United States Patent [19]

Bode et al.

[11] **3,914,635**

[45] **Oct. 21, 1975**

[54] **GASEOUS DISCHARGE DISPLAY/MEMORY DEVICE WITH IMPROVED MEMORY MARGIN**

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[73] Assignee: **Owens-Illinois, Inc.**, Toledo, Ohio

[22] Filed: **Sept. 26, 1972**

[21] Appl. No.: **292,437**

Related U.S. Application Data

[62] Division of Ser. No. 185,432, Sept. 30, 1971, abandoned.

[52] **U.S. Cl.** ..... **313/226;** 315/169 TV

[51] **Int. Cl.**[2] **H01J 61/16**

[58] **Field of Search** ..... 315/169 R, 169 TV; 313/108 R, 108 A, 108 B, 188, 201, 220, 224, 226, 484

[56] **References Cited**

UNITED STATES PATENTS

3,622,829	11/1971	Watanabe	315/169 R
3,634,719	1/1972	Ernsthauser	315/169 R
3,798,501	3/1974	Miller	315/169 R

Primary Examiner—Ronald L. Wibert
Assistant Examiner—Richard A. Rosenberger
Attorney, Agent, or Firm—Donald Keith Wedding

[57] **ABSTRACT**

There is disclosed a gas discharge display/memory device containing electrode arrays and an ionizable gaseous medium, the gaseous medium having incorporated therein an effective amount of helium sufficient to decrease the minimum applied voltage sufficient to sustain a gas discharge once initiated and increase the memory margin of the device. In the preferred embodiment, there is incorporated at least about 0.01 percent atoms of helium, based on the gaseous medium concentration after helium addition, to an initial gaseous medium consisting essentially of about 99.5 percent to about 99.99 percent atoms of neon and about 0.5 percent to about 0.01 percent atoms of at least one member selected from argon, xenon, and krypton. The gas discharge device is preferably of a display/memory type wherein electrical charges are stored on opposing dielectric surfaces.

