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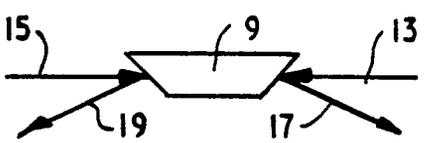
(54) Gaseous discharge display devices.

(57) The invention relates to a gaseous discharge display device (gas panel) of the kind comprising a pair of glass plates each having an array of parallel conductors formed thereon overlaid with a dielectric layer, the plates being sealed together at their edges in superimposed spaced parallel relationship with the conductor arrays being disposed substantially orthogonally to one another to define a plurality of discharge gaps, each formed at the cross-point of a conductor of one array with a conductor of the other array, and metal spacers disposed between the dielectric layers for maintaining the discharge gaps precisely spaced over the area of the display device.

The spacers are in the form of rods 9 having a trapezoidal cross-section so that light 13 or 15 emanating from an adjacent gas discharge tends to be reflected downwardly into the panel, as shown by rays 17 and 19, rather than outwardly from the panel. This reduces the visibility of the spacers 9 when the panel is viewed from the front.



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GASEOUS DISCHARGE DISPLAY DEVICES

This invention relates to gaseous discharge display devices, hereinafter referred to as gas panels.

It is necessary with large area high resolution devices of this type to provide a method of spacing the opposite plates of the device in a manner which does not inhibit the flow of gas particles within the panel and which maintains a uniform discharge gap between opposing cell electrodes across the entire display surface.

Various techniques have been employed in the prior art for providing and maintaining a uniform discharge gap between opposing glass plates of a gas panel, primarily involving the use of glass spacers in rod form. Other arrangements modify the gas panel structure by cutting grooves in one or both of the glass plates and forming conductor arrays within the grooves whereby the plates themselves consititute the spacer elements. However, such devices are difficult to fabricate, particularly in high resolution panels which may contain about 5,000 cells per square inch.

A further technique uses metallic spacers which are located on one of the glass plates prior to the deposition of the conventional dielectric coating.

Such a technique, however, makes it extremely difficult to provide a uniform dielectric coating over the entire surface of the panel so that the dielectric surface in the spacer areas is not perfectly flat and is mechanically weak, and unstable point contact may result. Additionally, differences in dielectric thickness in respect of individual cells resulting from such arrangements require variations in the electrical parameters of control signals used to control the device, and eliminate or severely restrict the panel margin. The operation of cells or firing sites which are located adjacent to the spacers is adversely affected due to the meniscus effect of the dielectric reflow, since perturbations of the dielectric surface alters the dielectric thickness over conductor lines adjacent to the spacer elements, thereby preventing reliable operation of such cells.

This disadvantage is avoided by the technique described in U.S. Patent 3,998,510, wherein metal spacers are sandwiched between the glass plates after deposition of the dielectric coatings. It is stated that U.S. Patent that in the resulting panel the spacers are substantially invisible to the observer. While this may be true for the spacers specifically disclosed therein, it would not be true for elongated spacers of rod form since the long edges thereof would present a substantial area for reflection. The use of rod-form spacers would be particularly desirable in high resolution panels with

a very small conductor spacing, since this would reduce the number of spacers which are required compared to that required if disc-shaped spacers were used as described in U.S. Patent 3,998,510, and also would facilitate their handling and placement due to their larger size. However, as mentioned above, the long edges of such spacers would present a substantial area for reflection and each would be visible to viewers as a narrow line of light in the displayed image.

Thus it is an object of the invention to provide a gas panel construction having spacers of rod-form in which the visibility of the spacers is substantially reduced.

According to the present invention there is provided a gaseous discharge display device comprising a pair of glass plates each having an array of parallel conductors formed thereon overlaid with a dielectric layer, the plates being sealed together at their edges in superimposed spaced parallel relationship with the conductor arrays being disposed substantially orthogonally to one another to define a plurality of discharge gaps, each formed at the cross-point of a conductor of one array with a conductor of the other array, and metal spacers disposed between the dielectric layers for maintaining the discharge gaps precisely spaced over the area of the display device, characterised in that the spacers (9) are in the form of rods having a trapezoidal cross-section with the non-parallel edges thereof converging in a direction away from the front plate (31) of the device.

An embodiment of the invention will now be described with reference to the accompanying drawings, in which:

Fig. 1 is an enlarged plan view of a portion of a gaseous display device illustrating one embodiment of the present invention,

Fig. 2 is a cross-sectional view of the device shown in Fig. 1 taken along the lines 2-2 of Fig. 1, and

Fig. 3 is a cross-sectional view of a spacer used in the device of figures 1 and 2.

