United States Patent [19]

Shirouchi et al.

[11] **3,818,258**

[45] **June 18, 1974**

[54] **DISPLAY DEVICE UTILIZING GAS DISCHARGE**

[75] Inventors: **Yasunari Shirouchi,** Akashi; **Toshinori Urade,** Kobe, both of Japan

[73] Assignee: **Fujitsu Limited,** Kanagawa-ken, Japan

[22] Filed: **Dec. 14, 1972**

[21] Appl. No.: **315,017**

[30] **Foreign Application Priority Data**

Dec. 29, 1971 Japan 46-751

[52] **U.S. Cl.** **313/188,** 313/220

[51] **Int. Cl.** **H01j 61/00**

[58] **Field of Search** 313/103,188,220

[56] **References Cited**

UNITED STATES PATENTS

3,614,511 10/1971 Baker et al. 313/188

Primary Examiner—Herman Karl Saalbach
Assistant Examiner—Darwin R. Hostetter
Attorney, Agent, or Firm—Maleson, Kimmelman & Ratner

[57] **ABSTRACT**

The present invention relates to a plasma display panel comprising two substrates defining a gap in which an ionizable gas is disposed. On at least one of the substrates there are a plurality of electrodes disposed on the side thereof closer to said gap. Covering said electrodes are dielectric means which contact said gap. The dielectric means comprises a first portion having a high secondary electron emissivity and a second portion having a secondary electron emissivity lower than said first portion. The plasma display panel according to the present invention can be used to improve the definition of a displayed pattern in the plasma display panel, or as a self shift plasma display panel, and or as a pattern generator in an information processing system.

