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Janning

[11] **3,839,714**

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[54] **PLASMA DISPLAY DEVICE FOR SELECTIVELY DISPLAYING SEVERAL FIXED IMAGES**

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[73] Assignee: **NCR Corporation,** Dayton, Ohio

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[52] **U.S. Cl.** ..... **340/324 M,** 313/220, 315/169 R, 340/166 EL

[51] **Int. Cl.** **G09f 13/22**

[58] **Field of Search** ..... 340/324 M, 343, 166 EL, 340/336, 380; 313/220; 315/169 R

[56] **References Cited**

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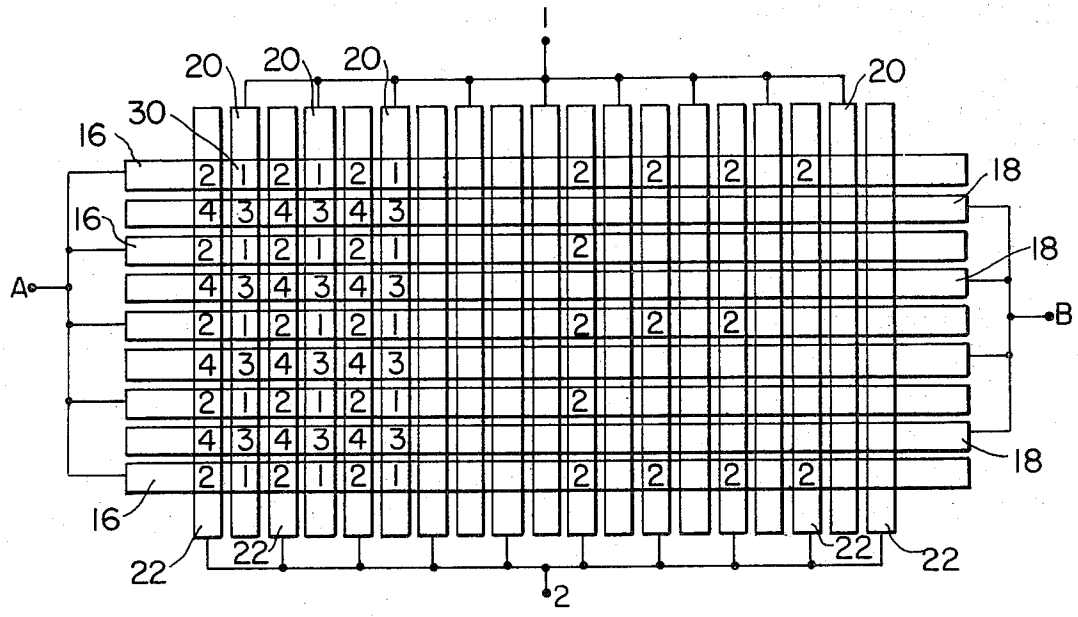
[57] **ABSTRACT**

A plasma display device uses the same area for selectively displaying several fixed displays images. The device has cavities which are arranged in rows and columns in a gridlike manner. Each fixed image has a fixed number of cavities associated with it only, and each image may extend substantially over the given area when necessitated by the design thereof. Rows of spaced parallel electrodes and columns of spaced parallel electrodes are aligned with their associated rows and columns of cavities. Alternate ones of the rows of electrodes are connected together and alternate ones of the columns of electrodes are connected together to form a simple selection scheme for energizing the device to display the selected fixed image.

