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Glaser et al.

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[54] **GAS PANEL DISPLAY APPARATUS**

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[52] **U.S. Cl.** ..... **340/336,** 315/169 R, 340/324 M, 340/343

[51] **Int. Cl.** **G09f 9/32**

[58] **Field of Search** ..... 340/324 R, 324 M, 334, 340/336, 343; 313/109.5; 315/169 R, 169 TV

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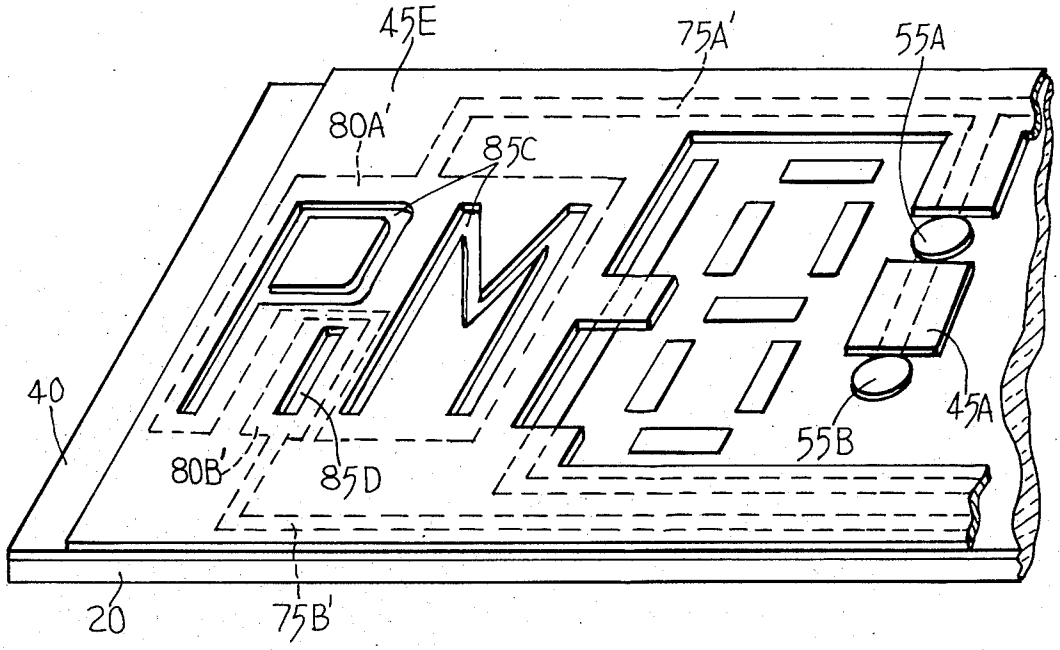
[57] **ABSTRACT**

A special format readout indicator of the gas discharge type includes several different character and symbol display positions in a flat sandwich structure. The device includes an insulating base plate on which a plurality of separate groups of cathode electrode segments and terminals for them are formed. Some of the cathode groups are interconnected arrays of electrode segments provided for displaying different characters or symbols, while others are preformed for displaying only predetermined symbols, and are interconnected if operation permits. Some of the anodes are associated both with a character display cathode group and with one or more of the symbol indicating cathode elements. The cathodes are formed of strips or bars of conductive material connected to conductors supported on the insulating base plate. The anode electrodes are suitably shaped to cooperate with appropriate ones of the character and symbol cathodes and are supported near them, preferably being carried by an insulating face plate.

