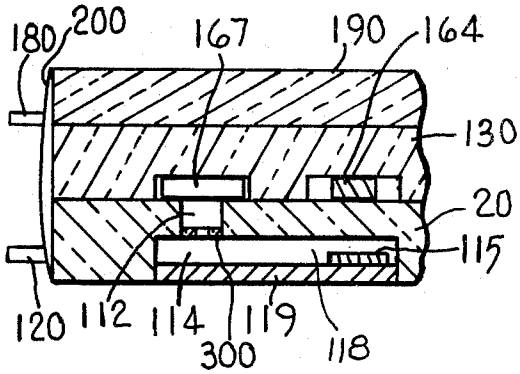


Fig. 4

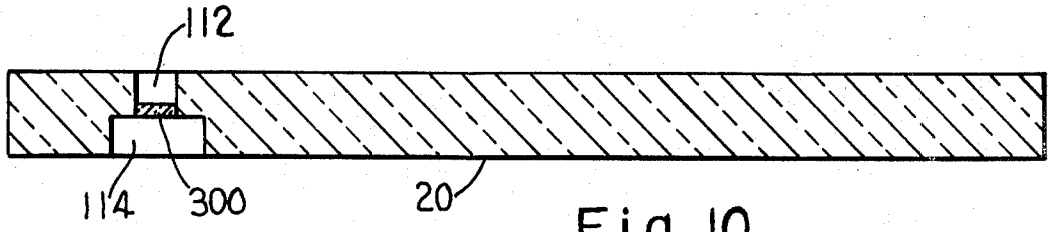


Fig. 10

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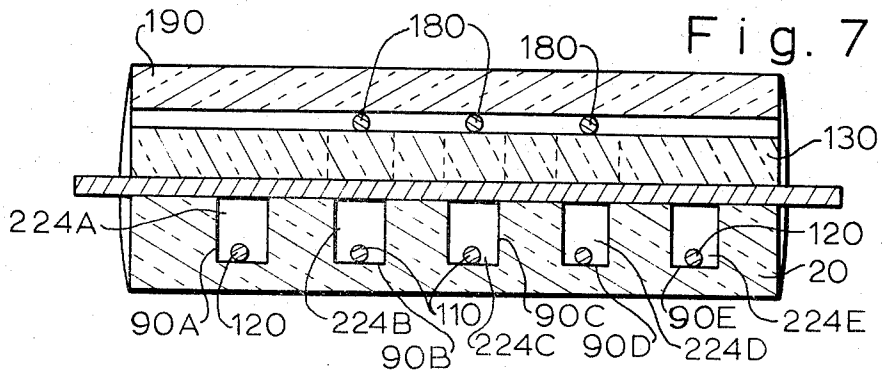