8 Claims, 12 Drawing Figures

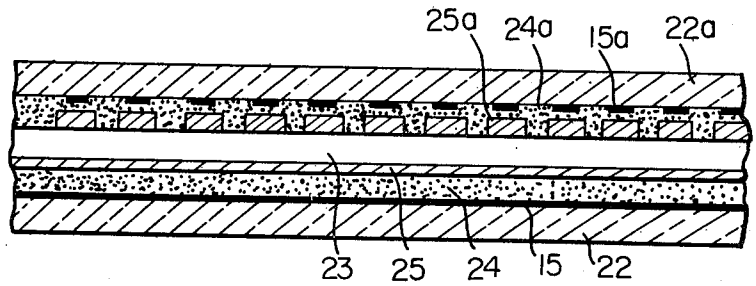


Fig. 1

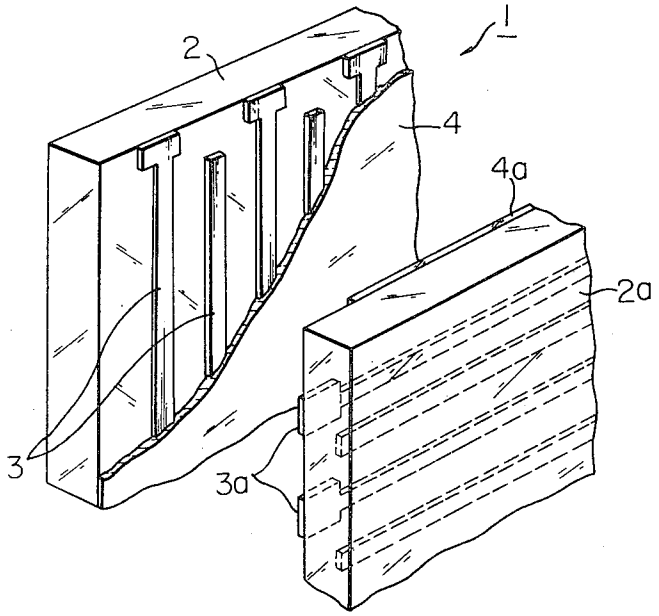


Fig. 2

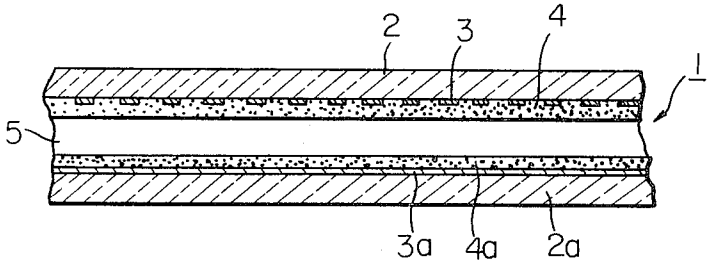


Fig. 3 PRIOR ART

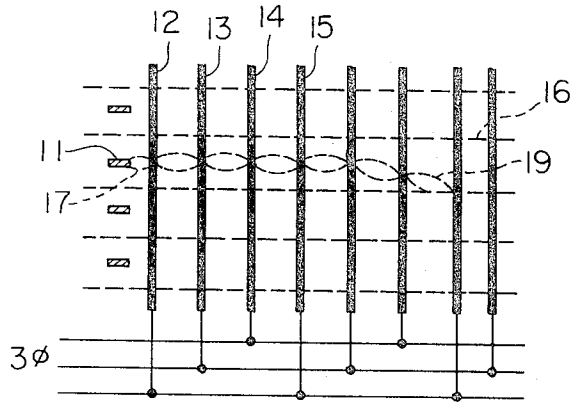


Fig. 4

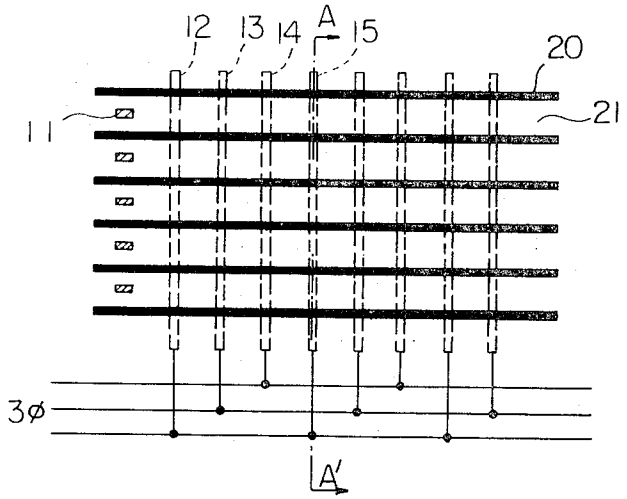


Fig. 5A

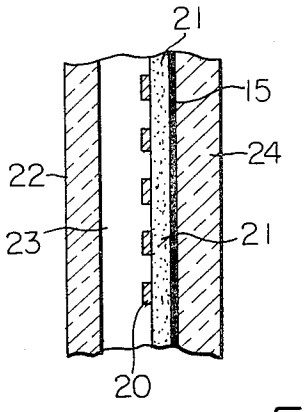


Fig. 5B

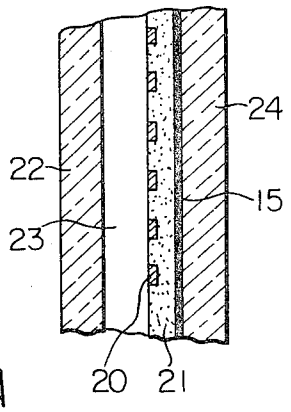


Fig. 6A

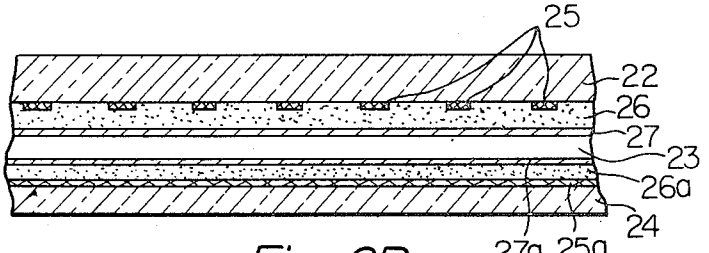


Fig. 6B

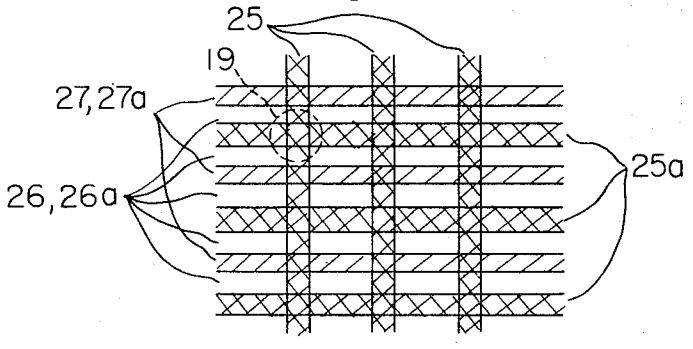


Fig. 7

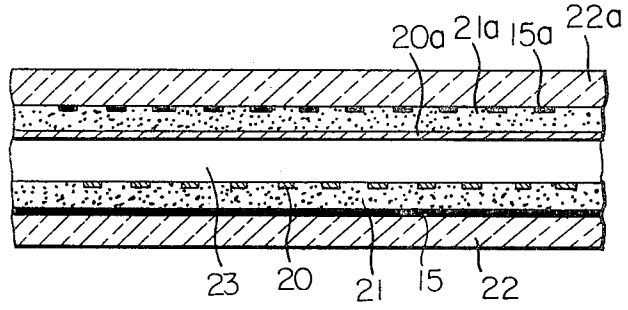


Fig. 8

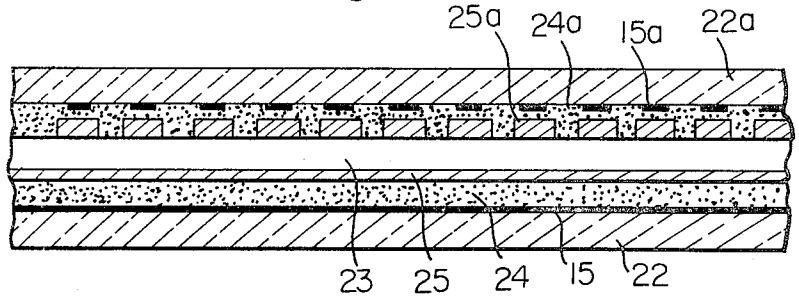


Fig. 9A

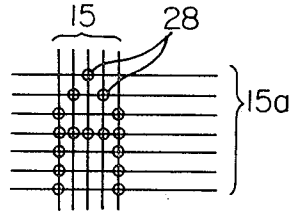
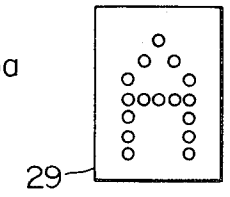


Fig. 9B



DISPLAY DEVICE UTILIZING GAS DISCHARGE

DETAILED EXPLANATION OF THE INVENTION

The present invention relates to an improvement of the display device utilizing gas discharge, especially to a novel display device which utilizes gas discharge dielectric walls contacting a gap filled with gas capable of ionization and is partially composed of two kinds of dielectric materials having respectively different secondary electron emissivity.

Generally, in a display device utilizing gaseous discharge, electrodes covered with dielectric layers are positioned to face each other. Between them, is a gap filled with gas capable of ionization. An alternating sustaining voltage is applied between the electrodes facing each other, and the discharge spots are produced when a writing voltage larger than the firing voltage is added to the sustaining voltage. When the discharge spots are produced, charges corresponding to the polarity of the applied voltage are formed. When the potential difference between the wall voltage due to the wall charges and the following sustaining voltage becomes larger than the firing voltage, the discharge spot is again produced, and the polarity of the wall voltage is reversed. Accordingly, once the discharge is produced, a