3 Claims, 6 Drawing Figures



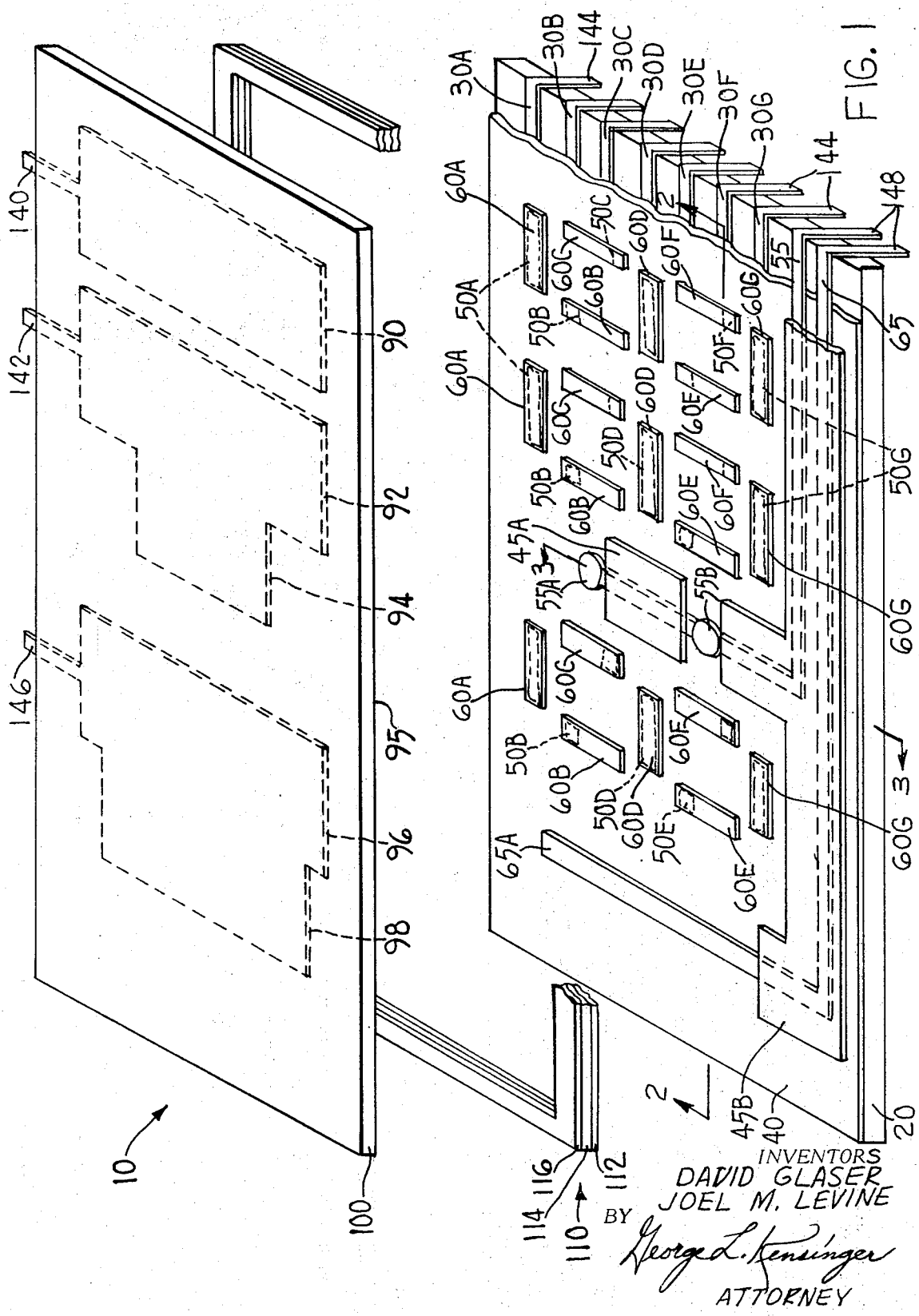


FIG. 1

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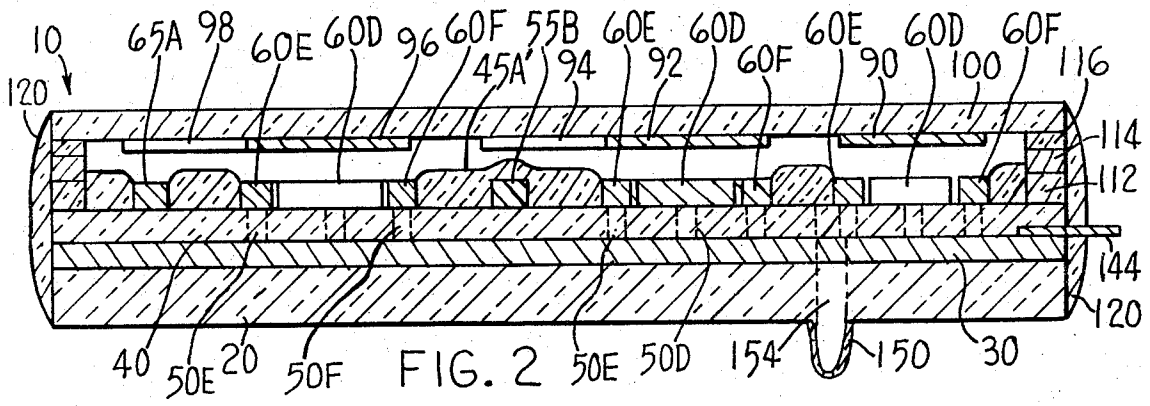