7 Claims, 5 Drawing Figures



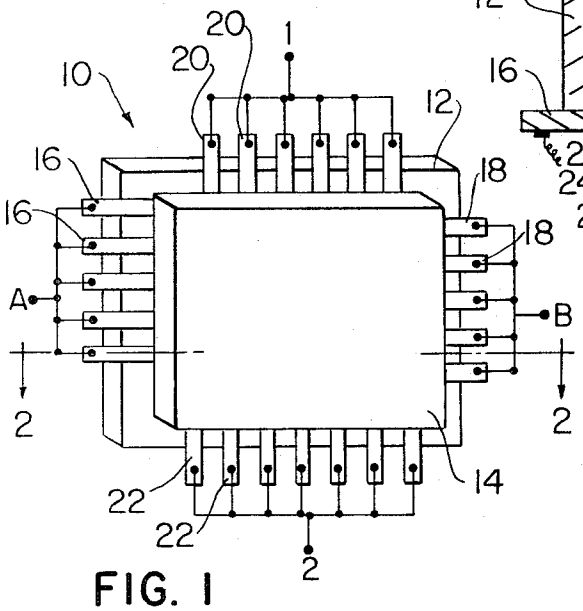


FIG. 1

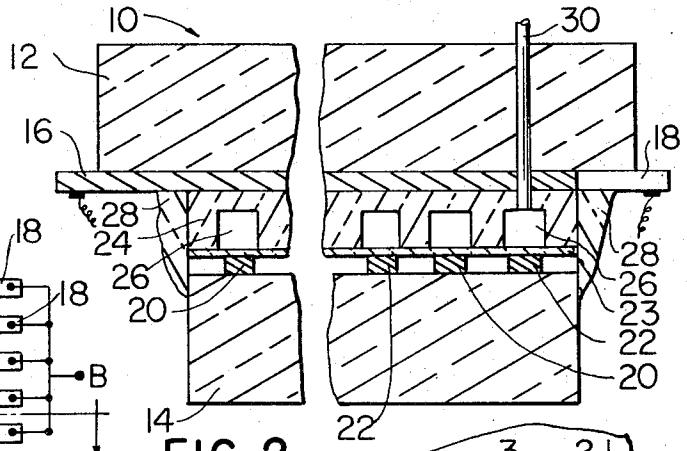


FIG. 2

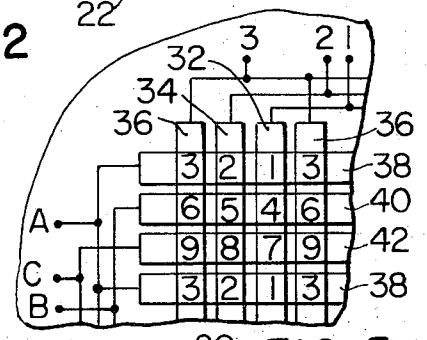


FIG. 5

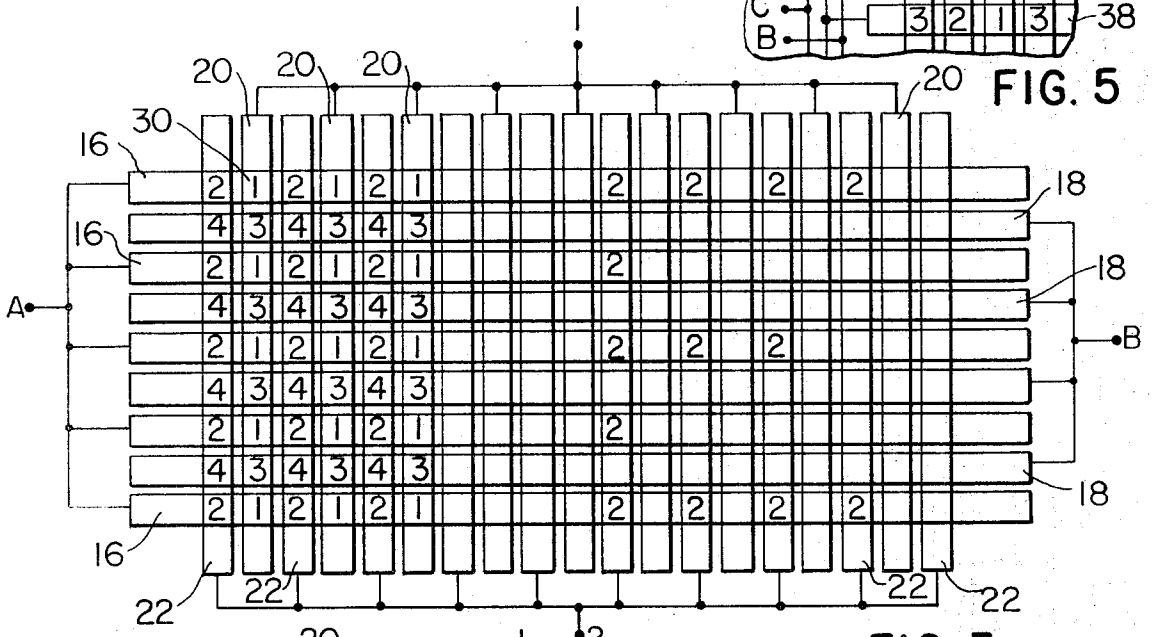


FIG. 3

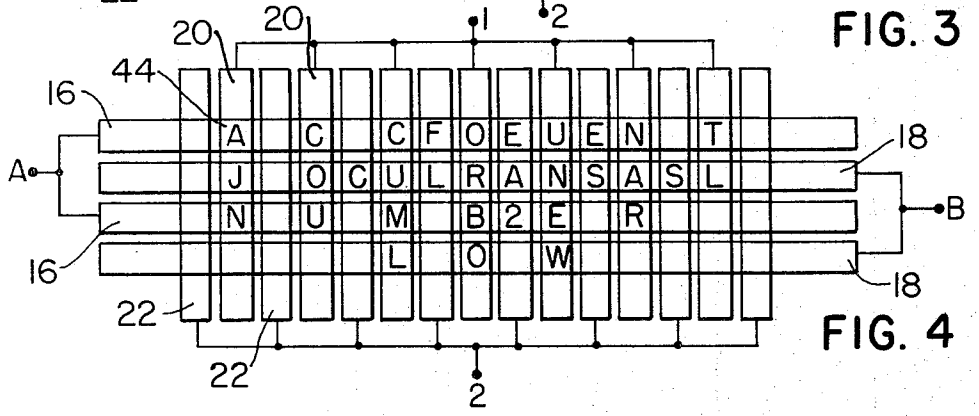


FIG. 4

PLASMA DISPLAY DEVICE FOR SELECTIVELY DISPLAYING SEVERAL FIXED IMAGES

This application is related to Applican's copending application Ser. No. 318,369, filed on Dec. 26, 1972, and assigned to the same Assignee as this application.

BACKGROUND OF THE INVENTION

This invention relates to a plasma display device for selectively displaying a fixed number of images or displays so that each image or display covers substantially the entire panel of the device while utilizing a minimum of connection electrodes therefor.

In certain plasma display devices or panels of the prior art, a number of fixed displays or "word messages" like "Account Number", "Journal Low", etc. need to be displayed on a particular device. If four messages are to be displayed on the device, for example, one way of displaying them would be to divide the area of the device into quadrants and to allocate one of the messages to each quadrant thereof. When this is done, the individual message in each quadrant is sometimes small in size and difficult to read.

By this invention, a predetermined number of displays or fixed messages is displayed on a plasma display device whereby each message selected to be displayed is spread over a much larger area of the device than it would occupy by the technique described in the previous paragraph, thereby making each individual message larger in size and easier to read. The larger-sized message is obtained essentially by spacing the characters of the "first message" so as to enable the characters of the "second message" to be inserted between the characters of the first message and by using a minimum of connection electrodes for energizing the device.

The U.S. Pat. No. 3,127,535, which issued on Mar. 31, 1964, on the application of H. T. Westerheim, shows a typical, prior-art, visual-readout device for displaying word messages, which device requires each cell thereof to be capable of printing a variety of characters which are individually, selectively energized.