Fig. 7

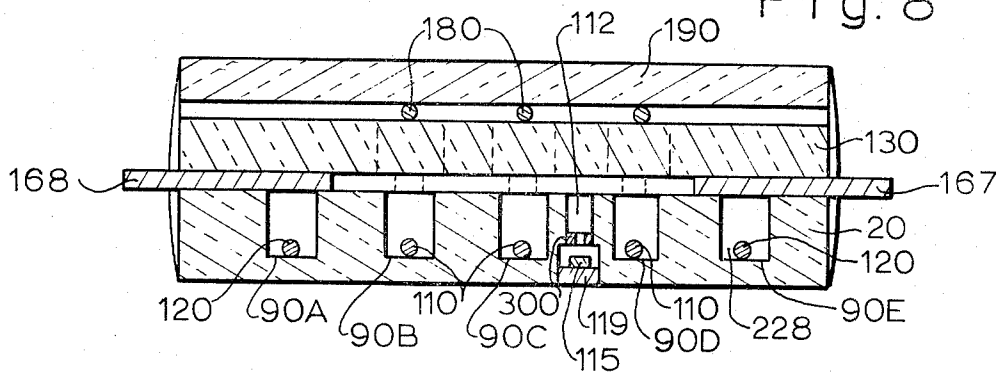


Fig. 8

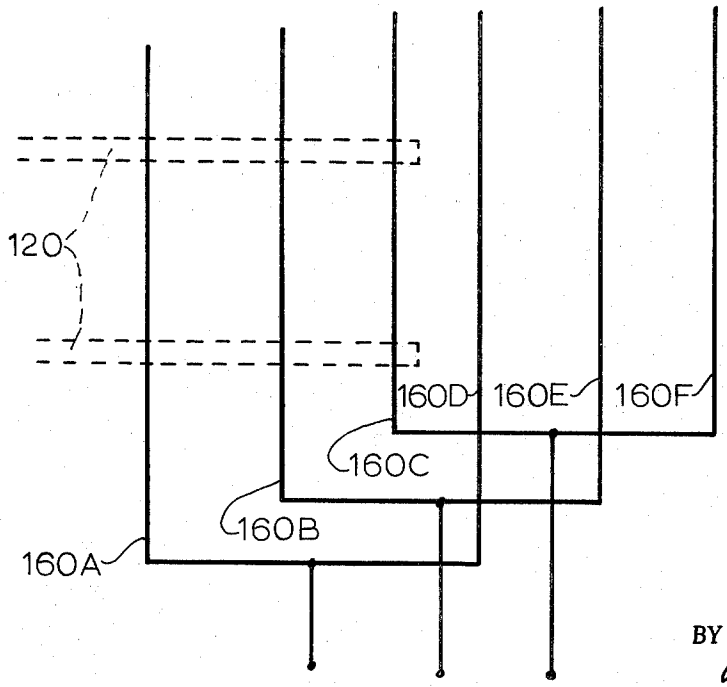


Fig. 9

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DISPLAY PANEL HAVING PARTICLE SOURCE

BACKGROUND OF THE INVENTION

The principles of the invention apply to all types of gas-filled display devices which are considered to require a glow triggering mechanism to achieve suitably high-speed firing or turn-on of the devices. According to one theory, the triggering mechanism provides electrons which are considered necessary to start the glow discharge process in a cell. In one arrangement for obtaining these initiating electrons, an auxiliary gas cell, called a keep-alive cell, is built into the panel and is held on continually by means of applied potential so that it is a constant source of electrons or other excited particles. This arrangement operates satisfactorily; however, more efficient keep-alive arrangements which do not require applied potentials are known, but one of these, which is particularly desirable, is adversely affected by processing steps used in making gas discharge devices.

SUMMARY OF THE INVENTION

A display panel embodying the invention includes a glow triggering mechanism which is sensitive to elevated temperature but is secured to the panel after all high-temperature processing steps have been carried out and by a process which does not require high temperatures.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective exploded view of a display panel embodying the invention;

FIG. 2 is a sectional view along the lines 2—2 in FIG. 1;

FIG. 3 is a sectional view along the lines 3—3 in FIG. 1;

FIG. 4 is a sectional view of a modification of a portion of the device shown in FIG. 3;

FIG. 5 is a sectional view along the lines 5—5 in FIG. 1;

FIG. 6 is a sectional view along the lines 6—6 in FIG. 1;

FIG. 7 is a sectional view along the lines 7—7 in FIG. 1;

FIG. 8 is a sectional view along the lines 8—8 in FIG. 1;

FIG. 9 is a schematic representation of some of the electrodes in the display panel of FIG. 1; and

FIG. 10 is a sectional view of a portion of the display panel of FIG. 1 at one stage in its manufacture.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The display panel described herein is a thin, flat, sheet-like member which may have substantially any desired size and shape from, for example, postage stamp size to wall size, and it may include substantially any number of display cells. The panel may also include any suitable ionizable gas such as neon, argon, xenon, etc., singly or in combination, with a vapor of a metal such as mercury usually included in the gas to minimize cathode sputtering.

A display panel **10** embodying the invention includes a bottom plate **20** of an hermetic, dielectric material, such as glass or ceramic, which has a top surface **30**, a bottom surface **40**, an upper edge **50**, a lower edge **60**, a left edge **70**, and a right edge **80**. The plate **20** has a plurality of parallel slots or channels **90** extending a convenient distance into the body of the plate from the top surface **30**. For purposes of illustrating and describing the invention, the panel is orientated so that the slots **90** extend horizontally across plate **20** from the left edge **70** to the right edge **80**.

The array of slots **90** is suitably positioned between the upper and lower edges of plate **20**, with the first slot **90A** being closest to the upper edge **50** of the plate, and the last slot **90E** being closest to the lower edge **60** of the plate.