3 Claims, 4 Drawing Figures

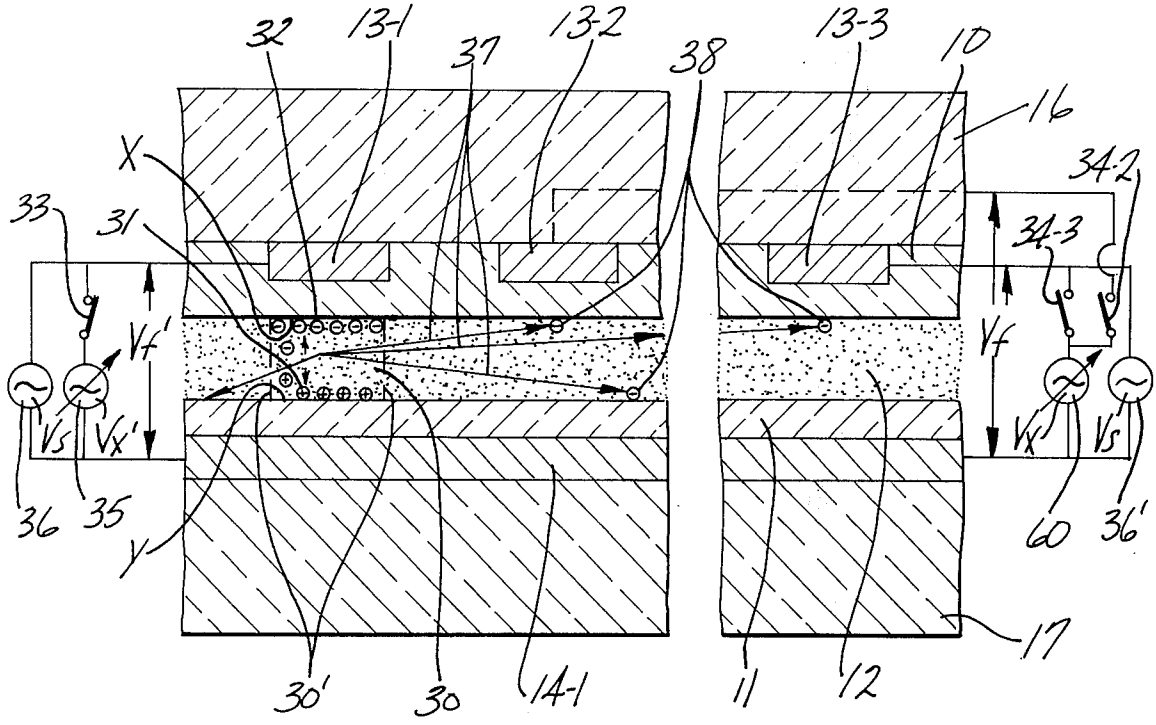


FIG. 2

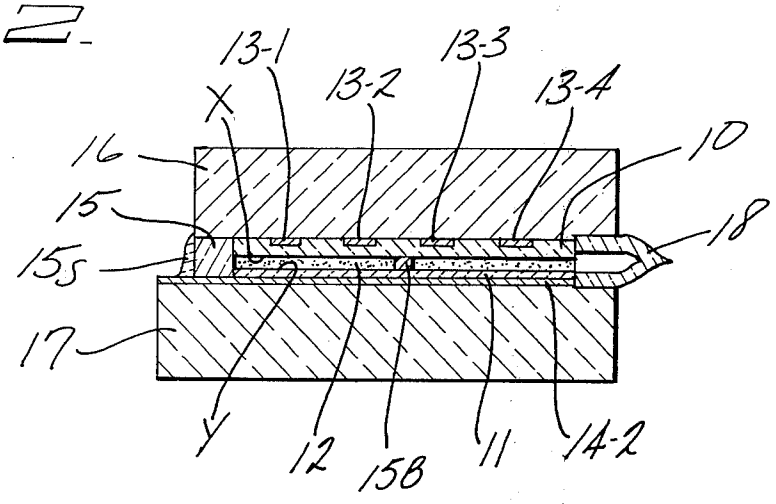

13-1
13-2
13-3
13-4
X
16
10
15
18
15S
17
Y
12
15B
11
14-2

FIG. 1

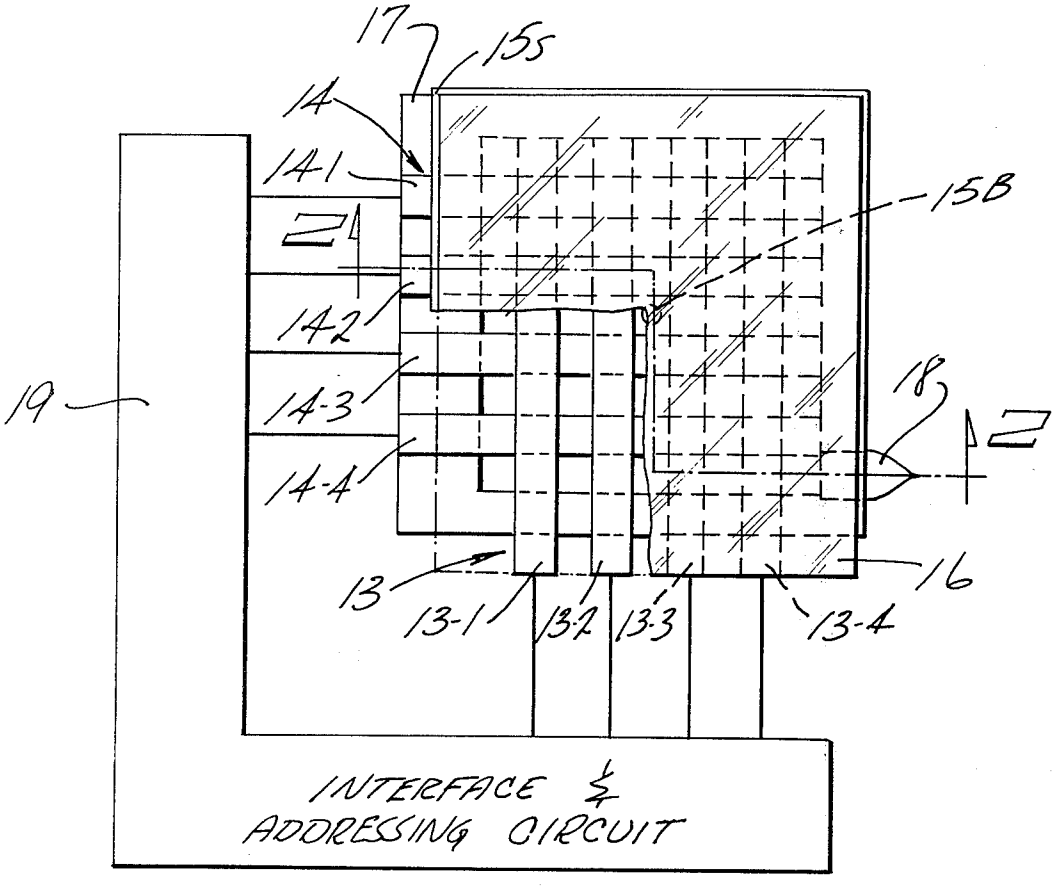

17
15S
14
14-1
2
15B
14-2
14-3
14-4
19
18
2
13
16
13-1
13-2
13-3
13-4
INTERFACE & ADDRESSING CIRCUIT

FIG. 3

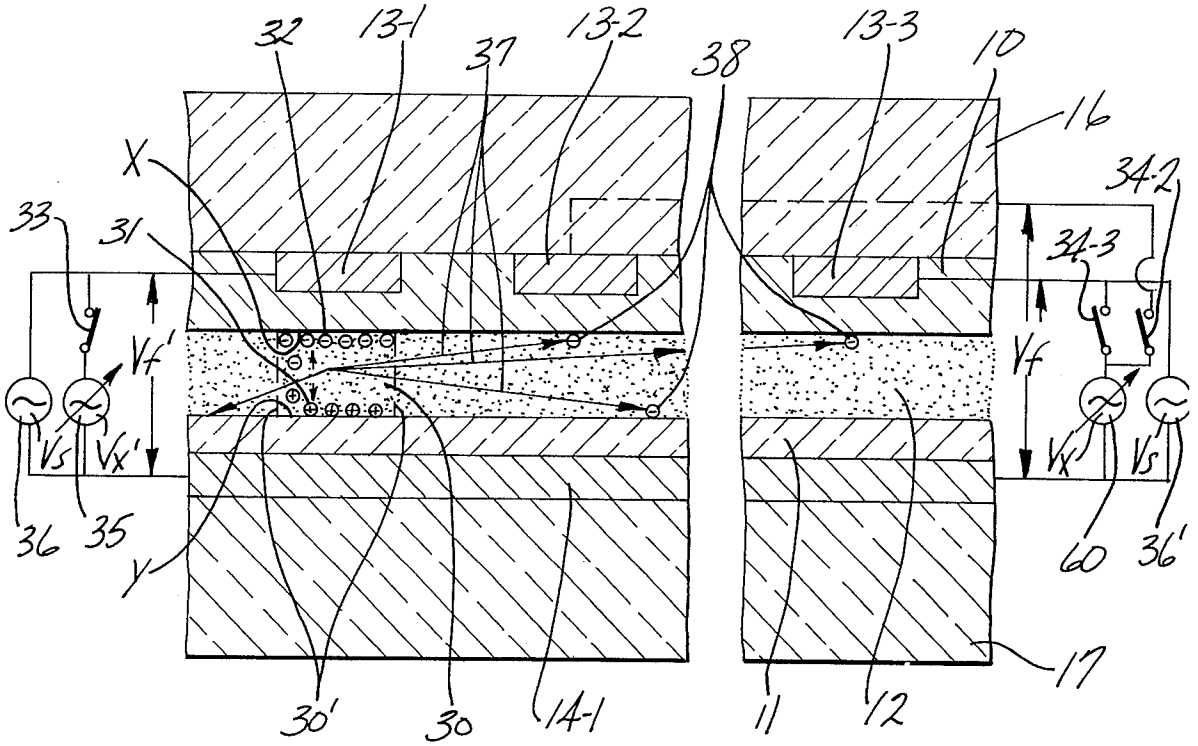