Referring now to the drawings, the gaseous discharge display device (or gas panel) there shown corresponds generally to that described in U.S. Patent 3,837,724, and the fabrication steps are generally similar except in so far as they relate to details of the spacers as described below.

In the plan view shown in Fig. 1, a plurality of parallel vertical lines includes groups of eight vertical lines such as that designated V_3, and groups of nine horizontal lines such as those designated H_5 and H_7. The horizontal lines are formed on the front plate of the device (upper plate in fig. 2), while the vertical lines V_3 are formed on the back plate of the panel. Each intersection of a group of horizontal lines and a group of vertical lines defines an 8 x 9 dot matrix for generating alpha-numeric each of the characters being generated within a 7 x 9 sub-matrix so as to leave a single column space between characters.

Fig. 2 is a sectional view of the gas panel. The bottom or back glass plate 21 has metallic conductors 23 formed thereon (corresponding to the vertical conductors such as V_3) and is overcoated with a layer of dielectric 25. While not strictly necessary, the dielectric layer 25 may be overcoated with a layer of refractory secondary emissive material 27 such as MgO. The upper or front plate 31 has conductors 33 formed thereon (corresponding to the horizontal conductors such as H_5 or H_7), the conductors 33 being disposed substantially orthogonal to conductors 23, and the plate 31 is also overcoated with a dielectric layer 35. Bonded to the dielectric layer 35 are metallic spacers 9, both the layer 35 and spacers 9 being overcoated with a further layer 37 of the refractory secondary emissive material to protect the dielectric surface and facilitate low voltage operation.

The plan view shown in Fig. 1 portrays an idealized situation, since the spacers 9 are shown located only between rows of characters which, in most practical applications, would not provide the best distribution of spacers. Rather, the spacing members are designed for positioning between any pair of adjacent drive lines, preferably between horizontal drive lines, and this permits a freedom of placement of spacers over the display surface to provide optimum load bearing characteristics. As described in the previously mentioned U.S. patent, the horizontal and vertical conductors are chrome-copper-chrome conductors, and in the present embodiment preferably have a resolution of about 70 lines per inch in each direction with 3 mil. wide conductors spaced on 14 mil. centres, giving a separation of 11 mils.

between adjacent conductors. The spacers 9 of this embodiment are 5 mils. wide (at their base), 4 mils. thick and 250 mils. long, and are positioned centre to centre in both vertical and horizontal directions with respect to adjacent spacers 2,000 mils. or 2 inches. It has been determined that the spacers 9 should be separated from the adjacent conductors 33 by 2 mils. to avoid an adverse effect on the electrical characteristics on adjacent conductors, particularly the panel margin or the difference between V_s max and V_s min where V_s represents the sustain signal. Thus the spacers 9 must be positioned to an accuracy of $\pm$ 1 mil. to avoid such problems.

As mentioned before, one of the problems associated with metal spacers relates to their visibility, which is caused primarily by reflection from the surface of the spacers such that the spacers are readily visible to viewers positioned at only a slight angle relative to the normal to the display surface. One way to reduce reflection from metal spacers is to oxidize the surface of the spacers to reduce the reflectivity. The spacers 9 in the present case are composed of a nickel-iron alloy having approximately equal percentages by weight of the two component elements, and the spacers are oxidised prior to assembly of the panel. An additional advantage of the oxide coating is that the spacers 9 are further protected from the plasma during operation. The spacers 9 are secured to the dielectric 35, prior to assembly of the lower plate 21, by conventional thermal compression or ultrasonic bonding techniques depending on the bonding medium. In one form of bonding, a drop of solder glass approximately 5 mils. in diameter and 1 mil. thick is

applied to the surface of the spacer to be bonded to the dielectric. The spacer is then positioned on the dielectric surface 35 under appropriate loading such as 15 grams and sufficient heat is applied to effect a glass-solder bond. Load and heat are chosen to optimize the strength of the bond and the reliability of the overall process.