The slots **90** are all identical in size, shape, width, depth, etc., and can be made by any suitable mass production process; however, first and last slots **90A** and **90E** are blocked and, in effect, terminated at a selected area along their lengths by an obstruction **93** (FIGS. **1** and **2**) such as a mass of a glass frit, for example, of the type known as Pyroceram. The slots **90A** and **90E** thus terminate nearer to left edge **70** of the plate **20** and of the panel, this being the end at which the scanning operation originates in one mode of operation of the panel.

Electrodes **110**, which are used as counting or scanning anodes in one mode of operation of the panel, are seated in the slots **90B**, C, and D, and these electrodes are long enough to extend beyond the left and right edges of plate **20** so that they are accessible outside the panel. Electrodes **110** are preferably individual wires; however, they may also be plated, evaporated or otherwise formed in the slots. The electrodes **110**, if separate wires, might also be secured in the slots **90** by means of a cement such as a fused glass frit or the like. An auxiliary wire electrode **120**, also an anode, is seated in each of the shortened slots **90A** and **90E**, and these originate at the obstruction **93** and extend only beyond the left end **70** of the plate **20**.

According to the invention, a cell used as an auxiliary keep-alive cell is provided in bottom plate **20** in communication with slot **150A** in center plate **130** which is described below. This auxiliary keep-alive cell includes a small hole **112** (FIGS. **1** and **3**) which extends downwardly from the top surface of bottom plate **20** at about midway between the upper and lower edges of the plate **20** and in the rib **113** which lies between two slots **90**, say between slots **90C** and **90D**. The point on bottom plate **20** at which the hole **112** originates lies beneath a portion of slot **150A** in center plate **130** disposed above it. The hole **112** extends vertically downwardly to near the bottom surface where it joins a relatively large opening or chamber **114** formed in the bottom surface of plate **20**. The chamber extends into the body of plate **20** and is of sufficient volume to receive a keep-alive electrode structure **115**.

The keep-alive structure **115** comprises a radioactive material such as tritium, a radioactive isotope of hydrogen, carried on a suitable solid support, as is well known in the art. The keep-alive electrode **115** is seated in the chamber and is positioned to provide excited particles which can diffuse through hole **112** and thus into communication with slot **150A** for a purpose to be described.

If desired, the chamber **114** may also include a lateral arm **118** (FIG. **4**) in which the keep-alive elec-

trode structure **115** can be seated, still in communication with hole **112** but more remote therefrom.

The chamber **114** (and **118**) is hermetically sealed with a mass **119** of an amalgam of mercury, gallium, or the like. The formation of this keep-alive structure is described in detail below.

Panel **10** also includes a center sheet or plate **130** of a dielectric material, like plate **20** if desired, which is seated on bottom plate **20** and has a top surface **132**, a bottom surface **134**, an upper edge **136**, a lower edge **138**, a left edge **140**, and a right edge **142**. The sheet **130** is provided with a plurality of rows and columns of apertures or holes **144**, and the bottom surface **134** thereof is provided with a plurality of generally rectangular, parallel slots **150**. Slots **150** have the same width and depth and extend along sheet **130** from the lower edge **138** to the upper edge **136**. The slots **150** are oriented at 90° to each of the slots **90**, and thus, in effect, cross each of the slots **90** in the bottom plate **20**. The array of slots **150** is suitably positioned between the left and right edges **140** and **142**, respectively, of center sheet **130**, with slot **150A** (FIGS. **1** and **5**) considered to be the first slot positioned close to the left edge **140** of sheet **130**, and the last **150F** being positioned close to the right edge **142** of sheet **130**. The columns in which apertures or holes **144** in center sheet **130** are arrayed are generally aligned with the slots **150C** to **150F**, as shown in FIG. **1**, and the rows in which they are arrayed are generally aligned with slots **90B**, C, and D in bottom plate **20**. The holes **144** are identical, and the slots **150** are identical, and each may be made by any suitable mass production process.

A plurality of electrodes, operated as cathodes, are associated with center sheet **130**, and these include scanning cathode electrodes **160A**, B, C, and D seated in the slots **150C**, D, E, and F in sheet **130**. The scanning cathode electrodes **160** are metal strips which substantially fill the slots **150** and extend along the entire length thereof and beyond the upper and lower edges of sheet **130**. The cathodes **160** are oriented at 90° to the anodes **110**, and each cathode crosses each anode. Each electrode **160** is provided with a plurality of tiny apertures **162** disposed along its length, with each apertures **162** being generally centrally positioned over a slot **90** (FIG. **6**) in bottom plate **20** and beneath a hole **144** in center sheet **130**. The cathodes **160** are identical in size and shape and can be made by any suitable mass production process.

