

[54] **VISUAL DISPLAY AND MEMORY
SYSTEM**

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340/343**

[51] Int. Cl. **G08b 5/36**

[58] Field of Search **340/324 R, 334, 343, 344;
315/169 R; 313/108 R**

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Primary Examiner—David L. Trafton

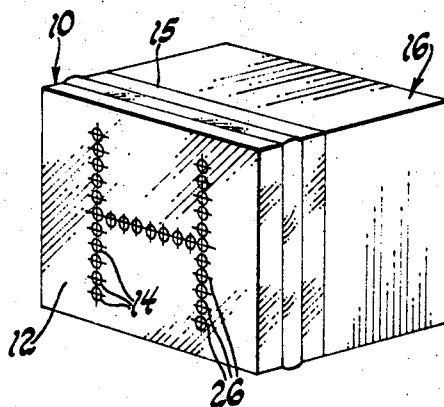
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[57]

ABSTRACT

A gas discharge display/memory device or panel comprises a pair of conductor arrays arranged on opposite sides of a gas chamber with the conductors of one array having a transverse orientation relative to the other array to provide a plurality of cross-points between the conductors in the opposite arrays across which discharges occur. Electroluminescence means is arranged relative to the chamber in one of the conductor arrays so that an electric field imposed by a potential generated by a gaseous discharge at a selected cross-point causes current flow through the electroluminescence means which thereupon emits light at the selected cross-point. Any desired color of light can be obtained by using different electroluminescent materials.

