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Dalton et al.

[11] **3,735,182**

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[54] **GRAY SCALE GAS PANEL**

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[73] Assignee: **International Business Machines Corporation,** Armonk, N.Y.

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[52] **U.S. Cl.**.....**313/188,** 313/217

[51] **Int. Cl.**.....**H01j 17/04**

[58] **Field of Search**.....313/188, 201, 210, 313/217, 220

[56] **References Cited**

OTHER PUBLICATIONS

"Electronics," May 10, 1971, pp. 35–36.

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[57] **ABSTRACT**

An improved gaseous discharge display arrangement is disclosed for providing a gray scale display capability with nominal modification of existing gaseous display apparatus. Conductor patterns of different resolution are utilized in the conductor drive configurations which are positioned on opposite sides of the panel in a conventional gaseous panel construction. By controlling the selective energization of the higher resolution lines associated with one of the driving configurations, a variation of intensities is provided depending on the ratio of the resolutions and the number of higher resolution conductors selected for each of the lower resolution conductors.

4 Claims, 2 Drawing Figures

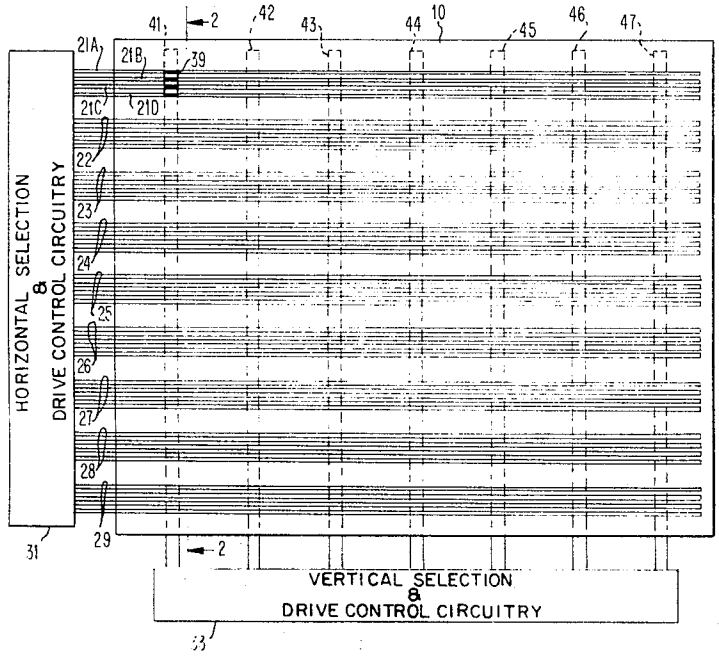
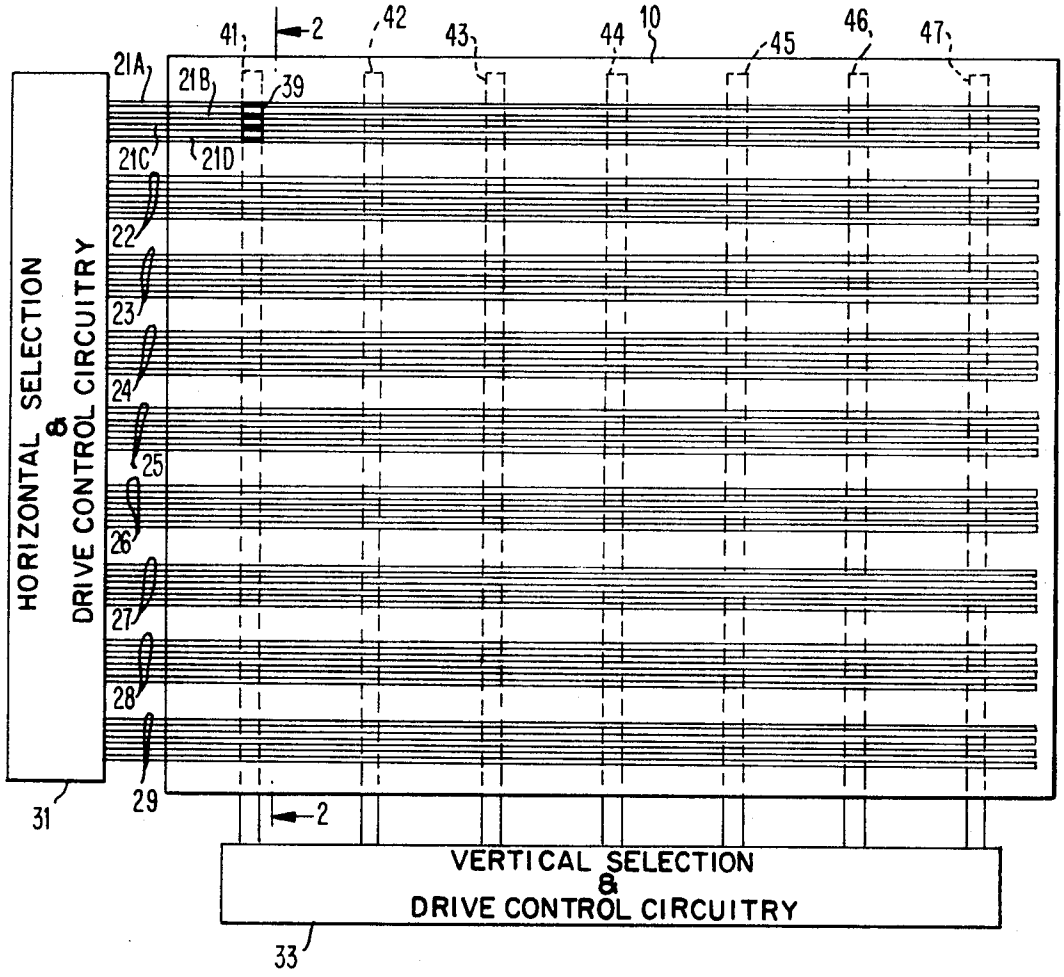