FIG. 2

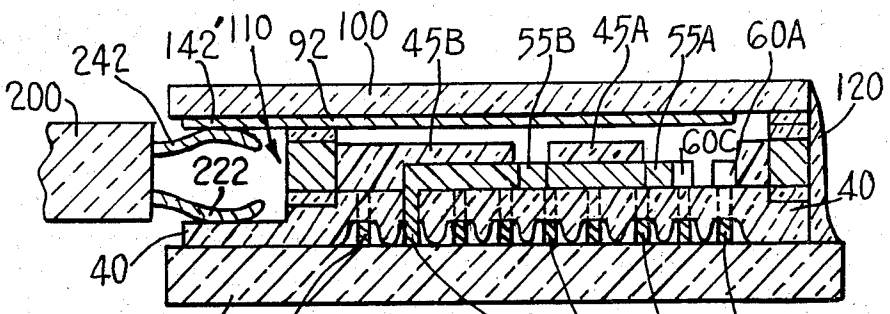

FIG. 3

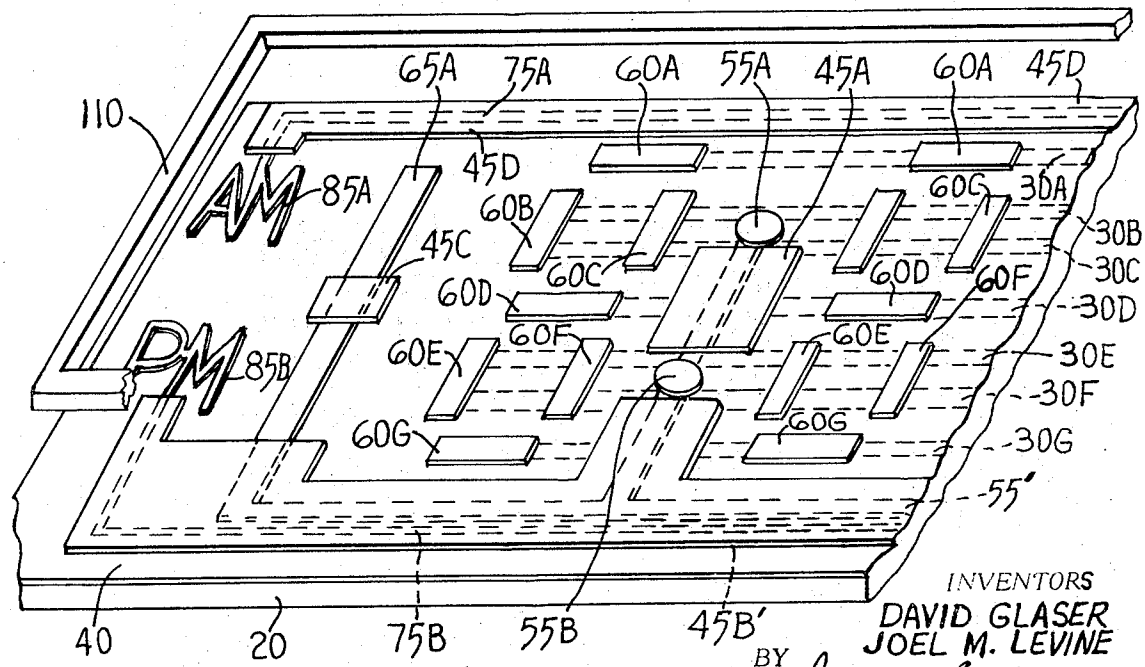

FIG. 4

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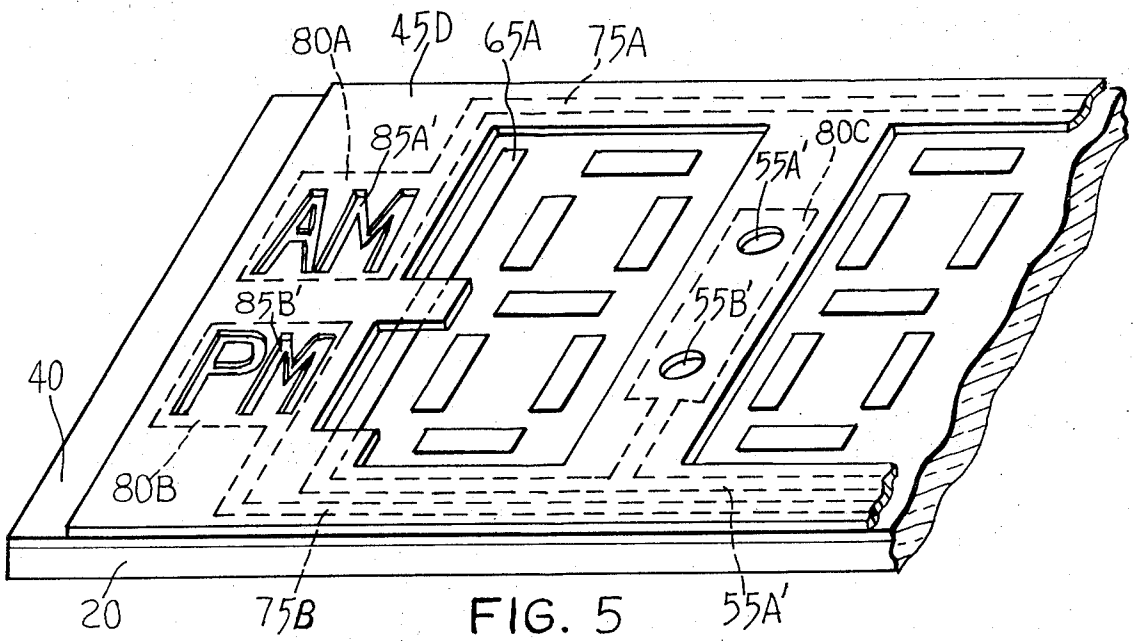