SUMMARY OF THE INVENTION

This invention relates to a plasma display device having a given area for selectively displaying at least two fixed displays or messages. The device includes a first substrate having electrode means thereon, and a second substrate having columns of spaced parallel electrodes thereon. A layer of glass overlies the electrode means and is positioned between the first and second substrates with this layer of glass having cavity location areas arranged thereon in parallel rows and parallel columns in a grid-like manner. The layer of glass has cavities located at the cavity location areas, with each of said displays having a number of cavities associated only with it, and with the number of cavities for each display bearing a predetermined relationship to the total number of fixed displays to be displayed. Each said fixed display may extend substantially over the given area of the device if necessitated by the design thereof. The columns of spaced, parallel electrodes are aligned with the columns of cavity location areas on the layer of glass. Connection terminal means connected to said electrode means and said parallel electrodes are used for energizing selected ones of the parallel electrodes and said electrode means in accordance with the display selected to be displayed. The displays comprise fixed word messages, and dot pattern artwork like pictures, drawings, curves, or the like.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a general view, in perspective, of the front or viewing panel of a plasma display device embodying the principles of this invention.

FIG. **2** is a cross-sectional view, taken along the line **2—2** of FIG. **1** to show additional details of the device, including front and rear substrates, electrode means, cavity locations, and means for filling the cavities of the device with an ionizable gas.

FIG. **3** is a schematic diagram showing one embodiment of the device which is capable of producing four different fixed displays by a "dot-like" representation and also showing the simplified electrode means for selecting the image to be displayed.

FIG. **4** is a view similar to FIG. **3** showing another embodiment of the invention in which each cell is large enough to display a single character in itself.

FIG. **5** is a view similar to FIG. **3** showing only a portion of a schematic diagram for another embodiment of the invention which is capable of displaying up to nine different fixed displays.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** is a general perspective view of the plasma display device of this invention which is designated generally as **10.** The device includes a rear substrate **12,** a front substrate **14** and electrode means and a cavity plate located therebetween. The rear substrate **12** is made of an insulating material like glass on which a first electrode means is positioned. The first electrode means includes a plurality of rows of spaced, parallel, thin, bar-like electrodes **16** and **18** which are made of a suitable, electrically-conductive material like silver.

The front substrate **14** is made of a transparent, insulating material like glass. This substrate **14** also has an electrode means positioned thereon, which electrode means includes a plurality of columns of spaced, parallel, thin, bar-like electrodes **20** and **22** which are made of a suitable, electrically-conductive, transparent material like tin oxide. In order to isolate the electrodes (**20, 22**) from an ionizable gas which fills the cavities, a layer **23** of transparent glass (FIG. **2**) is positioned over the electrodes on the front substrate **14.**

The cavity plate alluded to earlier is made of a layer **24** of glass which is positioned between the front and rear substrates **12** and **14** as shown in FIG. **2.** This layer **24** of glass preferably has a black dye added thereto to conventionally produce a glass which is black in color. As an illustration, the glass may be made from Corning glass No. 7570, a glass powder, manufactured by Corning Glass Company, and which powder is mixed with a powdered Drakenfeld dye No. 1795 manufactured by Drakenfeld Division of Hercules, Inc., Washington, Pennsylvania. A fixed weight of this dye equal to about five per cent of the weight of the powdered glass is used for the mixture's proportions. The outside dimensions of the layer **24** of glass correspond to the front substrate **14** which is smaller than the rear substrate **12.** This is done to enable the various electrodes **16, 18, 20** and **22** to extend beyond the boundaries of the layer **24**

and thereby facilitate the connection of the electrodes to connection terminals to be later described.

The layer **24** of glass has a plurality of cavities **26** (FIG. **2**) located therein. These cavities **26** are arranged in rows and columns so that a cavity is located at each crossover point between a horizontally positioned electrode (like **16, 18**) and a vertically positioned electrode (like **20, 22**). The cavities **26** may be produced by any conventional techniques such as photochemical machining, and typically have a depth of 0.007 inch; their cross-sectional shapes are substantially identical and may be any conventional shape such as circular or quadrilateral.