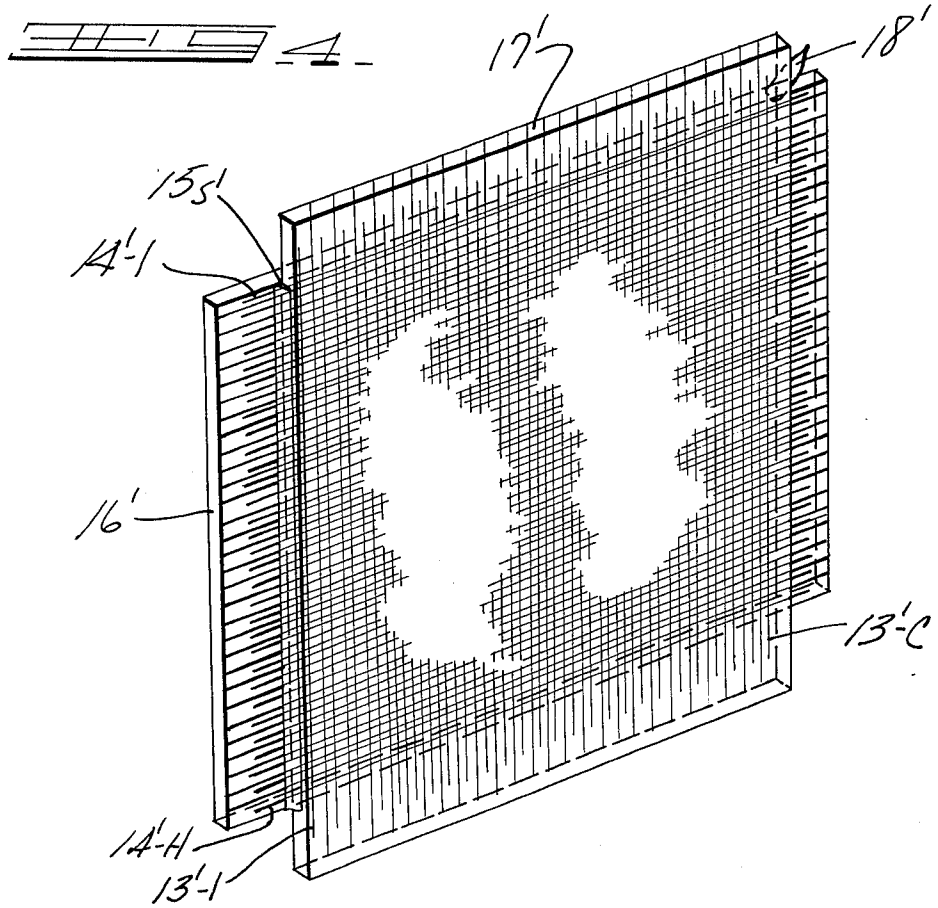

32
13-1
37
13-2
38
13-3
10
16
34-2
34-3
X
33
31
Vf'
Vf
Vs
Vx'
Vx
Vs
36
35
Y
60
36'
30'
30
14-1
11
12
17

FIG. 4


17'
18'
15s'
14'-1
16'
13'-C
14'-H
13'-1

GASEOUS DISCHARGE DISPLAY/MEMORY DEVICE WITH IMPROVED MEMORY MARGIN

This is a division of copending U.S. Pat. application Ser. No. 185,432 filed Sept. 30, 1971 now abandoned.

BACKGROUND OF THE INVENTION

This invention relates to gas discharge devices, especially multiple gas discharge display/memory panels or units which have an electrical memory and which are capable of producing a visual display or representation of data such as numerals, letters, radar displays, aircraft displays, binary words, educational displays, etc.