sustaining voltage lower than the firing voltage can continuously produce the discharge spot. That is, the written information is memorized in the form of a wall voltage and the display can be carried out. Such a gaseous discharge panel has become known in the art as the "plasma panel," and when it is utilized for display purposes, it is commonly called the "plasma display panel."

On the other hand, a display device capable of self shifting discharge spots is proposed as a modification of the display device utilizing gas discharge. Such a device is one of the plasma display panels and can shift the information of a discharge spot generated in the gap filled with gas capable of ionization by using the "primary current effect." The "primary current effect" is a phenomenon wherein the firing voltage for an adjacent point to the discharge point is decreased due to the emission of electrons, ions and metastable atoms produced by discharge. By the primary current effect, the discharge spot can be shifted in a predetermined direction by applying in order a polyphase voltage to the electrodes.

For carrying out the above-mentioned shift action in each column respectively, it is required that each column be mechanically or electrically separated in the direction of the shift. To achieve this purpose, it has been proposed that mechanical insulation barriers be provided between each column. However, mechanical barriers not only make the structure itself complicated, but also make the assembly work very complex. Further, the space between the columns becomes inevitably large and consequently, the displayed figure becomes unsightly. It has also been proposed that other electrodes be provided in the center of the columns or between each column, and a suitable voltage be supplied to these other electrodes to separate electrically the mutual effect between the columns. However, reliable functioning cannot be anticipated with this method.