The plasma display device **10** is shown in assembled relationship in FIG. **2.** The side of the front substrate **14** containing the columns of electrodes **20, 22** is placed adjacent to and in aligned relationship with the cavities **26** so that a cavity is located at each crossover point as previously explained. The device **10** is conventionally sealed by applying a glass frit **28** around the edges thereof and heating the device in a furnace to fuse the frit. After the device **10** is sealed, a tube **30,** communicating with the cavities **26,** is used to vacate the air therein and to fill the cavities with an ionizable gas. After filling, the tube is sealed. Usually, the contacting surfaces between the layers **23** and **24** of glass have minute surface irregularities therein which enable the gas within the cavities to equalize in pressure; however, if the pressure does not stabilize, conventional pressure equalization grooves (not shown) may be used to interconnect the cavities **26** and thereby stabilize the gas pressure therein.

The method for assigning cavities to the displays or fixed images to be displayed and the method of connecting the electrode means of the display device **10** to achieve the selection of the displays is most easily understood in connection with the schematic diagram shown in FIG. **3.** This figure shows only the electrode means and the connection terminal means used in selecting the fixed displays to be shown. Any cavity (like **26** in FIG. **2**) which is needed for displaying a particular fixed image is located at a crossover point (like **30** in FIG. **3**) between a horizontally positioned electrode like **16** and a vertically positioned electrode like **20.** If, for example, four fixed images are to be displayed, and each image is to cover substantially the entire display area of the device, the cavities associated with the first image would be located at the crossover points (like **30**) which are marked with a **1** in FIG. **3.** Similarly, the cavities associated with the second, third, and fourth images would be located at the crossover points marked with a **2, 3,** and **4,** respectively. The particular first image to be displayed, for example, can be produced by using a layer of photoresist which is placed in registration with the layer **24** of glass in which the cavities are to be produced prior to assembly of the device **10.** Conventional photo-chemical machining of the layer **24** will produce all the cavities (like **26**) needed to display the image, and each cavity needed would be positioned at one of the crossover points which are numbered **1** (like **30** in FIG. **3**). The image produced will be dot-like in form. Naturally, if the particular design or pattern of the first image to be produced, does not require a cavity at a particular crossover point marked **1,** no cavity would be produced thereat. This same technique is then utilized to produce the second, third and fourth images for the device shown in FIG. **3.**

As another illustration, a large letter E may be displayed by forming cavities at the crossover points which are marked **2** on the right half of FIG. **3.** The left side of FIG. **3** does not have any particular image displayed thereon; it merely shows the locations of the various crossover points which are assigned as cavity location areas associated with the first, second, third, and fourth images to be displayed on the device.

The connection terminal means for selecting the particular image to be displayed are also shown in FIG. **3.** These terminal means include first, second, third and fourth connection terminals. The first connection terminal, numbered **1,** is connected to alternate ones of the vertically aligned electrodes (numbered **20**), and the remainder of the vertically aligned electrodes (numbered **22**) are connected to the second connection terminal numbered **2.** The third connection terminal, lettered A, is connected to alternate ones of the horizontally aligned electrodes (numbered **16**), and the remainder of the horizontally aligned electrodes are connected to the fourth connection terminal, lettered B.