Multiple gas discharge display and/or memory panels of one particular type with which the present invention is concerned are characterized by an ionizable gaseous medium, usually a mixture of at least two gases at an appropriate gas pressure, in a thin gas chamber of space between a pair of opposed dielectric charge storage members which are backed by conductor (electrode) members, the electrode members backing each dielectric member typically being oriented so as to define a plurality of discrete discharge volumes, each constituting a discharge unit.

In some prior art panels the discharge units are additionally defined by surrounding or confining physical structure such as by cells or apertures in perforated glass plates and the like so as to be physically isolated relative to other units. In either case, with or without the confining physical structure, charges (electrons, ions) produced upon ionization of the gas of a selected discharge unit, when proper alternating operating potentials are applied to selected conductors thereof, are collected upon the surfaces of the dielectric at specifically defined locations and constitute an electrical field opposing the electrical field which created them so as to terminate the discharge for the remainder of the half cycle and aid in the initiation of a discharge on a succeeding opposite half cycle of applied voltage, such charges as are stored constituting an electrical memory.

Thus, the dielectric layers prevent the passage of substantial conductive current from the conductor members to the gaseous medium and also serve as collecting surfaces for ionized gaseous medium charges (electrons, ions) during the alternate half cycles of the A.C. operating potentials, such charges collecting first on one elemental or discrete dielectric surface area and then on an opposing elemental or discrete dielectric surface area on alternate half cycles to constitute an electrical memory.

An example of a panel structure containing non-physically isolated or open discharge units is disclosed in U.S. Pat. No. 3,499,167 issued to Theodore C. Baker, et al.

An example of a panel containing physically isolated units is disclosed in the article by D. L. Bitzer and H. G. Slottow entitled "The Plasma Display Panel — A Digitally Addressable Display With Inherent Memory," Proceeding of the Fall Joint Computer Conference, IEEE, San Francisco, Calif., Nov. 1966, pages 541–547. Also reference is made to U.S. Pat. No. 3,559,190.

In the operation of the panel, a continuous volume of ionizable gas is confined between a pair of dielectric surfaces backed by conductor arrays typically forming matrix elements. The cross conductor arrays may be

orthogonally related (but any other configuration of conductor arrays may be used) to define a plurality of opposed pairs of charge storage areas on the surfaces of the dielectric bounding or confining the gas. Thus, for a conductor matrix having H rows and C columns the number of elemental discharge volumes will be the product $H \times C$ and the number of elemental or discrete areas will be twice the number of elemental discharge volumes.

In addition, the panel may comprise a so-called monolithic structure in which the conductor arrays are created on a single substrate and wherein two or more arrays are separated from each other and from the gaseous medium by at least one insulating member. In such a device the gas discharge takes place not between two opposing members, but between two contiguous or adjacent members on the same substrate.

It is also feasible to have a gas discharge device wherein some of the conductive or electrode members are in direct contact with the gaseous medium and the remaining electrode members are appropriately insulated from such gas.

In addition to the matrix configuration, the conductor arrays may be shaped otherwise. Accordingly, while the preferred conductor arrangement is of the crossed grid type as described herein, it is likewise apparent that where a maximal variety of two dimensional display patterns is not necessary, as where specific standardized visual shapes (e.g., numerals, letters, words, etc.) are to be formed and image resolution is not critical, the conductors may be shaped accordingly.

The gas is one which produces visible light or invisible radiation which stimulates a phosphor (if visual display is an objective) and a copious supply of charges (ions and electrons) during discharge. In an open cell Baker, et al. type panel, the gas pressure and the electric field are sufficient to laterally confine charges generated on discharge within elemental or discrete dielectric areas within the perimeter of such areas, especially in a panel containing non-isolated units.

As described in the Baker, et al. patent, the space between the dielectric surfaces occupied by the gas is such as to permit photons generated on discharge in a selected discrete or elemental volume of gas to pass freely through the gas space and strike surface areas of dielectric remote from the selected discrete volumes, such remote, photon struck dielectric surface areas thereby emitting electrons so as to condition other and more remote elemental volumes for discharges at a uniform applied potential.