FIG. 5

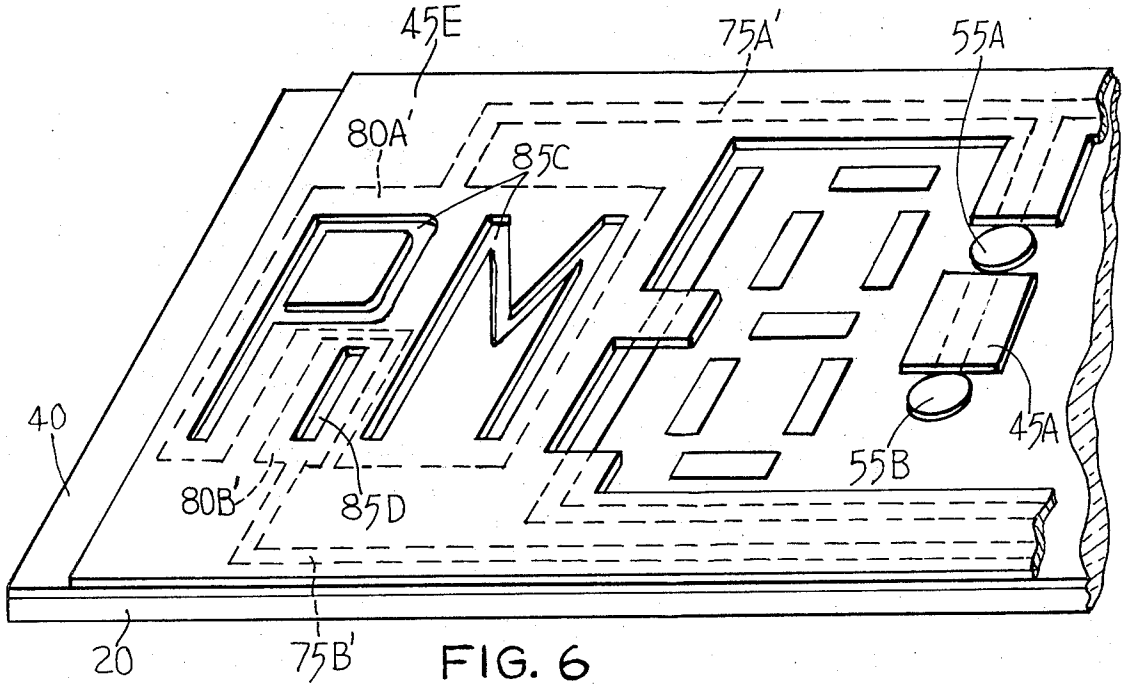

FIG. 6

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GAS PANEL DISPLAY APPARATUS

BACKGROUND OF THE INVENTION

Various numerical indicator devices for digital readouts and the like have been available for many years. One widely utilized indicator unit has been the NIXIE numerical indicator tube. More recently, various segmented cathode display devices such as the PANAPLEX numeric panel display have been made available.

The PANAPLEX numeric display device includes a plurality of segmented character display positions within a single panel structure which can be driven in a multiplex mode for displaying any desired series of numbers or the like. Each group of cathode segments is provided with a different anode electrode to provide a completely flexible and universally adaptable display unit.

A need has arisen, however, for a low cost readout indicator of limited format which is tailored for the efficient display of numerics and special symbols in certain applications. For example, clocks and many instruments such as E-I-R meters can readily use a readout indicator having several numeric indicator positions plus a 1 symbol indicator in the most significant display position (the left-most position in the device). Such an indicator would be useful as well in month and day indicators for date recorders or elapsed time indicators and in amount indicators for cash or distance registering devices, for example. Some such devices also have use for a + or a − symbol in the left-most or right-most position of the device, or for other symbols.