The object of the present invention is to improve the above-mentioned drawbacks of the plasma display panel of the prior art.

Another object of the present invention is to provide a plasma display panel capable of self shifting the discharge spot by providing electrical barriers on the surface of the dielectric layer.

A further object of the present invention is to provide a plasma display panel which can produce figures defined by small, fine spots by providing electrical barriers on the surface of the dielectric layer.

Still another object of the present invention is to provide a plasma display panel which can be used as a pattern generator, utilizing the difference between firing voltages, by providing electrical barriers on the surface of the dielectric layer.

In the present invention, the surface of the dielectric layer covering the electrodes, which face each other with a gap therebetween filled with gas capable of ionization, is partially composed of two dielectric portions. The surface of one of the dielectric portions has a large secondary electron emissivity and that of the other dielectric portion has a small secondary electron emissivity. In the device capable of self shifting the discharge spot, the above difference in secondary electron emissivities is utilized to separate each column and in the usual matrix type display device, to restrict the position of the discharge spot.

The present invention is especially effective in the display device utilizing gas discharge and having a function of self shifting discharge spots. However, as mentioned above it is also effective in the usual matrix type display device utilizing gas discharge.

Further features and advantage of the present invention will be apparent from the ensuing description with reference to the accompanying drawings to which, of course, the scope of the invention is in no way limited.

FIG. **1** is a general view of the typical plasma display panel;

FIG. **2** is a sectional view of the plasma display panel shown in FIG. **1**;

FIG. **3** is a plan view of the conventional plasma display panel capable of self shifting the discharge spot;

FIG. **4** is a plan view of one embodiment of the plasma display panel capable of self shifting the discharge spot according to the present invention;

FIGS. **5A** and **5B** are two examples of sectional views along A–A′ of the plasma display shown in FIG. **4**;

FIGS. **6A** and **6B** are sectional and plan views of another embodiment of the plasma display panel according to the present invention;

FIG. **7** is a further embodiment of the plasma display panel according to the present invention;

FIG. **8** is still another embodiment of the plasma display panel according to the present invention;

FIGS. **9A** and **9B** are plan views of still another embodiment of the plasma display panel according to the present invention.

Referring to FIG. **1**, a display device utilizing a gaseous discharge **1** has a pair of substrates **2** and **2***a* supporting electrodes. The supporting substrate **2** provides a group of electrodes **3** arranged in columns, which are parallel to a vertical axis and are covered by a dielectric layer **4**. The supporting substrate **2***a* provides a group of electrodes **3***a* arranged in rows, which are parallel to a horizontal axis and are covered

by a dielectric layer 4*a*. The supporting substrates of electrodes 2 and 2*a* are positioned in spaced parallel relation so that the groups of electrodes 3 and 3*a* are disposed at right angles to each other. As shown in FIG. 2 these parallel rows and columns are separated from each other by a gap 5. This gap 5 is filled with a rare gas having a suitable pressure and being capable of ionization. When the device is utilized for display purposes, it is necessary that at least one of the substrates 2, 2*a* and one of the dielectric layers 4, 4*a* are transparent.

In the above-mentioned display device utilizing gas discharge 1 shown in FIGS. 1 and 2, when an electric voltage higher than the firing voltage V_f is selectively applied between the groups of electrodes in columns 3 and rows 3*a*, each cross point of the electrodes in columns and rows discharges into the gap 5 filled with ionizable gas. At the time of this discharge, a wall charge is formed on the surfaces of the dielectric layers 4 and 4*a* corresponding to the above-mentioned cross point. With the effect of this wall charge, the discharge, once generated, is sustained with the pulsive sustaining voltage V_s smaller then the firing voltage V_f. That is, the input information which is the voltage exceeding the firing voltage V_f is memorized by the above-mentioned wall charge.

Referring to FIG. 3, this device provides a plurality of shift electrodes 12, 13, 14, 15, etc. arranged parallel and connected at intervals of two electrodes to a common buss of a three phase alternating current electric source. Also, a plurality of write electrodes 11 is arranged in every column longitudinally along the first shift electrode 12. These electrodes 11, 12, 13, 14, 15, etc., are covered with a dielectric layer and face a gap filled with gas capable of ionization.