29 Claims, 7 Drawing Figures



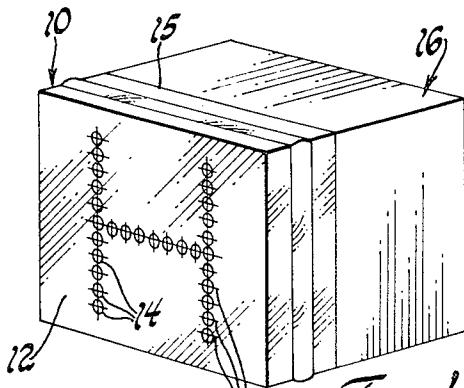


Fig. 1

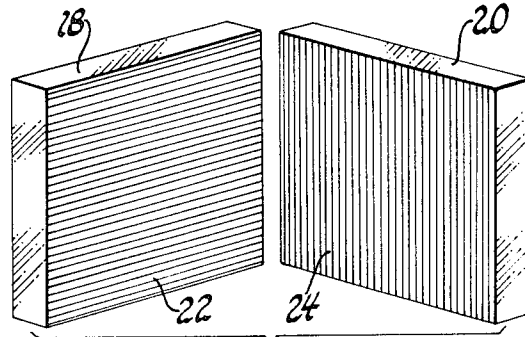


Fig. 2

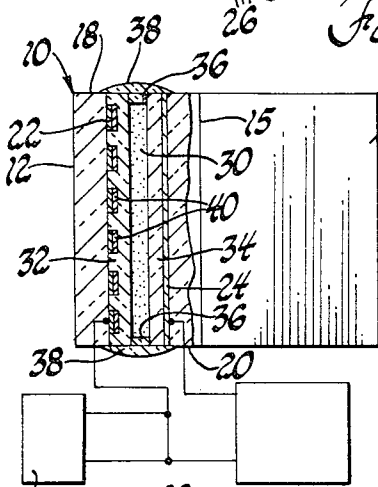


Fig. 3

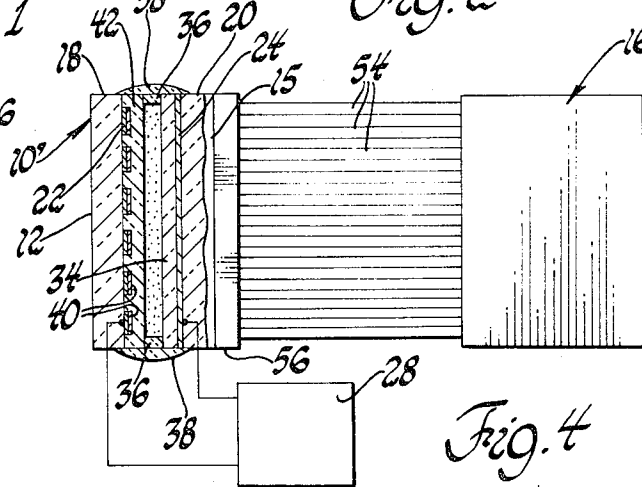


Fig. 4

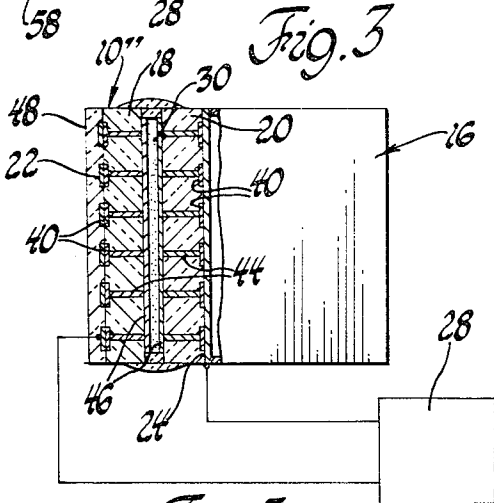


Fig. 5

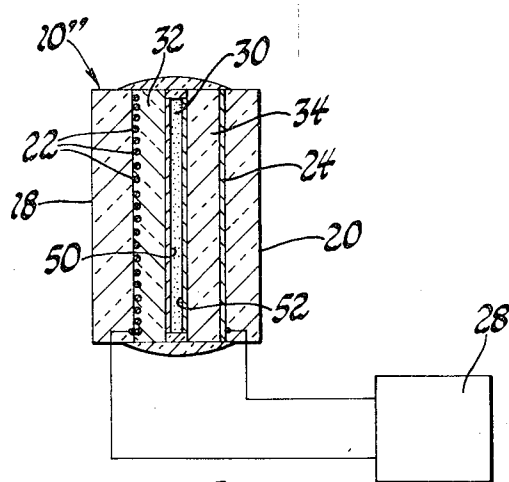


Fig. 6

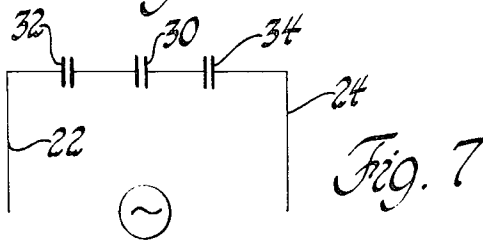


Fig. 7

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VISUAL DISPLAY AND MEMORY SYSTEM

This invention relates to improvements in visual display and memory systems of the type incorporating a gas discharge panel.

The conventional gas discharge panel has a sealed gas chamber between a pair of dielectric members. Each of these dielectric members is backed by a conductor array and then a glass viewing plate. The conductor arrays have transverse relative orientation and when an appropriate driving potential is applied across selected conductors in each array, a glow discharge occurs within the chamber at the cross-points of these selected conductors. Thereafter, this glow discharge can be sustained with a reduced operating potential, which accounts for the panels memory ability.

These panels are useful in providing visual displays of various data, such as numerals, letters, etc. Because this data must be easily identified and observed, it is necessary that the gas discharges present adequate light emission for this visual observation. It is this viewing requirement, which necessitates compromises in the selection of operating parameters and a gaseous mixture, otherwise they could be chosen so as to provide a panel with optimum firing and memory capabilities without concern for light emission.

With the foregoing in mind, a visual display and memory system is contemplated which incorporates a gas discharge panel capable of providing a visual readout without reliance upon the light emission from the discharges, thereby permitting the operating parameters and the gaseous mixture to be selected for optimum firing and memory operation of the panel.

Also contemplated is a new and different visual display and memory system that provides improved light emission for visual viewing purposes.

Another objective is the provision of a visual display and memory system that affords multiple color readouts and is easily adaptable to different applications of the system.

Other objectives include the provision of a gas discharge panel that has a light emission source separate from the glow discharge; that can be operated in high ambient light environments; that can display images in a multiplicity of colors; that affords improved lighting contrasts; that enables greater versatility in construction and modes of readout; and that can utilize luminescent materials in various ways to provide improved panel operation.

The foregoing and other objects and advantages of the invention will become apparent from the following description and the accompanying drawings in which:

FIG. 1 is a perspective view of a gas discharge panel type visual display and memory system incorporating the principles of the invention;

FIG. 2 is an exploded view of a gas discharge panel with portions separated to show the conductor arrays;

FIG. 3 is a schematic view of the FIG. 1 system showing in section a gas discharge panel which includes a luminescent material;

FIG. 4, 5 and 6 are sectional views of alternative gas discharge panel constructions; and

FIG. 7 is a diagram of an equivalent circuit for the FIG. 3 gas discharge panel.

Referring now to the drawings in detail and first to the visual display and memory system in FIG. 1, the numeral 10 denotes a gas discharge panel with a viewing

face at 12. When the panel 10 is operated in a way to be explained, information is visually displayed on the viewing face 12 in a pattern formed by a series of glowing spots 14. In FIG. 1, for demonstration purposes only, this pattern is depicted as the letter H. Many other types of visual information can be portrayed, e.g., numerals, words, pictures, etc. This same visual information can be transferred from an opposite face 15 to an external readout device 16 and/or transferred to internal readout circuitry as will be further described. The readout device 16 functions to convert the visual display to some form of information and can be a camera, or include an array of light detectors such as photodiodes or photoconductors which in turn could control a printer or a computer memory (not shown).

The gas discharge panel 10 may be of any well known construction, e.g., that described in U.S. Pat. No. 3,499,167 to Baker et al. issued Mar. 3, 1970. The following panel description is considered adequate for an understanding of the invention. If additional information is wanted, reference can be made to this application.