FIG. 1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HORIZONTAL SELECTION & DRIVE CONTROL CIRCUITRY
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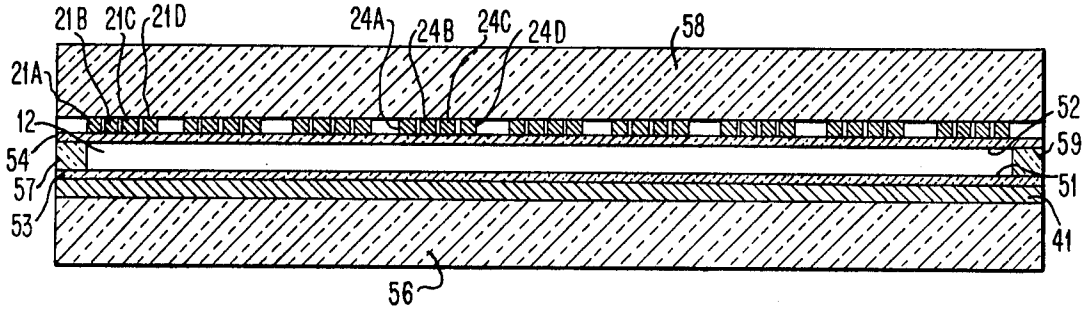
VERTICAL SELECTION & DRIVE CONTROL CIRCUITRY
33

FIG. 2


21B
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GRAY SCALE GAS PANEL

CROSS-REFERENCE TO RELATED APPLICATIONS

Application Ser. No. 209,235, filed on Dec. 17, 1971 for "Improved Electrode Configuration for a Gaseous Display Panel" by Peter H. Haberland et al.

Application Ser. No. 214,348, filed on Dec. 30, 1971 for "Gas Panel Fabrication" by Peter H. Haberland et al.

Application Ser. No. 268,219, filed on June 23, 1972 for "Method and Apparatus for Gas Display Panel" by Tony N. Criscimagna et al., a continuation of application Ser. No. 885,086, filed Dec. 15, 1969.

BACKGROUND OF THE INVENTION

This invention relates to display devices and more particularly to display devices of the gaseous discharge type upon which images are generated by the selective energization of individual display cells or sites.