With respect to positioning the spacers on the dielectric 35, techniques for automated placement as well as bonding are well known in the art, and positioning of the spacers as heretofore described could be controlled by a modified X-Y table which could operate under digital programming control to position the spacers at any selected location using digital controlled servo devices to move the table in a horizontal, vertical or both directions as specified. The spacer positioning previously described has been designed to represent the best configuration for maximum load bearing with a 10" x 12" display surface, since loads of up to 50,000 PSI, near the breaking point of the dielectric coating, may be encountered during the backfill operation or under maximum vacuum conditions. In addition to reducing spacer visibility, the oxidized surface of the spacer improves the adhesion between the solder glass and the spacer, and also improves the adhesion of the MgO layer 37 which is applied by evaporation over the dielectric 35 and the spacers 9 to provide a refractory surface which protects the device from sputtering of the dielectric or the spacers and simultaneously by virtue of its secondary emission characteristics permits lower operating voltages. The use of magnesium oxide for both purposes is well known. The nickel-iron alloy

was developed so that its coefficient of thermal expansion would match that of the plate glass on which it is mounted.

The essential feature of the spacers 9 relates to their shape. The metallic spacers 9 are in rod form and have a cross-section which corresponds to an inverted trapezoid as shown in Fig. 3, the base or widest part of the trapezoid being disposed facing the front or upper plate 31. Thus, it will be seen that if incident light from the display falls on the sloped edges of the trapezoid, as indicated by light rays 13 and 15 eminating from opposite sides of the spacer, the light will tend to be reflected downwardly into the panel, as shown by the relfected light rays 17 and 19, rather than outwardly from the display, thus eliminating or substantially reducing the reflective light which represents the primary source of visibility of the spacers. This combined with the oxidation of the surface of the spacers renders them substantially invisible during normal panel operation, a highly desirable result.

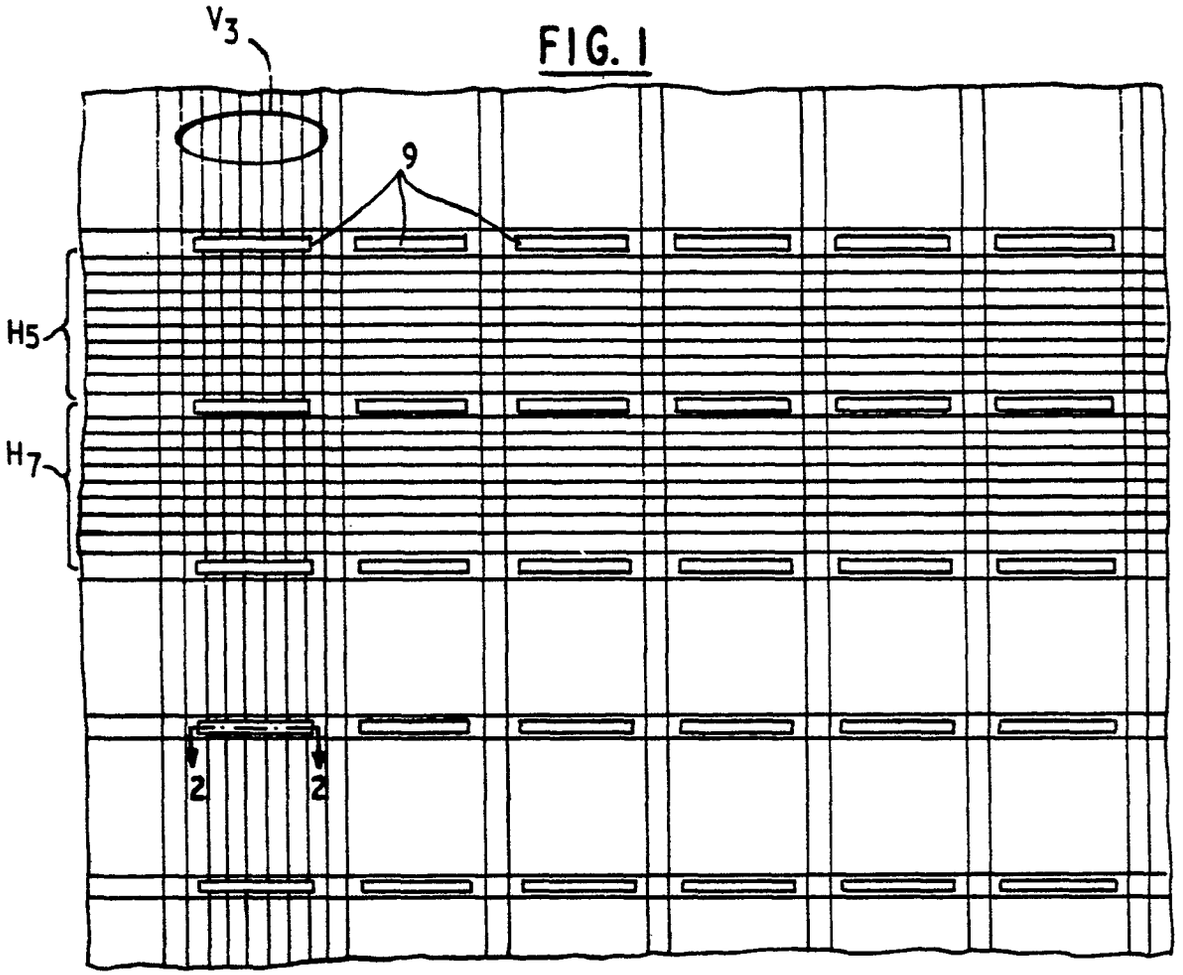
It is to be understood that the conductor configuration and composition, the specific method of fabricating gaseous discharge display devices and the apparatus by which the chamber is evacuated and then charged with an illuminable gas are considered known in the art, and are disclosed, for example, in the above-mentioned U.S. Patent 3,837,724. Accordingly, certain of such details have been omitted in the present specification in the interest of succinctness and as unnecessary for an understanding of the present invention.