Some so-called 3½ or 4½ digit displays have been provided by segmented devices such as semiconductor light-emitting display (LED) devices in which each individual segment of the display is connected to a different pair of terminals. Indeed, the 3½ or 4½ digit segmented display devices now available all include separate terminals for each of the display segments. Each segment must be driven separately and independently, whether formed of semiconductor elements, light-emitting films, or incandescent or cold cathode elements. This is true even if single terminals of each of the segments of such devices are connected together for reducing the number of external terminals that must be provided.

SUMMARY OF THE INVENTION

Accordingly, it is an object of this invention to provide a simple readout indicator device of the gas discharge type having a plurality of segmented character and fixed format symbol indicating cathode positions for the efficient display of information.

Another object of the invention is to provide a limited format readout indicator having both fixed and universal format character display positions, suitably interconnected as appropriate, and anode electrodes common to some of the character and symbol display positions for the simplified display of information.

In accordance with these objects, there is provided a readout indicator device of the gas discharge type including a plurality of character display and special symbol indicator positions in a suitable envelope. The indicator display positions include interconnected groups of cathode electrode segments and special symbol indicator cathodes which may be interconnected or not.

An anode electrode is operably associated with each group of cathode elements and anodes may be associated in common with a character display position and a symbol indicator position for convenience and efficiency in operation of the display.

DESCRIPTION OF THE DRAWINGS

Other advantages and features of the invention will be made clear in the following description, relating to the attached drawings, wherein:

FIG. **1** is an enlarged exploded view of one embodiment of the readout indicator of the invention shown in perspective;

FIG. **2** is a sectional view of that indicator taken at line **2—2** of FIG. **1**;

FIG. **3** is a sectional view taken at line **3—3** of FIG. **1** and showing a connector engaged with the device; and

FIG. **4** is an enlarged exploded view of a portion of another embodiment of the readout device of the invention:

FIG. **5** is a perspective view of a portion of another embodiment of the invention; and

FIG. **6** is a perspective view of a portion of still another embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The display panels described herein are thin, flat, sheet-like members which may have substantially any desired size and shape, and may include substantially any number of character display positions. The panels also include any suitable ionizable gas such as neon, argon, xenon, etc., either singly or in combination, with a vapor of a metal such as mercury usually included in the gas to minimize cathode sputtering. A wide range of gas pressures may be used for example, from about 20 to about 250 Torr at ambient temperature, with about 70 to 120 Torr being a commonly used pressure range.

Referring to FIGS. **1** and **2**, a display device **10** embodying the invention includes an insulating base plate **20** of glass, ceramic, or the like, with an inexpensive glass being suitable and preferred. A plurality of conductive connectors or runs **30A** to **30G** is formed on the top surface of the insulating plate **20.** The runs **30** are parallel to each other and are aligned with the horizontal axis of the base plate. Seven such runs **30A** to **30G** are shown; however, more or fewer may be provided, the number being determined by the total number and type of characters to be displayed. The runs **30** may be formed by an evaporation process, a silk-screen process, an electroless plating process or the like, or they may be discrete strips of metal, heat sealed, arc plasma sprayed, or otherwise secured to the insulating plate **20.** A silk-screen printing process is particularly suitable because it is fast, efficient, and reproducible.

A thin layer **40** of insulating material such as glass or ceramic is formed on the conductive runs **30,** preferably by a silk-screen process, and the layer **40** includes a plurality of groups of vias or apertures **50A** to **50G,** each aperture exposing a portion of the runs **30A** to **30G.** Thus, each group of apertures includes aperture **50A** which exposes run **30A,** aperture **50B** which exposes run **30B,** aperture **50C** which exposes run **30C,** etc. Three such groups of apertures are illustrated.

Panel **10** includes a group of cathode electrodes **60** (A to G) for each group of apertures **50.** The cathodes are generally elongated bars or segments, and they are generally arrayed in a FIG. **8** pattern, as is well known in the art. The cathodes **60** may be formed on insulating layer **40** by means of a silk-screen process with a conductive paste such as palladium-gold, platinum-gold, palladium-silver, or the like. Each cathode element is in direct contact with one of the runs **30** exposed in an aperture or via **50,** and it fills the aperture **50** and covers a portion of layer **40** to achieve the desired shape and size.

The cathodes **60,** as well as cathodes **55** and **65** described hereinafter may also be formed of discrete strips of metal, preferably brazed to a conductive run **30** by means of a mass of brazing material deposited in each of the apertures **50** in the insulating layer **40.** The brazing material itself may be deposited by a silk-screen process. One suitable brazing material is a gold-germanium substance known as FORMON and sold by E. I. DuPont de Nemours and Co. The cathodes may also be formed in any other suitable manner such as by electrolytic or electroless plating of nickel or the like or by arc plasma spraying through a suitable mask.