With respect to the memory function of a given discharge panel, the allowable distance or spacing between the dielectric surfaces depends, inter alia, on the frequency of the alternating current supply, the distance typically being greater for lower frequencies.

While the prior art does disclose gaseous discharge devices having externally positioned electrodes for initiating a gaseous discharge, sometimes called "electrodeless discharge," such prior art devices utilized frequencies and spacings or discharge volumes and operating pressures such that although discharges are initiated in the gaseous medium, such discharges are ineffective or not utilized for charge generation and storage at higher frequencies; although charge storage may be realized at lower frequencies, such charge storage has not been utilized in a display/memory device in the manner of the Bitzer-Slottow or Baker, et al. invention.

The term "memory margin" is defined herein as

$$M.M. = \frac{V_f - V_E}{V_f/2}$$

where V_f is the half amplitude of the smallest sustaining voltage signal which results in a discharge every half cycle, but at which the cell is not bi-stable and V_E is the half amplitude of the minimum applied voltage sufficient to sustain discharges once initiated.

It will be understood that the basic electrical phenomenon utilized in this invention is the generation of charges (ions and electrons) alternately storable at pairs of opposed or facing discrete points or areas on a pair of dielectric surfaces backed by conductors connected to a source of operating potential. Such stored charges result in an electrical field opposing the field produced by the applied potential that created them and hence operate to terminate ionization in the elemental gas volume between opposed or facing discrete points or areas of dielectric surface.

The term "sustain a discharge" means producing a sequence of momentary discharges, at least one discharge for each half cycle of applied alternating sustaining voltage, once the elemental gas volume has been fired, to maintain alternate storing of charges at pairs of opposed discrete areas on the dielectric surfaces.

In addition to gas discharge display/memory devices, as generally and specifically described hereinbefore, this invention also relates to gas discharge devices wherein a portion of the electrodes, but not all, are in direct contact with an ionizable gas medium. Direct contact devices are well known in the prior art. Reference is made to *Cold Cathode Glow Discharge Tubes*, a text by G. F. Weston, London, J. W. Arrowsmith Ltd., 1968.

In accordance with the practice of this invention, it has been surprisingly discovered that the memory margin of a gas discharge display/memory device may be increased by incorporating an effective amount of helium into the ionizable gaseous medium of the device.

More particularly, an effective amount of helium is incorporated into the ionizable gaseous medium of a gas discharge display/memory device so as to decrease the minimum applied voltage sufficient to sustain a gas discharge once initiated and increase the memory margin of the device.

The helium is typically incorporated in an amount of at least about 0.01 percent atoms of helium based on the total amount of gaseous medium after the addition of the helium, usually about 0.01 to about 50 percent atoms. However, it is contemplated that higher concentrations may be suitable.

The helium may be incorporated by any suitable means in any suitable gaseous medium.

In prior art, a wide variety of gases and gas mixtures have been utilized as the gaseous medium in a gas discharge device. Typical of such gases include CO; CO_2; halogens; nitrogen; NH_3; oxygen; water vapor; hydrogen; hydrocarbons; P_2O_5; boron fluoride; acid fumes; $TiCl_4$; Group VIII gases; air; H_2O_2; vapors of sodium, mercury, thallium, cadmium, rubidium, and cesium; carbon disulfide; laughing gas; H_2S; deoxygenated air; phosphorus vapors; C_2H_2; CH_4; naphthalene vapor; enthracene; freon; ethyl alcohol; methylene bromide; heavy hydrogen; electron attaching gases; electron free gases; sulfur hexafluoride; tritium; radioactive gases; and the rare or inert gases.

In one embodiment hereof, the helium is incorporated in a mixture of rare gases, e.g., at least two gases selected from neon, argon, xenon, and krypton.