In order to select any one of the four fixed images with the connection terminal means shown in FIG. **3,** all that is necessary is to select one of the terminals (like **1** or **2**) associated with the vertically aligned electrodes and one of the terminals (like A or B) associated with the horizontally aligned electrodes, and to apply a voltage to the selected terminals. The following chart shows what fixed image will be displayed when voltage is applied to selected terminals of the display device **10**:

When Voltage is Applied to Terminals	Image Displayed
A and 1	1
A and 2	2
B and 1	3
B and 2	4

When terminals A and **1** (FIG. **3**) are energized to display the first image, for example, any cavity located at the crossover points marked with a **1** will be energized and will glow in the plasma display device **10.** Naturally, the nature of the first image to be displayed will depend upon the pattern of cavities located at the crossover points marked with a **1.** This particular arrangement shown in FIG. **3** permits images or displays of the dot variety to be produced. Each image may extend over the entire area of the device **10** and may consist of word messages or dot pattern artwork such as drawings, curves, and the like. Because each fixed image may extend over the entire panel, each image is considerably larger than it would be when compared to a prior art plasma display device which allocates one quadrant of its viewing area to each of four fixed images to be displayed.

While the display device shown schematically in FIG. **3** is wired to produce four images, it can be conveniently wired to produce a different number of fixed images. For example, the horizontally positioned electrodes **16** and **18** may be replaced by one common electrode extending over the entire back of the display device **10,** and the vertically positioned electrodes **20** and **22** may remain wired as they are to the first and second connection terminals, respectively. All the cavities associated with the first image would then be

aligned with the vertically positioned electrodes **20,** and all the cavities associated with the second image would be aligned with the vertically positioned electrodes **22.** To display the first fixed image, for example, of such a two image display, the common electrode and the first connection terminal marked **1,** would be energized.

When more than four fixed images are to be displayed on a display device of this invention, the wiring of the device may take the form shown in FIG. **5.** This figure is similar to FIG. **3** and shows cavity locations which are located at the crossover points between the vertically aligned electrodes and the horizontally aligned electrodes. These cavity locations are numbered **1** through **9** inclusive in FIG. **5** and are laid out in a repeating pattern similar to that shown in FIG. **3** except the repeating pattern in FIG. **5** is based on multiples of three whereas the repeating pattern in FIG. **3** is based on multiples of two. Consequently, up to nine fixed images can be displayed on a display device **10** employing the wiring pattern shown in FIG. **5,** whereas up to four fixed images can be displayed on a display device **10** using the wiring pattern shown in FIG. **3.**

Only a portion of the wiring pattern is shown in FIG. **5,** which is a view similar to the upper left hand corner of FIG. **3;** however, the general wiring pattern for the entire display device can be discerned therefrom. The vertically positioned electrodes **32, 34,** and **36** are respectively connected to connection terminals **1, 2,** and **3.** Every third electrode (proceeding from left to right as viewed in FIG. **5**) is connected to one of the connection terminals, as for example, the two electrodes marked **36** are connected to the connection terminal marked **3.** The horizontally positioned electrodes **38, 40,** and **42** are respectively connected to the connection terminals marked A, B, and C. Every third electrode when proceeding from the top to the bottom as viewed in FIG. **5** is similarly connected to one of the connection terminals, as for example, the electrodes marked **38** are connected to the connection terminal marked A. All the cavities necessary for producing the first image in the display device **10** would be located at the cross-over points of the horizontal and vertical electrodes which are marked with a **1,** and similarly, the cavities associated with the ninth image, for example, would be located at the crossover points marked with a **9.** In order to display the ninth image, for example, the connection terminals marked **3** and C would be energized, and similarly, in order to display the sixth image, the connection terminals marked **3** and B would be energized.

The embodiment of the invention shown in FIG. **4** is generally similar to the embodiment shown in FIG. **3;** however, the cavities shown in FIG. **4** are not dot like, but are large cavities which are shaped to produce a complete character in themselves. For example, the cavity marked **44** in FIG. **4** is shaped to produce the letter A which is shown at the cross-over point of the vertically positioned electrode **20** and the horizontally positioned electrode **16.** These electrodes **16** and **20** correspond to the electrodes shown in FIG. **3;** however, they are naturally much wider in width to enable them to cover a complete character. The wiring and energizing scheme for the embodiment shown in FIG. **4** is exactly the same as that shown in FIG. **3** and already described. It should also be noted that the assignment of cavity location areas like **1, 2, 3,** and **4** shown in FIG. **3** are the same in FIG. **4.** For example, the cavity marked **44** in FIG. **4** corresponds to the cavity location area marked as a **1** and also marked with the reference numeral **30** in FIG. **3.**