Thus, cathodes **60** are preferably thin, flat members which do not project to any significant extent above the top surface of insulating layer **40.** ADDITIONAL patterns include a colon formed by cathodes **55A** and **55B** having a common connector **55** and cathode **65A** in the form of a numeral 1 having a connector **65** provided on insulating layer **40.** Conductive runs **55** and **65** are parallel to conductors **30A** to **30G** and connect to colon electrodes **55A** and **55B** and numeral 1 electrode **65A,** and are formed on insulating layer **40,** for example, by the same process and, preferably, at the same time that cathodes **60** are formed. Colon electrodes A and B, are positioned between the first and second group of cathodes **60** to separate the display of hours/minites and minutes/seconds from each other. Any other desired symbol such as a separator, a mathematical symbol, or other indicator could likewise be employed.

An additional insulating layer **45** of glass or ceramic is provided including shield portion **45A** formed or placed over the conductor connecting cathodes **55A** and **55B** and shield portion **45B** formed or placed over conductive runs **55** and **65** for colon cathodes **55A** and **55B** and numeral 2 cathode **65A,** respectively. These insulating shields **45A** and **45B** prevent the connectors or conductive runs which they cover from glowing when the device is operated.

Panel **10** includes anode electrodes **90, 92** and **96** for the groups of cathode electrodes **60.** The anode electrodes comprise thin, transparent conductive films of gold, NESA, or the like formed on the lower surface **95** of the panel face plate or viewing plate **100** which is made of glass. The anode films are of the order of a few Angstroms thick and, in effect, are coplanar with the bottom surface **95** of the face plate. Thus, the anodes, for all practical purposes, do not project into the gas discharge space in the panel. The anode films are generally rectangular in shape, or are otherwise shaped, depending on the orientation of the cathodes. Anodes **90, 92** and **96** are dimensioned and positioned so that they overlay the total area defined by the associated group of cathode electrodes and an adjacent symbol position in the case of anodes **92** and **96.** If desired, each anode may be somewhat narrower and shorter than the area defined by its cathodes as shown, but in any case, the anode must overlay and be in operative relation with a sufficient portion of each of its cathodes.

Anode electrode **90** is formed in the shape of a single rectangle since it need only cooperate with a group of cathodes **60.** Anode **92** includes a large rectangle associated with a group of cathodes **60,** together with a rectangular extension **94** to cooperate with colon cathodes **55A** and **55B.** Anode **96** includes a large rectangle associated with a group of cathodes **60,** together with an attached rectangle of sufficient size to cooperate with the full extent of numeral 1 cathode element **65A.** Other suitable anode shapes may be employed, depending upon the character and symbol configuration of the cathodes to be operated.

Preferably, the spacing between each anode and its group of cathodes should be of the order of 20 to 25 mils, and the spacing between each anode and the adjacent group of cathodes should be of the order of 30 to 40 mils. With this relationship, each anode is in a favorable operating position with respect to its own cathodes, but is sufficiently remote from adjacent groups of cathodes so that the panel may be operated over a suitably wide range of potentials without developing cross-talk between adjacent groups of electrodes. Another factor tending to prevent cross-talk is the location of the anodes in substantially coplanar relation with the surface of the glass cover plate and not projecting into the gas space in which cathode glow takes place.

The top glass cover plate **100** is of substantially the same length as the insulating layer **40** and the bottom plate **20,** and it is spaced from the base plate **20** by an insulating frame **110** which is disposed between the top glass plate **100** and the insulating layer **40.** The illustrated frame **110** includes a flat metal piece **114** coated with glass or ceramic layers **112** and **116.** Alternatively, rectangular frame **110** may be formed of glass or ceramic or may be an integral part of the top and/or bottom plates. This rectangular frame serves thus to provide the desired spacing between the anodes **90, 92, 96** and the associated groups of cathode electrodes **60.** The top glass plate **100** is also preferably slightly wider than the insulating layer **40** and base plate **20** so that one edge, such as the upper edge, extends beyond the remainder of the panel and is accessible to permit the connection of leads **140** to each of the anode films **90.** The three glass members **20, 100,** and **110** are sealed together in any suitable manner, for example, by means of a seal **120** formed of a glass frit or the like.

Connection to the runs **30** may be made, as an example, by means of L-ahaped pins or contacts **144** which are embedded in the seal **120** ar one or both ends of the panel. Likewise, connectors **55** and **65** for the symbol indicating cathodes **55A, 55B** and **65A** may be terminated by connection to pins or contacts **148,** as illustrated.

The panel **10** can be filled with the desired gas atmosphere through a tubulation **150** secured to the base plate **20** and communicating with the interior of the panel through a hole **154** in plate **20** and layer **40,** and, generally, mercury is introduced from a glass capsule (not shown) held in the tubulation and suitably processed at the desired stage in the assembly process.