Conventional display devices such as the cathode ray tube, for example, include various disadvantages related to size, cost, ruggedness and power requirements such as various types of replacement devices have been proposed. Recent display developments include the gaseous discharge panel and/or storage device, one example of which is disclosed in U. S. Pat. No. 3,599,190, "Gaseous Display and Memory Apparatus," patented Jan. 26, 1971 by Donald L. Bitzer et al. and assigned to the University of Illinois. This device may comprise a three-layer glass cell construction including a center layer of physically isolated cells arranged in rows or columns, each individual cell being filled with an ionizable gas, or alternatively, may comprise an open panel configuration of electrically isolated but not physically isolated cells. Individual cells or sites are selected by energizing associated pairs of orthogonal drive lines disposed on opposite sides of the panel which, when appropriately and selectively energized produce a breakdown discharge of the gas resulting in light emitting plasma. Such plasma displays are digitally addressable and have inherent memory, the latter eliminating the need for external memory storage and associated circuitry to generate the display image. However, since the plasma display device is operated in binary characteristic, only a single light image is provided for each individual cell such that they are not suitable for exhibiting black and white pictures or the like with the necessary gray scale. Gray scale display is also a required feature in graphic applications, scanning applications, facsimile reproduction, etc.

Time division multiplexing arrangements have been proposed for providing such displays with the required gray scale by varying the duty cycle, i.e., by energizing individual display cell elements for varying durations during each scanning frame to thus vary the light intensity. However, such known arrangements have so far proven to be too costly and complex as to render them a practical solution. Another proposed arrangement has been to provide a spot cell cluster, each cell of which cluster can be selectively addressed, resulting in a display having a stepped intensity. The amount of light emitted from this cluster can be controlled by selectively addressing none, one or any combination of cells in the cluster, thus providing a gray scale and a variable level brightness. This approach has been unsatisfactory due to manufacturing problems and problems related to cell addressing and image resolution. Still a third suggested approach has been to use a stack of gaseous discharge panels, each separated by line attenuating layers from adjacent panels, each layer attenuating the display light reaching the surface by a factor of two such that binary weighted gray scale is provided. However, this approach represents both a high cost solution since it essentially requires a separate panel for each gray scale level, rendering it both costly and difficult to implement from a manufacturing standpoint.

SUMMARY OF THE INVENTION

By utilizing conductor arrays having conductor patterns of high resolution on one axis of the panel as compared to the resolution on the orthogonal conductor array, a gray scale display capability is provided by selective energization of a number of higher resolution drive lines with each lower resolution line. In a conventional gaseous discharge, the resulting light emitted by the plasma under appropriate gas mixture and pressure conditions will be emitted around the fringes of the conductors on the viewing side of the panel, assuming opaque conductors are utilized. Assuming a gray scale resolution of four levels by way of example, four individual conductors are available for the selective energization for each associated orthogonal conductor such that one, two, three or four of these conductors may be selectively energized to vary the light intensity. No modification of the gas panel fabrication is required other than the artwork, which is an obvious and well known process to those skilled in the art. The gas discharge device arrangement according to this invention is reliable, is significantly less expensive than any of the known prior art arrangements described above and provides better resolution than arrangements using cell clusters.

Accordingly, a primary object of the present invention is to provide a new and improved gaseous display arrangement having a multilevel gray scale display capability.

Another object of the present invention is to provide an improved multilevel gray scale gaseous discharge display panel utilizing conductor patterns of different resolution on one axis of the panel as compared to the resolution on the associated orthogonal axis of the panel.

Still another object of the present invention is to provide an improved plasma discharge device having gray scale capability wherein a conductor array of high resolution is provided on the display side of the gaseous discharge device as compared to the conductor array on the non-viewing side of the panel whereby the resultant light output is directly proportional to the selective energization of the high resolution conductors.

The foregoing and other objects, features and advantages of the present invention will be apparent from the following description of a preferred embodiment of the invention as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic illustration of a gaseous discharge and display panel illustrating details of the driving conductor configuration used to provide a gray scale capability.

FIG. 2 is an enlarged cross-sectional view taken along the lines 2—2 of FIG. 1 to clarify details of the invention illustrated in FIG. 1.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring now to the drawings and more specifically to FIG. **1** thereof, there is illustrated a gaseous discharge display panel **10** having transverse conductor arrays disposed on opposite sides of the gaseous chamber **12**, but insulated from direct contact with the gas by a dielectric member as described more fully hereinafter. The horizontal and vertical conductor arrays are addressed by horizontal and vertical selection and drive control circuitry shown as blocks **21, 23,** respectively. In the preferred embodiment herein described, the horizontal array is on the viewing side of the panel, while the vertical array is disposed on the opposite or rear wall of the panel.