The following chart shows what representative fixed images will be displayed when voltage is applied to selected terminals of the display device **10** whose connection terminals are shown in FIG. **4:**

When Voltage is Applied to Terminals	Image Displayed
A and 1	ACCOUNT NUMBER
A and 2	FEE 2
B and 1	JOURNAL LOW
B and 2	CLASS

The operating voltages, gas mixtures, and pressures, etc. used in the plasma display device may be conventional. For example, in the embodiments shown, the ionizable gas used in the cavities **26** is a mixture of 99.7% Neon, 0.2% Nitrogen, and 0.1% Argon, with the cavities being filled to a gas pressure of approximately 100 Torr. The energizing voltage used to energize the selected connection terminals was approximately 240 volts A.C., consisting of pulses of from two to six microseconds wide spaced approximately fifty microseconds apart.

What is claimed is:

1. A plasma display device having a given area for selectively displaying at least two fixed images, comprising:

a first substrate having electrode means thereon;

a second substrate having vertically aligned, spaced parallel electrodes thereon;

a layer of glass overlying the electrode means on said first substrate with said layer of glass having cavity location areas arranged thereon in parallel rows and parallel columns in grid-like manner;

said layer of glass havng cavities positioned at at least some of said cavity location areas, each said image having a number of cavities associated only therewith, with said number bearing a predetermined relationship to the total number of fixed images to be displayed, and with the cavity location areas for a particular image being distributed over said given area in a regularly repeating pattern thereon, and in which said image may extend substantially over said given area if necessitated by the design thereof;

said vertically aligned spaced parallel electrodes being aligned with the columns of cavity location areas on said glass layer;

connection terminal means connected to said electrode means and said parallel electrodes for energizing selected ones of said parallel electrodes and said electrode means in accordance with the image to be displayed;

means for sealing together said first and second substrates and for filling said cavities with an ionizable gas; and an ionizable gas within said cavities.

2. The device as claimed in claim **1** in which said connection terminal means include first and second connection terminals with alternate ones of said columns of spaced parallel electrodes being connected to said first connection terminal and the remainder of said parallel electrodes being connected to said second connection terminal; said cavities associated with a first image

being aligned with said alternate ones of said spaced parallel electrodes, and the cavities associated with a second one of said images being aligned with the remainder of said columns of spaced parallel electrodes.

3. The device as claimed in claim **2** in which the cross sectional shapes of said cavities are substantially identical and of the same size.

4. The device as claimed in claim **3** in which said electrode means on said first substrate extends over all said cavity location areas, and in which said vertically aligned electrodes are transparent.

5. The device as claimed in claim **2** in which said electrode means comprises rows of spaced parallel electrodes being aligned with said rows of cavity locations;

said connection terminal means further comprising third and fourth connection terminals with alternate ones of said rows of spaced parallel electrodes being connected to said third connection terminal and the remainder of said rows of parallel electrodes being connected to said fourth connection terminal;

said cavities associated with a third image being aligned with said remainder of the rows of spaced parallel electrodes and said alternate columns of parallel electrodes; and

said cavities associated with a fourth image being aligned with said remainder of said rows of parallel electrodes and said remainder of said columns of spaced parallel electrodes; said cavities associated with said first and second images being aligned with said alternate rows of spaced parallel electrodes.

6. The device as claimed in claim **5** in which the cross sectional shapes of said cavities are substantially identical and of the same size; and in which said layer of glass is opaque.

7. The device as claimed in claim **5** in which each said cavity associated with each said image has a character formed therein; and in which said layer of glass is opaque.

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