CLAIMS

1. A gaseous discharge display device comprising a pair of glass plates each having an array of parallel conductors formed thereon overlaid with a dielectric layer, the plates being sealed together at their edges in superimposed spaced parallel relationship with the conductor arrays being disposed substantially orthogonally to one another to define a plurality of discharge gaps, each formed at the cross-point of a conductor of one array with a conductor of the other array, and metal spacers disposed between the dielectric layers for maintaining the discharge gaps precisely spaced over the area of the display device, characterised in that the spacers (9) are in the form of rods having a trapezoidal cross-section with the non-parallel edges thereof converging in a direction away from the front plate (31) of the device.

2. A device as claimed in claim 1, wherein the surface of the spacers is oxidized.

FIG. 1



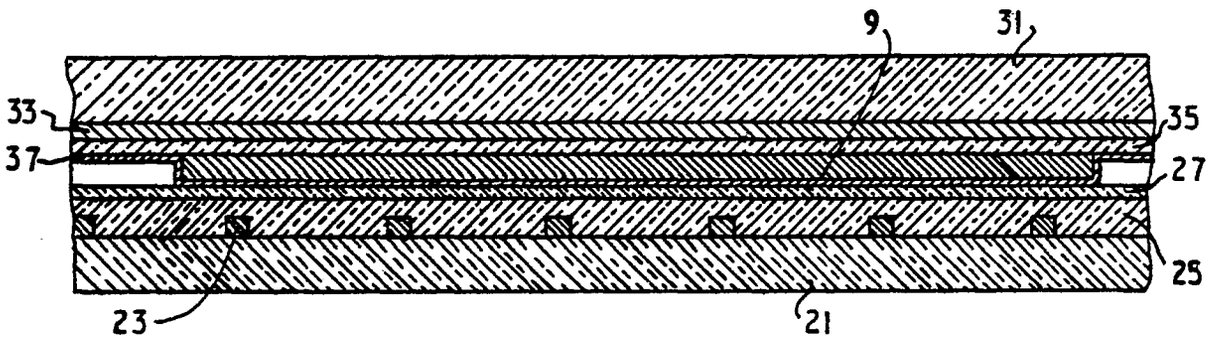


FIG. 2

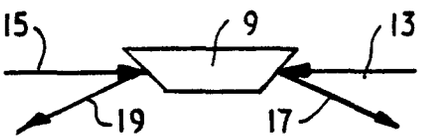


FIG. 3

European Patent Office

EUROPEAN SEARCH REPORT

Application number
0012140
EP 78 30 0830

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
D,A	US - A - 3 998 510 (Ch.W. SALISBURY) * abstract; column 1, lines 8-14; column 3, lines 34-40; column 4, lines 20-26; figures 1 and 2 *	1
A	US - A - 4 091 305 (N.M. POLEY and al.) * abstract; column 2, lines 17 to 44; column 3, line 4 to column 4, line 24; figures 1 and 2 * & DE - A - 2 655 498 & FR - A - 2 337 913 & GB - A - 1 509 487	1
A	US - A - 3 798 483 (F. WALTERS) * abstract; column 2, lines 20 to 50; column 3, lines 28 to 47; figure 3 * & GB - A - 1 326 384	1
A	US - A - 3 935 500 (F.G. OESS and al.) * column 2, lines 4-8; column 2, line 55 to column 4, line 41; figures 2 and 3 *	1

CLASSIFICATION OF THE APPLICATION (Int. Cl.²)

H 01 J 65/04

TECHNICAL FIELDS SEARCHED (Int.Cl.²)

H 01 J 65/04
H 01 J 17/49

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	10-07-1979	MAUGUIN

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