Before continuing with the description, a brief description of plasma display panel theory will facilitate an understanding of the subject invention. Gaseous discharge panels or plasma display panels operate under the "wall charge" theory wherein writing is accomplished by applying a discharge potential across the conductors associated with selected cells to provide the initial discharge and resulting light output and sustained by a lower amplitude signal. In a gaseous discharge display panel, a sealed gaseous envelope composed of dielectric material and containing an ionizable illuminable gas, such as a mixture of 99.9 percent nitrogen, 0.1 percent neon, has substantially orthogonal conductors disposed on opposite sides thereof. An alternating potential connected to selected pairs of conductors is capacitively coupled to the gas through the dielectric material, producing an alternating voltage across the gas in the region defined by the intersection of the selective conductors. When this potential exceeds the breakdown voltage of the gas, the gas becomes conductive through the voltage induced production of electrons and gas ions and selected gas cells are said to have broken down. In this conductive state, electrons in the gas migrate to the wall which is temporarily negative. The charge particles collected on the dielectric walls, or wall charge, produce a potential between the dielectric surface and the conductors which oppose the externally applied potential and thus reduces the voltage across the cell. As current continues to flow through the gas, the opposing wall charge increases until the gas voltage drops below that necessary to maintain the gas in a conductive state, i.e., the sustain level, and the current discharge is extinguished. On the following phase-reversed half cycle of the sustain signal, the voltage produced by the wall charge initially adds to the externally produced sustain signal so that the gas voltage is augmented and the cell reignited. Thus, due to wall charge effect, the breakdown voltage V_b of the gas is obtained at a lower value of external potential, a current discharge of opposite sense to the initial discharge is initiated, and a wall charge of opposite polarity to the initial wall charge is established of sufficient magnitude to cause the discharge to be extinguished. Thus, after initial breakdown, the wall charge condition is maintained in selected cells by application of a lower potential designated the sustain signal which, combined with the wall charge, causes the selected cells to be reignited and extinguished continuously at the frequency of the sustain signal to maintain a continuous display. Light output for display purposes is produced during the passage of the discharge current. For additional details regarding the operation of such panels in write, sustain and erase modes, reference is made to the aforenoted Criscimagna et al. application.

In the preferred embodiment of the instant invention herein described by way of example, a ratio of four horizontal conductors to each vertical conductor is employed to provide four levels of gray scale, although it is obvious that the resolution ratio selected is a matter of design choice and not a limitation. Each of horizontal conductors **21A, 21B, 21C** and **21D** in the upper row of the display on panel **10** is associated with the seven vertical conductors **41** through **47.** The specific character format selected to illustrate the present invention is an enlarged 7×9 character matrix using nine sets of four horizontal conductors and seven vertical conductors, wherein the respective intersections define the gaseous cells or sites. When opaque metallic conductors such as copper, gold, chrome, silver, aluminum or various combinations thereof suitable for fabrication on glass are utilized on the viewing side of the panel, the light output is restricted to the fringes around the intersections but may be adjusted within relatively wide tolerances by appropriate selection of gas, pressure, size of conductors, etc. In the instant invention, the light output from each of the intersections of conductors **21A, 21B, 21C** or **21D** with any of the associated vertical conductors **41–47** is assumed uniform such that the total light output at any intersection will be directly proportional to the number of horizontal conductors selected. For example, if conductors **21A** and **21B** are simultaneously selected with conductor **41,** with respective light output at intersection **39** will be twice that of either of the inputs or one-half the light output if all four conductors **21A, 21B, 21C** and **21D** were simultaneously selected with conductor **41.** The horizontal and vertical selection circuitry have been shown in block form in the interest of clarity, since binary decoding and selection circuitry are well known in the art and any details relative thereto would be superfluous and unnecessary to an understanding of the present invention. The drive circuitry including circuitry for write, sustain and erase is shown in detail in the Criscimagna et al. application heretofore designated.