In one preferred embodiment, the helium is incorporated in an initial mixture comprising about 90 percent to about 99.99 percent atoms of neon and about 10 percent to about 0.01 percent atoms of at least one member selected from argon, xenon, or krypton.

In one highly preferred embodiment, the helium is incorporated in an initial mixture consisting essentially of about 99.5 percent to about 99.99 percent atoms of neon and about 0.5 percent to about 0.01 percent atoms of at least one member selected from argon, xenon, or krypton. Beneficial amounts of other additives, such as mercury, may also be present.

Typically the gaseous medium, after the addition of the helium, has a pressure within the gas discharge device of about 50 to about 1500 Torr, usually about 200 to about 800 Torr.

Reference is made to the accompanying drawings and the figures thereon.

FIG. **1** is a partially cut-away plan view of a gaseous discharge display/memory panel as connected to a diagrammatically illustrated source of operating potentials,

FIG. **2** is a cross-sectional view (enlarged, but not to proportional scale since the thickness of the gas volume, dielectric members and conductor arrays have been enlarged for purposes of illustration) taken on lines **2** — **2** of FIG. **1**,

FIG. **3** is an explanatory partial cross-sectional view similar to FIG. **2** (enlarged, but not to proportional scale),

FIG. **4** is an isometric view of a gaseous discharge display/memory panel.

The invention utilizes a pair of dielectric films **10** and **11** separated by a thin layer or volume of a gaseous discharge medium **12**, the medium **12** producing a copious supply of charge (ions and electrons) which are alternately collectable on the surfaces of the dielectric members at opposed or facing elemental or discrete areas X and Y defined by the conductor matrix on non-gas-contacting sides of the dielectric members, each dielectric member presenting large open surface areas and a plurality of pairs of elemental X and Y areas. While the electrically operative structural members such as the dielectric members **10** and **11** and conductor matrixes **13** and **14** are all relatively thin (being exaggerated in thickness in the drawings) they are formed on and supported by rigid nonconductive support members **16** and **17** respectively.

Preferably, one or both of nonconductive support members **16** and **17** pass light produced by discharge in the elemental gas volumes. Preferably, they are transparent glass members and these members essentially define the overall thickness and strength of the panel. For example, the thickness of gas layer **12** as determined by spacer **15** is usually under 10 mils and preferably about 4 to 6 mils, dielectric layers **10** and **11** (over the conductors at the elemental or discrete X and Y areas) are usually between 1 and 2 mils thick, and conductors **13** and **14** about 8,000 angstrons thick. However, support members **16** and **17** are much thicker (particularly in larger panels) so as to provide as much ruggedness as may be desired to compensate

for stresses in the panel. Support members **16** and **17** also serve as heat sinks for heat generated by discharges and thus minimize the effect of temperature on operation of the device. If it is desired that only the memory function be utilized, then none of the members need be transparent to light.

Except for being nonconductive or good insulators the electrical properties of support members **16** and **17** are not critical. The main function of support members **16** and **17** is to provide mechanical support and strength for the entire panel, particularly with respect to pressure differential acting on the panel and thermal shock. As noted earlier, they should have thermal expansion characteristics substantially matching the thermal expansion characteristics of dielectric layers **10** and **11.** Ordinary ¼ inch commercial grade soda lime plate glasses have been used for this purpose. Other glasses such as low expansion glasses or transparent devitrified glasses can be used provided they can withstand processing and have expansion characteristics substantially matching expansion characteristics of the dielectric coatings **10** and **11.** For given pressure differentials and thickness of plates, the stress and deflection of plates may be determined by following standard stress and strain formulas (see R. J. Roark, *Formulas for Stress and Strain*, Mc-Graw-Hill, 1954).