A cathode electrode **164**, used as a reset cathode, is seated in slot **150B**. Cathode **164** has the same thickness and length as electrodes **160**; however, it is narrower so that there are spaces **170** on either side of it which extend all along the slot **150B**. Cathode **164** crosses all anodes **110** and **120**.

The panel also includes a pair of cathode strip electrodes **167** and **168** (FIG. **1**) used as keep-alive cathodes, and seated in slot **150A**, with electrode **167** having its inner end originating at a location between slot **90D** and slot **90E** and extending out of the panel beyond the lower edge of the panel. Similarly, the inner end of electrode **168** originates at a location between slot **190A** and slot **190B**, and the electrode extends out of the panel beyond the upper edge. Electrodes **167** and **168** are identical in size and shape to electrodes **160** so that they, too, fill the slot **150A**. Thus, cathodes **167** and **168** can be formed by removing a center portion from a cathode **160**.

A second group of wire electrodes **180**, used as display anodes, are seated on the top surface **132** of sheet **130**, or in slots (not shown) in top surface **132**, each being aligned with or overlaying a row of holes **144** in center sheet **130**. The electrodes **180** need not be centered over the holes; they need only communicate with the gas in the holes, with no particular alignment required.

A transparent cover or viewing plate **190** of a dielectric material such as glass completes the panel and is seated on center sheet **130**. The wire electrodes **180** might be seated in slots in the bottom surface of top plate **190** (not shown), if desired. In the completed panel **10**, the three plates **20**, **130**, and **190** are hermetically secured together by a seal **200** formed along their adjacent edges by any suitable means such as a fused glass frit (Pyroceram) or the like.

The gas used in panel **10** is introduced in any suitable manner, for example, by means of a bell jar or by means of a tubulation **203** (shown only in FIG. **2**), secured to bottom plate **20** and communicating with the portion of slot **90E** or **90A** to the right of mass **93**.

As described, panel **10** includes a lower layer of counting or scanning gas cells **210** (FIGS. **5** and **6**) arrayed in rows and columns, with each cell comprising a portion of a lower anode electrode **110** in slot **90**, a portion of the apertured strip cathode electrode **160** above it, and the gas volume between them in slot **90**. Thus, each column of counting cells is defined by each cathode **160** and its crossing of a slot **90** and the associated portion of a counting anode **110**. As seen in FIG. **1**, there are four columns of counting cells **210**, and, for purposes of description, the first column is associated with cathode **160A**, the second column with cathode **160B**, the third column with cathode **160C**, and the fourth column with cathode **160D**. Each column of scanning cells **210** communicates with the adjacent column, that is, each scanning cell in one column communicates with the corresponding cell in the adjacent column, through the associated slot **90**.

The panel **10** also includes an upper layer of display cells **220** associated with and vertically aligned with, the counting cells **210**. Each display cell **220** (FIGS. **5** and **6**) is made up of a portion of a cathode **160**, the associated gas-filled hole or cell **144** in center sheet **130**, and the associated portion of upper anode electrode **180**. As with the counting cells, there are also four columns of display cells **220**, each associated with a cathode **160**, with the first column associated with cathode **160A**, etc.

The panel **10** also includes a column of auxiliary cells which are known variously as starter cells, reset cells, particle-supply cells, or glow-spreading cells **224** (FIG. **7**), and these cells supply excited particles to facilitate the turn-on of the first column of counting cells **210** associated with cathode **160A** at the beginning of a scanning cycle. For convenience, cells **224** will be called reset cells. These reset cells are arrayed in a column to the left of the first column of counting cells and communicating therewith through slots **90B**, C, and D. Cells **224** are constituted by the cathode strip **164** and the portion of each anode **110** and **120** which it crosses and the gas volume in the slots **90** therebetween.

Panel **10** also includes keep-alive cells **228** (FIG. **8**) which are provided to insure firing of the reset cells **224**. Keep-alive cells **228** are constituted by cathodes **167** and **168** and the anode electrodes **120** which they cross and the gas volume between them in slots **90A** and **90E**. The keep-alive cells **228** communicate with the reset cells through slots **90A** and **90E** and through the portion of slot **150A** between keep-alive cathodes **167** and **168** and through the slots **90B**, C, and D which slot **150A** crosses. Auxiliary keep-alive cell **111** provides excited particles to the reset cells through slot **150A** in plate **130** and slots **90** in plate **20**. Keep-alive cells **228** are held ON continually, and keep-alive cell **111**, by its radioactive material, provides electrons continually throughout the useful life of the material.