Referring now to FIG. **2,** an enlarged cross-sectional view taken along the lines **2—2** of FIG. **1** is illustrated to clarify details of the display panel assembly utilizing the instant invention. The inner surfaces **51** and **52** of dielectric members **53** and **54** are heat sealed by spacer members **57** and **59** to form the gas chamber **12.** The glass substrates **56** and **58** are utilized as support members for the thin gas envelope formed by dielectric members **53** and **54,** respectively. In the preferred embodiment herein described, substrates **56** and **58** are composed of ¼-inch commercial grade soda-line-silica glass on which transverse conductor arrays **21–29** and **41–47,** respectively, are formed on the inner surfaces thereof. Conductors may be formed or deposited on glass substrates **56, 58** by any conventional process such as vacuum deposition, stencil screening, etc. Alternatively, if desired, conductor arrays could be composed of wires or filaments of copper, gold, silver, aluminum or any other conductive metal or materials or combinations thereof. In the preferred panel assembly constructed in accordance with the teaching of the instant invention, the center-to-center conductor spacing in the horizontal array utilized 3 mil lines on 10 mil centers, while that on the associated vertical array utilized 10 mil lines on 40 mil centers. Details of the size

and composition of the various materials used to form the gaseous discharge device as well as the process of fabricating such device are fully described in the aforenoted copending application Ser. No. 214,348 to Haberland et al. The panel configuration illustrated in FIG. **1** includes, an previously indicated, only the viewing area of a single character on the panel in the interest of clarity. In practice, both the horizontal and vertical plates **56, 58** of the panel would be extended beyond the viewing area and the drive conductors in turn would be extended to or near the respective horizontal and vertical edges of the panel for interconnection to their associated driving sources. In the above described or referenced physical parameters of a gas panel, a sustain frequency of 400KC was employed, and a panel cell, not shown, used to facilitate initial ionization condition.

Referring back to FIG. **1,** there are four cells associated with each intersection such that one of four light levels is developed depending on the number of horizontal conductors selected in a given operation. When a write signal of appropriate amplitude and polarity is applied from the respective row addressing network **11** and the column addressing network, a defined gas discharge takes places at the respective intersections of the selected conductors, resulting in light output at the selected intersections. For example, if signals of half-write amplitude are simultaneously applied to any of conductors **21–29A–D** and the associated vertical conductors **41–47,** each of the cells at the associated intersection will be fired producing a light output. Thus, in the preferred embodiment herein described, a total of 252 cells is used to define 63 intersections, each intersection capable of producing one of four light outputs plus a zero light output comprising the background. It should be noted that the normal light output from a gas panel is substantially higher than that of the conventional display devices such as a cathode ray tube and is relatively widely adjustable as previously indicated by varying certain parameters thereof. While the preferred embodiment has been described in terms of a four or five gray scale output, the principle of the invention can obviously be extended to provide any desired degree of gray scaling desired, the selected gray scale being merely a matter of design choice. Likewise, while the horizontal conductors are shown on the viewing side in the preferred embodiment, the conductor arrangement may be modified and either the horizontal or vertical pattern may be the higher resolution configuration.

While the invention has been particularly shown and described with reference to a preferred embodiment thereof, it will be understood by those skilled in the art that certain other changes in form and details may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. A gaseous discharge display device for providing a variable intensity display comprising in combination

a pair of support plates sealed to form a chamber filled with an ionizable gas,

said plates having dielectrically coated conductor arrays formed thereon, each of said conductor arrays comprising a plurality of parallel conductors, said conductor arrays being substantially orthogonally related to define discrete gas discharge sites at respective intersections thereof,

said gas discharge sites being adapted when appropriately energized by control signals applied thereto to provide discrete localized discharges, the light emitted from each such discharge site forming one element of a display,

said conductor arrays being characterized by higher and lower line resolutions, the intersections of a plurality of said higher resolution lines with each of the lower resolution lines defining a gas cell area, the intensity of the light output from each said gas cell area being varied in accordance with the number of higher resolution lines selected with respect to each said lower resolution lines.

2. Apparatus of the type claimed in claim **1** wherein said higher resolution conductor array is on the viewing side of said display device.

3. Apparatus of the type claimed in claim **2** wherein said variable intensity display comprises a gaseous discharge display device having gray scale capability.

4. In a gaseous discharge pulsing display panel apparatus including a gaseous medium in the chamber of said display panel,

dielectric coated conductor arrays forming the inner wall of said chamber whereby said conductors are insulated from direct contact with said gas,

said conductor arrays being positioned in substantially orthogonal relationship, the intersections of pairs of said conductors when appropriately energized defining display points,

said conductor arrays being comprised of different line resolutions wherein each lower resolution line has a plurality of higher resolution lines associated therewith to selectively control the resultant display intensity at cell areas in accordance with the number of higher resolution lines energized, each said cell area comprising the intersection of a low resolution line with a plurality of higher resolution lines.

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