When the firing voltage is supplied between the write electrode 11 and the first shift electrode 12, a discharge spot 17 is produced between these two electrodes. In this case, when the three phase sustaining voltage is commutated to shift electrodes 12, 13, 14, etc., in order, the above-mentioned discharge spot is shifted in order, in a direction at right angles to the shift electrodes. However, to carry out the above-mentioned shift action, it is required that each column be mechanically or electrically separated in the direction of the shift. To achieve this purpose, it has been proposed that mechanical insulation barriers 16 be provided between each column for the purpose of preventing the deviation of the discharge spot as shown in the deviation 19. However, the mechanical barriers 16 not only make the structure complex, but also complicate assembly work. Further, the spaces between columns become inevitably large and the displayed figure becomes unsightly. It has also been proposed that other electrodes be provided in the center of each column or between each column and these electrodes be supplied by the voltage to separate electrically the mutual effect between the columns. However, reliable functioning cannot be anticipated with this method.

The preferable embodiment according to the present invention will now be explained with respect to FIGS. 4–9. FIGS. 4, 5A and 5B are one example of the present invention applied to the device capable of self shifting discharge spots. The electrodes 12, 13, 14, 15, etc., shown in FIG. 4 are formed parallel to the common plane of the base plate 24 which is shown in the sectional view of FIG. 5A. As in FIG. 5A, the wall surface, which is composed of two portions 20 and 21, covers the above-mentioned electrodes and faces another base plate 22 and gap 23 between them is filled with gas capable of ionization. The dielectric wall surface 21, which contacts the gap 23 at positions corresponding to each column, can be constructed with material having high secondary electron emissivity γ_H, for example, low melting temperature glass which includes more than 70 per cent PbO. The dielectric wall surface 20, which contacts the gap 23 between each column, can be constructed with material having a lower secondary electron emissivity γ_L than that of material 21, for example, Al_2O_3, SiO_2 . Referring to FIG. 5A, the dielectric wall surfaces 20, which separate each column, are disposed on the dielectric wall surface 21, which has high secondary electron emissivity γ_H. Referring to FIG. 5B, the dielectric wall surfaces 20, having low secondary electron emissivity γ_L, are buried between each column in the dielectric wall surface 21, having high secondary electron emissivity γ_H, in such a manner that the surfaces of 20 and 21 facing the gap 23 have the same surface plane.

As a result of this, a difference of the firing voltages in a ratio of about 1 : 2 is produced between the dielectric wall surface 21, composed of low melting temperature glass including PbO, and the dielectric wall surface 20, composed of high melting temperature glass including Al_2O_3, due to the difference in secondary electron emissivity. This difference of firing voltages between the dielectric wall surfaces 20 and 21 can be increased to a ratio of about 1 : 5 by chemically treating with cesium C_S or a compound of cesium C_S the dielectric material having a high secondary electron emissivity γ_H. Furthermore, this difference in the secondary electron emissivity can also be provided by selectively treating the dielectric surface by means of etching with acid or alkaline solvent. Then, when the voltage applied to the shift electrodes 12, 13, 14, etc., is previously selected below the firing voltage of the dielectric wall surface 20, having a low secondary electron emissivity γ_L, the discharge spots of each column can be prevented from moving to an adjacent column.

FIGS. 6A and 6B represent another embodiment of the present invention applied to the device capable of self shifting the discharge spot. Referring to the sectional view shown in FIG. 6A, a plurality of electrodes 25 disposed in parallel on the base plate 22 are covered with a first dielectric layer 26. As is clear from the plan view of FIG. 6B, second dielectric layers 27 are provided at right angles to the electrodes 25 on the surface of the first dielectric layer 26. On the other hand, a plurality of electrodes 25*a*, disposed parallel to the base plate 24 are covered with a first dielectric layer 26*a*. The second dielectric layers 27*a* disposed parallel to and between the electrodes 25*a* are provided on the surface of the first dielectric layer 26*a*. As already shown, the group of electrodes 25 and that of electrodes 25*a* are disposed at right angles to each other and the second dielectric layers 27 and 27*a* are disposed parallel to and facing each other with the gap 23 filled with ionizable gas therebetween. The first dielectric layers 26, 26*a* and the second dielectric layers 27, 27*a* are respectively composed of dielectric materials having different secondary electron emissivity γ. For example, the first dielectric layers 26, 26*a* can be composed of low melting temperature glass which includes more than 70 percent PbO, and the second dielectric

layers **27**, **27***a* can be composed of Al_2O_3 or SiO_2. The plasma display panel shown in FIGS. **6**A and **6**B provides electric barriers **26**, **26***a*, **27** and **27***a* disposed parallel to the electrodes **25***a*. Consequently, when the polyphase voltage is supplied to the electrodes **25**, the discharge spot **19** can be shifted along the passages between said electric barriers.