At this point, it might be noted that the extent to which the inner ends of the keep-alive anodes **120** can extend to the right in the panel as determined by the obstructions **93** is controlled by whether these anodes will interfere with the operation of any of the cathodes **160** and the associated counting cells. Thus, the anodes **120** and mass **93** (FIG. **2**) might terminate inside the panel between reset cathode **164** and the first counting cathode **160A**. If the counting cathodes are connected in groups and driven by common drivers, as described in copending application, Ser. No. 850,984 and as shown schematically in FIG. **7**, with cathode **160A** connected to cathode **160D**, cathode **160B** connected to cathode **160E**, and cathode **160C** connected to cathode **160F**, then the anodes **120** could extend only to between cathodes **160C** and **160D** but not into operative relation with cathode **160D**. This is because cathodes **160A** and **160D** are connected together and their normal operation in the scanning cycle would be disturbed.

In addition, as shown in FIG. **8**, the keep-alive cathodes **167** and **168** may not extend into operative relation with the counting anodes **110**.

In manufacturing the panel **10**, all parts are prepared and assembled as described except that plate **20** has hole **112** and chamber **114** separated by a thin glass wall **300** (FIG. **10**) so that the inside of the panel envelope is not exposed to the atmosphere. With the parts held together in any suitable apparatus and with the sealing material placed around the edges of the plate, the assembly is passed through an oven to fuse the sealing material, and, when the assembly is cooled, the hermetic seal **200** is formed. The panel is then pumped out through tubulation **203**, baked out, filled with the desired gas through tubulation **203**, and the tubulation is sealed off. Temperatures of the order of 450° C. are used in the foregoing assembly procedure.

Next, the completed panel is placed in a controlled atmosphere chamber which may be at room temperature and has an atmosphere, preferably, the same as the gas filling of the panel. The thin wall **300** is now punctured (FIGS. **3** and **4**) or removed entirely to permit communication between hole **112** and chamber **114**. The keep-alive electrode **115** is placed in the chamber **114**, and the chamber is filled with the amalgam **119** of mercury or gallium or the like. The electrode **115** is held exposed to the hole **112** to provide electrons thereto, and the amalgam is set into chamber **114** without obstructing this relationship between electrode **115** and hole **112**. The panel, with the keep-alive opening thus sealed, is held in the assembly chamber until the amalgam seal is cured and forms the desired hermetic seal, and the panel is now ready for further processing, if necessary, and for use.

Methods of making electrode **115** are well known, but it might be noted briefly that, in one suitable method, a thin film of titanium is formed on any suitable metal substrate and the tritium is sorbed into the titanium film.

Concerning the amalgam, gallium is preferred as a base material since it wets glass well. Powders of metals such as copper, gold, silver, tin, or the like, singly or alone, are added to the gallium to achieve the desired amalgam characteristics. Amalgams of this type are well known in the art, particularly the dental art, and need not be described in any greater detail here.

In the description of the operation of the invention set forth below, reference is made to "scanning" or "glow transfer" from cell to cell or column to column. Several different types of actions occur including glow transfer from a keep-alive cell **228** to a reset cell **224**, from a reset cell to a reset cell, from a reset cell **224** to a scanning or counting cell **210**, from a scanning cell to a scanning cell, and from a scanning cell to a display cell **220**. The exact mechanism by which each such operation occurs cannot be described with complete certainty; however, the operations may involve actual transfer of a mass of glowing ionized gas, or the diffusion of excited particles including metastable states which facilitate a new firing of an OFF cell, or both mechanisms may be involved.

In operation of the panel **10**, the keep-alive cells **228** communicate with the reset cells **224** through slots **90A** and **90E** primarily, and through slot **150A** and slots **90B**, C, and D, secondarily, and excited particles thus can diffuse from keep-alive cells **228** through both paths to the reset cells **224**. The most direct path for diffusion is through slots **90A** and **90E** to the two immediately adjacent reset cells **224A** and **224E** (FIG. **7**) associated with slots **90A** and **90E** between keep-alive cathodes **167** and **168** and then through slots **90B**, C, and D to reset cells **224B**, C, and D. Keep-alive cell **111** provides excited particles through the aforementioned secondary path by diffusion. As noted, the keep-alive cells are always on, and, when it is desired to turn on the reset cells **224**, operating potential is applied to the reset cathode **164** and to all of the anodes **110** and **120**. With the aid of the keep-alive cells, glow starts first in reset cells **224A** and E and spreads immediately along the entire length of the reset cathode **164** in the spaces **170**. This is the reason for having electrode **164** narrower than its slot **150B**. The spread of glow along the reset cells is facilitated by the secondary diffusion path described above.