The sectional view of FIG. **2** shows the layers deposited or screened onto the insulating back plate **20** to form the cathodes and connectors of the device. The

first layer includes conductive runs or connectors **30.** The second layer includes the insulating layer **40** having apertures **50** exposing the underlying conductive runs at suitable locations. The third layer includes cathode segments **60, 55,** and **65** in contact with conductive runs **30** through apertures **50** in the second layer. The cathode elements and connectors **55** and **65** are disposed on top of insulating layer **40** and portions of them extend into the holes in layer **40** and contact connector **30.**

The fourth layer includes insulating shields **45A** and **45B** (FIG. **3**) of glass or ceramic positioned to cover the extent of cathode connectors **55** and **65** disposed on top of insulating layer **40** and may include portions **45A'** filling the space between the display positions up to a level slightly above them, as illustrated in FIG. **2.** Most of the fourth layer rests on the top surface of insulating layer **40** between adjacent display positions as raised barriers or dividers (**45A'**) between them or as a shield (**45B**) which covers cathode connectors **55** and **65** associated with cathodes **55A, 55B,** and **65A** on top of insulating layer **40.** These elevated barriers increase the insulating surface area between adjacent display positions and reduce the likelihood of unwanted conductive paths being formed by sputtered cathode material in the device.

A certain amount of cathode material evaporates during the discharges in such devices and deposits on adjacent surfaces, even in devices containing mercury vapor or other substance to suppress it. This can eventually reduce the isolation between adjacent display positions and result in conductive coupling between them as an ultimate failure mechanism in the device. The raised insulating barriers **45A'** between adjacent positions, however, increase the insulating surface area between them and lessen the extent and the conductivity of such deposits. They also provide physical barriers to the free travel of the conductive cathode material between the adjacent display positions and onto adjacent surfaces.

The drawing of FIG. **3** illustrates a section of the device of FIG. **1** taken at line **3—3** cutting through colon electrodes **55A** and **55B.** Anode **92** is shown having a lead **142'** brought out to the front of the device, however, rather than only at the rear edge as illustrated in FIG. **1.** Sealing frame **110** is narrower than the top and bottom plates so that when they are sealed together, an open space is provided between the top and bottom plates for the insertion of connector contacts, if desired. This is particularly useful when anode electrodes are formed on the under side of the top glass **100** as thin layers of material to provide the desired transparency. Such thin layers are fragile and are difficult to make contact with by welding, soldering, or the like. The use of a resilient metal contact **242** has been found to be suitable for establishing the desired contact to terminal **142'** of anode **92,** for example. Connector contact **242** and a similar opposing member **222** can be formed of resilient metal supported by a connector housing **200** so that a friction or pressure contact is maintained with the anode lead **142'.** Similar contacts are provided for connecting the other anodes. The cathode electrodes are terminated at their ends as illustrated in FIG. **1.**

An arrangement has been described for providing special symbol indicating cathodes in a display device together with digit or character indicator cathodes, which may cooperate with common anode electrodes to simplify the operation of them. A four digit clock readout device including a colon separator may thus be driven by three, four, or five sets of multiplexed control signals, depending upon whether three, four, or five anodes are utilized. The anodes are shaped to cooperate specifically with predetermined ones of the character and symbol indicator cathodes. Special symbols, single numerals or the like are provided for simplified driving, when required, rather than adding a complete array of cathode segments for each symbol to be displayed. Cathode connectors in the form of conductive runs or the like for connecting the digit display cathodes and for special symbol indicator cathodes are provided on different layers in the device, insulated from each other, and suitably shielded from glowing. An embodiment of a readout indicator for a clock is illustrated in FIG. **4** in which cathodes **85A** and **85B** are provided as AM and PM indications, respectively. The AM indicating cathode **85A** is connected to conductive run **75A,** and the PM indicator cathode **85B,** in turn, is connected to conductive run **75B** on the surface of insulating layer **40.**

The numeric indicator cathodes **60** and **65** are formed in the same manner as illustrated and described with respect to FIGS. **1–3.** A common conductive run **55'** on insulating layer **40,** however, is connected to both the colon indicating cathodes **55A** and **55B** and to the tens digit cathode **65A** in the hour readout position. A single anode of suitable size (not shown) may be provided to cooperate variously with cathodes **60** and **65** of the hour digit position and with the AM and PM indicator cathodes **85A** and **85B.** Any combination of the hour and special AM and PM indicators may be caused to glow by appropriately energizing the selected cathode element together with the anode electrode or electrodes that are associated with them.