FIG. **7** is a sectional view of a further embodiment of the present invention applied to a matrix type display device utilizing gas discharge. Referring to FIG. **7**, X electrodes **15** and Y electrodes **15***a*, disposed respectively on a pair of base plates **22** and **22***a*, are covered with dielectric layers **21** and **21***a* having high secondary electron emissivity γ_H. These base plates **22** and **22***a* are disposed in spaced parallel relation facing each other with a gap **23** filled with gas capable of ionization therebetween. Further, in the display device shown in FIG. **7**, dielectric layers **20**, having low secondary electron emissivity γ_L, are provided upon the dielectric layer **21**, having high secondary electron emissivity γ_H in positions which correspond to the intervals between the Y electrodes **15***a*. Similarly, dielectric layers **20***a*, having low secondary electron emissivity γ_L are provided upon the dielectric layers **21***a*, having high secondary electron emissivity γ_H, in positions which correspond to the intervals between the X electrodes **15**. Accordingly, the cross points of X electrodes **15** and Y electrodes **15***a* correspond to meshes of the dielectric layers **20** and **20***a* which are disposed in lattice form each other. According to the construction shown in FIG. **7**, the cross points of X electrodes **15** and Y electrodes **15***a* are exposed to portions of the dielectric layers **21** and **21***a* which have high secondary electron emissivity γ_H. The firing voltages at these cross points are low, and, consequently, the dimensions of the discharge spots generated at these cross points are restricted. That is, the discharge spot is prevented from enlarging unnecessarily and incorrectly moving to the adjacent position to be discharged, as is seen frequently in the conventional display device.

FIG. **8** is a sectional view of still another embodiment of the present invention applied to a display device utilizing gas discharge. In FIG. **8**, contrary to that shown in FIG. **7**, X electrodes **15** and Y electrodes **15***a*, disposed respectively on a pair of base plates **22** and **22***a*, are covered with dielectric layers **24** and **24***a* respectively, which have low secondary electron emissivity. Dielectric layers **25** and **25***a*, having high secondary electron emissivity, are disposed on the surface of the dielectric layers **24** and **24***a*, and face each other with the gap **23** filled with ionizable gas therebetween, to cover the cross points of the electrodes X and Y. In the construction shown in FIG. **8** the cross points of X electrodes **15** and Y electrodes **15***a* are also exposed to a portion of the dielectric of the layers **25** and **25***a*, which have high secondary electron emissivity γ. The firing voltages at these cross points are low and consequently, the dimensions of the discharge spots generated at these cross points are restricted. That is, similar to the case of FIG. **7**, the discharge spot is prevented from enlarging unnecessarily and incorrectly moving to an adjacent position, as is seen frequently in the conventional display device.

FIGS. **9**A and **9**B are an embodiment of the present invention applied to a pattern generator. In the embodiment shown in FIG. **9**A, X electrodes **15** and Y electrodes **15***a* are disposed at right angles to each other in the plasma display panel. The portions of the dielectric layers having high secondary electron emissivity are selectively provided on the selected cross points of the X and Y electrodes, that is, cells **28** having low firing voltage are selectively provided. It is understood that the above-mentioned cells **28** form a pattern in accordance with the desired figure, such as the character A shown in FIG. **9**A. In the plasma display panel constructed according to FIG. **7**, when the voltage having a suitable value is supplied to the cross points of whole electrodes, the selected cells **28** having low firing voltage, that is, only the cells forming the desired pattern, can fire selectively. Consequently, the electric signal corresponding to the pattern can be obtained by reading electrically the state of each cell. As shown in FIG. **9**B, the same effect can be obtained by the negative pattern **29** having low secondary electron emissivity disposed on the surface of a dielectric layer having high secondary electron emissivity and making the high firing voltage correspond to the portion of the negative pattern.