When the reset cells **224** have fired, the first column of counting cells **210** can be fired with the aid of excited particles generated in the reset cells and able to diffuse to the first column of counting cells through slots **90B**, C, and D. An arrangement for using reset cells to fire counting cells is described and claimed in copending application, Ser. No. 791,208, filed Jan. 7, 1969. In addition, methods and apparatus including circuits for scanning columns of counting cells and energizing display cells therefrom are described and claimed in the above-mentioned application Ser. No. 850,984. These circuits are not shown here. In a typical

scanning operation, the scanning or counting anodes **110** are connected to driver circuits for applying generally positive operating potential thereto, and each of the cathodes **160** is connected to a driver circuit for applying generally negative operating potential to each, sequentially, to cause each column of lower counting cells **120** to fire and glow. The firing of each column of counting cells, after the first has been fired, is facilitated by the diffusion of excited particles through the slots **90** from ON counting cells to the adjacent OFF counting cells to be fired. The columns of counting cells **210** are fired sequentially from left to right, as seen in FIGS. **1** and **2**. This sequential firing of the columns of lower counting cells **210** is carried out cyclically from left to right. Each time the last column of counting cells at the right-hand edge of the panel is reached, the column of reset cells **224** at the left-hand edge of the panel is turned on again, with the aid of the keep-alive cells, and the above-described cycle is repeated. If desired, circuit means may be provided to sense the turn-on of the last column of counting cells **210** and automatically turn on the reset cells to start the cycle again.

When it is desired to fire cells **220** in the upper layer to represent the display of information or the like, generally positive operating potentials are applied to the proper upper anodes **180** associated with the cells **220** to be fired and glow transfers from the associated lower cells **210** through the apertures **162** in cathode electrodes **160** to the upper cells where the glow can be viewed through top plate **190**. As described above, the glow transfer is facilitated by the presence of excited particles in each of the lower counting cells **210** when it is fired.

It is clear from the foregoing description of the invention that, since there is optimum uniformity in the parts used in the display panel, optimum ease of assembly and operation can be achieved. Of course, considerable savings in parts and assembly time are also achieved.

It is clear that modifications may be made in the panels described within the scope of the invention. For example, although the panel as described is scanned from left to right, the scanning may be effected in other ways, and this might require a rearrangement of parts. In addition, although two keep-alive cells have been shown, one may be sufficient.

In general, the drawings are not intended to be dimensionally exact, and, in a typical display panel embodying the invention, the top plate **190** and bottom plate **20** are about one-fourth inch in thickness, and the center plate **130** is about 40 mils in thickness. In addition, in plate **20**, slots **90** are 10 mils wide and 35 mils deep, and electrodes **110** and **120** are 5 mils in diameter. In plate **130**, slots **150** are 36 mils wide and 1 to 3 mils deep, with cathodes **167**, **168**, and **160** having approximately the same dimensions. The holes **162** in the cathodes are 1 to 3 mils in diameter, the holes **144** in plate **130** are 18 to 24 mils in diameter and 40 mils deep, and electrodes **180** are about 3 mils in diameter.

What is claimed is:

1. A display panel comprising
an insulating gas-filled envelope including
a plurality of gas-filled cells,
an anode electrode and a cathode electrode associated with each cell, and
a source of excited particles embedded in a chamber in said envelope remote from said cells and communicating from said chamber through a gas communication path with said cells, said source comprising an electrode which is adversely affected by high temperatures such as those at which said envelope is formed,
said source being sealed in said chamber by means of a sealing material which forms a hermetic seal with said envelope at about room temperature.

2. The panel defined in claim **1** wherein said sealing material is an amalgam of gallium and selected metals.

3. The panel defined in claim **1** wherein said sealing material is an amalgam of gallium and one or more metals selected from the group consisting of copper, gold, silver, and tin.