Spacer **15** may be made of the same glass material as dielectric films **10** and **11** and may be an integral rib formed on one of the dielectric members and fused to the other members to form a bakeable hermetic seal enclosing and confining the ionizable gas volume **12.** However, a separate final hermetic seal may be effected by a high strength devitrified glass sealant 15S. Tubulation **18** is provided for exhausting the space between dielectric members **10** and **11** and filling that space with the volume of ionizable gas. For large panels small beadlike solder glass spacers such as shown at 15B may be located between conductor intersections and fused to dielectric members **10** and **11** to aid in withstanding stress on the panel and maintain uniformity of thickness of gas volume **12.**

Conductor arrays **13** and **14** may be formed on support members **16** and **17** by a number of well-known processes, such as photoetching, vacuum deposition, stencil screening, etc. In the panel shown in FIG. **4,** the center-to-center spacing of conductors in the respective arrays is about **17** mils. Transparent or semitransparent conductive material such as tin oxide, gold or aluminum can be used to form the conductor arrays and should have a resistance less than 3000 ohms per line. Narrow opaque electrodes may alternately be used so that discharge light passes around the edges of the electrodes to the viewer. It is important to select a conductor material that is not attacked during processing by the dielectric material.

It will be appreciated that conductor arrays **13** and **14** may be wires or filaments of copper, gold, silver or aluminum or any other conductive metal or material. For example 1 mil wire filaments are commercially available and may be used in the invention. However, formed in situ conductor arrays are preferred since they may be more easily and uniformly placed on and adhered to the support plates **16** and **17.**

Dielectric layer members **10** and **11** are formed of an inorganic material and are preferably formed in situ as an adherent film or coating which is not chemically or physically effected during bake-out of the panel. One such material is a solder glass such as Kimble SG-68 manufactured by and commercially available from the assignee of the present invention.

This glass has thermal expansion characteristics substantially matching the thermal expansion characteristics of certain soda-lime glasses, and can be used as the dielectric layer when the support members **16** and **17** are soda-lime glass plates. Dielectric layers **10** and **11** must be smooth and have a dielectric strength of about 1000 v. and be electrically homogeneous on a microscope scale (e.g., no cracks, bubbles, crystals, dirt, surface films, etc.). In addition, the surfaces of dielectric layers **10** and **11** should be good photoemitters of electrons in a baked out condition. Alternatively, dielectric layers **10** and **11** may be overcoated with materials designed to produce goood electron emission, as in U.S. Pat. No. 3,634,719, issued to Roger E. Ernsthausen. Of course, for an optical display at least one of dielectric layers **10** and **11** should pass light generated on discharge and be transparent or translucent and, preferably, both layers are optically transparent.

The preferred spacing between surfaces of the dielectric films is about 4 to 6 mils with conductor arrays **13** and **14** having center-to-center spacing of about 17 mils.

The ends of conductors **14-1 . . . 14-4** and support member **17** extend beyond the enclosed gas volume **12** and are exposed for the purpose of making electrical connection to interface and addressing circuitry **19.** Likewise, the ends of conductors **13-1 . . . 13-4** on support member **16** extend beyond the enclosed gas volume **12** and are exposed for the purpose of making electrical connection to interface and addressing circuitry **19.**

As in known display systems, the interface and addressing circuitry or system **19** may be relatively inexpensive line scan systems or the somewhat more expensive high speed random access systems. In either case, it is to be noted that a lower amplitude of operating potentials helps to reduce problems associated with the interface circuitry between the addressing system and the display/memory panel, per se. Thus, by providing a panel having greater uniformity in the discharge characteristics throughout the panel, tolerances and operating characteristics of the panel with which the interfacing circuitry cooperate, are made less rigid.

We claim:

1. In a process for operating a gas discharge display/memory device containing an ionizable gaseous medium, the device having at least two opposed arrays of electrodes with at least one array being insulated from the gaseous medium, the improvement which comprises decreasing the minimum applied voltage sufficient to sustain a gas discharge once initiated and increasing the memory margin of the device by incorporating into the ionizable gaseous medium at least about 0.01% atoms of helium based on the total amount of gaseous medium after the addition of the helium.

2. The invention of claim **1** within at least one electrode array comprises a matrix of electrodes.

3. The invention of claim **1** wherein the ionizable gas medium before the incorporation of the helium is a mixture of at least two rare gases selected from the group consisting of neon, argon, xenon, and krypton.

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