The tens digit hour indicating cathode **65A** and the colon indicating cathodes **55A** and **55B** can be connected in common by a single conductive run **55'** and yet be operated independently because they are associated with different anodes, such as anodes **94** and **98** of FIG. **1.** An energizing signal pulse applied to conductor **55'** will result in either tens digit hour cathode **65A** or the colon indicator cathodes **55A** and **55B** glowing, or both, depending upon whether anode **94** or anode **98,** or both, are concurrently energized with an opposite polarity signal.

The device illustrated in FIG. **4** further includes an insulating member **45C** placed at the mid-section of tens digit hour indicator **65A** so that its indication is segmented similar to that of the other digit indicators in the device. Also, an insulating layer **45B'** covers conductive runs **55'** and **75B** to prevent them from glowing. Likewise, an insulating layer **45D** is deposited or formed upon conductive run **75A** associated with AM cathode indicator **85A** to prevent that conductor from glowing. Otherwise, the device is formed substantially as before.

Further variations of clock readout indicators are shown in FIGS. **5** and **6** in which relatively large cathode areas are provided for certain special symbol indications such as the AM, PM, and colon indicators and are suitably masked in the desired format. In FIG. **5,** cathode masses **80A** and **80B** are formed on insulating layer **40** to the left of the numeric digit positions. Likewise, a cathode area **80C** is formed between the hour

digit positions and the minute digit positions, also on insulating layer **40.** A single insulating layer **45D**, which may be an integral stratum or formed of closely adjacent portions, is disposed on insulating layer **40** which is suitably masked by insulating layer **45E** to provide the PM indication. A smaller cathode area **80B'**, however, also provided on insulating layer **40,** is masked by insulating layer **45E** with an opening **85D** to provide a segment or leg near the P portion of aperture **85C** to convert it to an A symbol, when energized, for the AM indication.

Colon indicating cathodes **55A** and **55B** are provided in a manner previously described and are coupled in common with cathode area **80A'** by conductive connector **75A'**. This is advantageous since it may be desirable to energize both the PM indication (**85C**) and the colon indicator cathodes (**55A** and **55B**) continuously from a bias potential or from the output of a flip-flop, for example. This reduces the number of pulse signals that must be provided for a clock readout indicator. It is then only necessary to provide a signal to conductor **75B'** in order to change the constantly illuminated PM indication to the AM indication when that is appropriate.

The use of an insulating layer such as **45D** or **45E** in FIGS. **5** and **6** with shaped openings **85A'**, **85B**, **85C**, and **85D** is much better than simply providing large-area cathodes in the device with a separate stencil or mask either inside or outside the device. The masking of cathode areas such as **80A** and **80A'** by a layer formed on or in direct contact with them, as illustrated in FIG. **5** and FIG. **6,** allows only the exposed portions of the cathode areas to glow. This prevents the rest of those cathode areas from glowing, confining the glow to the shape of openings or apertures **85A'** and **85C**, for example. This confinement of the glow greatly limits the current required to support the glow discharge on these cathodes to a level much lower than if the entire cathode areas **80A** and **80'** were permitted to glow and their illumination simply masked at some distance from them, either within or without the envelope. It also provides a better optical indication and eliminates possible problems with parallax or insufficiency of viewing angle.

We claim:

1. In a gas panel display device having first and second flat insulating plates, said first plate being transparent and spaced apart from said second plate to define a sealed, gas-filled electric discharge region between said first and second plates, the improvement in discharge producing apparatus comprising:

a plurality of parallel conductive runs disposed within said region on said second plate;

a relatively broad cathode disposed within said region on said second plate, said broad cathode being connected to one of said broad cathode being connected to one of said conductive runs;

an apertured insulating layer overlaying said second plate for insulating or exposing portions of each of said conductive runs at a plurality of locations, at least one of said apertures in said layer completely defining a symbol on said broad cathode;

a plurality of groups of cathode elements, each one of said elements being disposed on said insulating layer and forming an electrical connection through a said exposed portion to said conductive runs; and

a plurality of transparent anode elements disposed on said first plate and within said region for selectively discharging with said broad cathode and said cathode elements, said plurality of anode elements including at least one anode element for discharging both with said broad cathode and at least one of said groups of cathode elements.

2. The improvement in discharge producing apparatus of claim **1** wherein said symbol is PM and wherein said improvement includes a selectively controllable discharge area for changing said symbol PM to the symbol AM.

3. The improvement in discharge producing apparatus of claim **2** wherein said discharge area comprises an auxiliary cathode disposed on said second plate adjacent said broad cathode and connected to a different conductive run from the run connected to the broad cathode and a substantially rectangular aperture in said insulating layer disposed within the area of said symbol PM for changing the letter P to the letter A, said rectangular aperture overlaying said auxiliary cathode, and wherein said at least one anode element also discharges said auxiliary cathode.

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