4. A display panel comprising
an insulating gas-filled envelope including
a dielectric bottom plate and top plate and a plurality of gas-filled cells therebetween,
an anode electrode and a cathode electrode within said envelope associated with each cell, and
an electrode source of excited particles, for facilitating firing of said cells, embedded in a chamber in said bottom plate of said envelope remote from said cells and communicating with said cells from said chamber through a hole in said bottom plate,
said source being sealed in said chamber by means of an amalgam which forms a hermetic seal with said bottom plate at a relatively low temperature below the temperatures at which said panel is assembled and processed.

5. The panel defined in claim **1** wherein said source comprises a radioactive electron-emitting electrode.

6. A display panel comprising
a sandwich of dielectric plates including a bottom plate, a center plate, and a top plate,
a plurality of gas-filled glow cells disposed between said bottom plate and said center plate with an anode electrode and a cathode electrode associated with each cell, said cells being arrayed in rows and columns, and
an electrode source of excited particles disposed in operative relation with selected ones of said cells for facilitating the firing of said selected cells at a predetermined time in the operation of said panel,
said source being disposed within said bottom plate out of sight of a viewer but communicating through a gas communication path with at least one of said selected cells, said source being hermetically sealed within said bottom plate by a sealing material which forms a hermetic seal with said bottom plate at a relatively low temperature which is below the temperatures at which said panel is assembled and processed.

7. The panel defined in claim **6** wherein said sealing material is an amalgam of gallium and selected metals.

8. The panel defined in claim **6** wherein said sealing material is an amalgam of gallium and one or more metals selected from the group consisting of copper, gold, silver and tin.

9. A display panel comprising
a sandwich of dielectric plates including a bottom plate, a center plate, and a top plate,
a plurality of gas-filled glow cells disposed between said bottom plate and said center plate with an

anode electrode and a cathode electrode associated with each cell, said cells being arrayed in rows and columns,

said bottom plate having slots formed therein and comprising gas communication paths interconnecting said glow cells in a predetermined pattern, and

an electrode source of excited particles disposed in operative relation with selected ones of said cells for facilitating the firing of said selected cells at a predetermined time in the operation of said panel,

said source being disposed within said bottom plate out of sight of a viewer but communicating through a gas communication path with at least one of said selected cells, said source being hermetically sealed within said bottom plate by a sealing material which forms a hermetic seal with said bottom plate at a relatively low temperature which is below the temperatures at which said panel is assembled and processed.

10. The panel defined in claim **9** wherein said sealing material is an amalgam of gallium and selected metals.

11. The panel defined in claim **9** wherein said sealing material is an amalgam of gallium and one or more metals selected from the group consisting of copper, gold, silver, and tin.

12. A display panel comprising

a sandwich of dielectric plates including a bottom plate, a center plate, and a top plate,

a plurality of gas-filled glow cells disposed between said bottom plate and said center plate with an anode electrode and a cathode electrode associated with each cell, said cells being arrayed in rows and columns, there being a first column and a last column,

a column of auxiliary cells adjacent to said first column of glow cells,

said bottom plate having slots formed therein extending along rows of cells an comprising gas communication paths interconnecting said column of auxiliary cells with said first column of glow cells and each column of glow cells with the adjacent column of glow cells, and

an electrode source of excited particles disposed in operative relation with said column of auxiliary cells for facilitating the firing of said auxiliary cells,

said source being disposed within said bottom plate out of sight of a viewer but communicating through a hole in said bottom plate into a gas communication path coupled to said column of auxiliary cells, said source being disposed in a chamber in said bottom plate, said chamber communicating with said hole and being hermetically sealed by an amalgam which forms a hermetic seal with said bottom plate at a relatively low temperature below the temperatures at which said panel is assembled and processed.

13. The panel defined in claim **12** wherein said hole associated with said source extends to the top surface of said bottom plate between selected ones of said slots therein and in alignment with the rib present between said selected ones of said slots.

14. The panel defined in claim **12** wherein said source comprises a radioactive electron-emitting electrode.

15. The panel defined in claim **12** wherein said amalgam consists of gallium and selected metals.

16. The panel defined in claim **12** wherein said amalgam consists of gallium and one or more metals selected from the group consisting of copper, gold, silver, and tin.

17. The panel defined in claim **12** wherein said source comprises a radioactive electron-emitting electrode and said amalgam consists of gallium and one or more selected metal additives.

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