What is claimed is:

1. A display device utilizing gas discharge which is composed of:

a. a pair of substrates which are facing each other so as to define a discharge gap which is filled with a gas capable of ionization,

b. a plurality of electrodes which are disposed on at least one of said substrates on the side thereof closer to said gap, and

c. dielectric means covering said electrodes and contacting said discharge gap, said dielectric means comprising a first portion which has a high secondary electron emissivity in accordance with a predetermined configuration and a second portion which has a secondary electron emissivity lower than that of said first portion.

2. A display device according to claim **1** wherein said plurality of electrodes are disposed in parallel, wherein said second dielectric portion comprises a layer covering said electrodes, and wherein said first dielectric portion comprises a plurality of strips disposed in contact with said dielectric layer and facing said gap.

3. The display device according to claim **2** with the addition of means for applying a polyphase voltage to said electrodes thereby shifting discharge spots generated between adjacent electrodes along said strips.

4. The display device according to claim **1** wherein said plurality of electrodes includes a first and second set of electrodes arranged at right angles to each other and are respectively covered by said dielectric means, said sets being positioned in spaced parallel relation facing one another with said discharge gap therebetween, the first portions of said dielectric means comprising a plurality of parallel dielectric strips having a higher secondary electron emissivity than that of said dielectric means, said strips corresponding to said first set of electrodes and means for applying a polyphase voltage to said second set of electrodes, said voltage applying means being connected to said second set of electrodes and being disposed at right angles to said strips, said applying means producing discharge spots at cross points between said first and second set of electrodes which are shifted along said strips by said applied voltage.

5. The display device according to claim 1 wherein said plurality of electrodes includes first and second sets of electrodes arranged at right angles to one another, wherein said dielectric means comprises first and second dielectric layers respectively covering said first and second sets of electrodes, said dielectric layers being positioned and spaced in parallel relation with their surfaces facing each other across said discharge gap, wherein the respective second portions of said layers comprise a plurality of dielectric strips arranged at right angles to one another.

6. A display device according to claim 1 wherein said plurality of electrodes includes first and second sets of electrodes arranged at right angles to one another and wherein said dielectric means includes first and second dielectric layers respectively covering said first and second sets, said dielectric layers being positioned and spaced in parallel relation on each side of said discharge gap, wherein the first portions of said two dielectric layers comprise first and second pluralities of dielectric strips.

7. The gas discharge device according to claim 1 wherein said plurality of electrodes comprises first and second sets of electrodes, wherein said dielectric means comprises first and second dielectric layers covering said first and second electrodes, said dielectric layers being spaced from one another with said discharge gap between, the first portion of at least one of said layers being covered with a predetermined configuration of a dielectric material having a higher secondary electron emissivity than that of said dielectric layer.

8. The gas discharge device according to claim 1 wherein said plurality of electrodes comprises two sets of electrodes, wherein said dielectric means comprises two dielectric layers respectively covering said sets of electrodes, said dielectric layers being spaced from one another with said discharge gap between them, and wherein the second portion of at least one of the said layers is covered with a pattern of dielectric material having lower secondary electron emissivity than that of said one of said layers.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,818,258

DATED : June 18, 1974

INVENTOR(S) : YASUNARI SHIROUCHI et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 8, line 8, delete "covered with";

line 10, before "said" insert --said second portion of--

line 18, delete "covered with";

line 20, before first occurrence of "said" insert --said first portion of--.

This certificate supersedes certificate issued May 30, 1978.

Signed and Sealed this

First Day of *August 1978*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

DONALD W. BANNER
Commissioner of Patents and Trademarks

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,818,258 Dated June 18, 1974

Inventor(s) YASUNARI SHIROUCHI et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 8, line 7, delete "at least one of";

line 8, delete "covered with";

line 10, after "said" insert--second portion of said-

line 17, delete "at least one of the";

line 18, after "is" insert--a predetermined configuration--;

line 18, delete "covered with a pattern";

line 20, delete "one";

line 20, before "of" insert--first portion--.

Signed and Sealed this

Thirtieth Day of May 1978

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

LUTRELLE F. PARKER
Acting Commissioner of Patents and Trademarks

Notice of Adverse Decision in Interference

In Interference No. 99,541, involving Patent No. 3,818,258, Y. Shirouchi and T. Urade, DISPLAY DEVICE UTILIZING GAS DISCHARGE, final judgment adverse to the patentees was rendered Oct. 21, 1983, as to claims 2 and 6.

[*Official Gazette June 5, 1984.*]