The panel 10 as viewed in FIG. 3 has two spaced apart support members or plates 18 and 20, these support plates 18 and 20 are formed of an electrically inert material, such as a polished commercially available soda lime plate glass and are both usually optically transparent so as to pass light as well as being capable strengthwise of withstanding the pressures and the temperature changes to which the panel 10 is subjected during operation. This optical transparency requirement, as will become apparent will be determined by the application of the panel.

As viewed in FIG. 2, the support plates 18 and 20 have on their confronting faces, conductor arrays 22 and 24 respectively. These conductor arrays 22 and 24 are shown at right angles to each other but they may have any other suitable transverse relative orientation so as to provide at their intersections, a series of cross-points 26. Also, the conductor arrays 22 and 24 may, for certain applications, be in the form of a single conductor; e.g., a conductive coating covering all of one or both of the support plate faces. When the arrays 22 and 24 are supplied with an adequate driving or sustaining potential and selectively supplied with an appropriate addressing or write-in potential by an appropriate driving and addressing circuit 28, the gas discharge 14 will occur at the selected cross-points 26. The circuit 28 may be of the general type disclosed in application U.S. Ser. No. 699,170 to Johnson et al., filed Jan. 19, 1968, now U.S. Pat. No. 3,618,071.

The conductors in the arrays 22 and 24 may be formed on the support plates 18 and 20 by any usual process, such as photoetching, vacuum deposition, stencil screening, etc., or they may be in the form of wires or filaments. These arrays 22 and 24 should be made of a good current conducting material, for instance, copper, gold, silver or aluminum. If optical transparency is desired, transparent or semitransparent conductive materials, e.g., tin-oxide, gold or aluminum may be employed. The individual conductors may be from 0.1 to 0.5 mils thick and from 2 to 6 mils wide with center to center spacing of the conductors in the respective arrays 22 and 24 of about 20 to 30 mils. These dimensions are merely for illustrative purposes

and are subject to considerable variation as those versed in the art will appreciate.

To enable the panel 10 to perform its memory function, the conductor arrays 22 and 24 are spaced from a gas discharge chamber 30 by dielectric members 32 and 34. These dielectric members 32 and 34 are in the form of a film or coating and the material also, as determined by how the panel is used, may or may not be optically transparent. The material should, however, be thermally compatible with the material of the support plates 18 and 20. The exposed surfaces of the dielectric members 32 and 34 should be relatively uniform and have good charge trapping capabilities. By way of example only, the dielectric members 32 and 34 can be made of a low melting glass material which can be screened on the support plates 18 and 20 in the form of glass frit which is cured in place to form a uniform dielectric coating. The thickness of the dielectric members 32 and 34 can be something less than 1 to 2 mils. Also, if wires are employed as conductors, they can be clad with the same dielectric material suggested for the dielectric members 32 and 34.

Spacers 36 separate the dielectric members 32 and 34 to establish the gap size for the chamber 30. This gap size may without limitation be about 4 to 9 mils.

The support plates 18 and 20, the dielectric members 32 and 34 and the spacers 36 are all suitably connected with an appropriate sealant 38, a high strength devitrified glass, and arranged so that the gas discharge chamber 30 can be evacuated, baked, and filled with any well known gaseous discharge medium at the proper operating pressure and then sealed. The gaseous mixture should be capable of being discharged upon application of a firing potential to selected conductors in each array 22 and 24 and produce an abundant supply of ions and electrons. Exemplary is a gaseous mixture consisting of neon gas as a major constituent and a small effective amount of at least one minor constituent selected from argon, krypton, or xenon, in an amount to provide a Penning mixture. A 90 percent neon and 10 percent nitrogen mixture is another example.

One way to operate the panel 10, as so far described, being mindful that an electric breakdown of a gas occurs when a sufficient electric field is applied to a gas containing one or more free charge carriers, particularly electrons, is to apply to selected conductors of the arrays 22 and 24 an operating voltage sufficient to provide such a breakdown field in the gas chamber 30. The driving and addressing circuit 28 is therefore rendered operative to supply this voltage, which will include a write-in voltage pulse representing the information to be entered plus a sustaining voltage. Then, if it is assumed that this operating potential is increasing during its positive half-cycle, there will be a correspondingly increasing electric field applied across the chamber 30 at the selected cross-points 26. This electric field will accelerate any free electrons and ions present to initiate collisions with the gas molecules and the dielectric members surfaces. This activity creates additional electrons and ions which are accelerated by the electric field and ultimately there is an electron avalanche resulting in an electric breakdown of the gas or a gas discharge. The visual glow from these discharges results from the electron ion recombination and the

return of the excited gas molecules to their ground state accompanied by the emission of photons of light.

These gas discharges will customarily be used to portray the information that is to be written in by the driving and addressing circuit 28. In FIG. 1, this could be the letter H. Hence, only those cross-points 26 defining the letter H would have the write-in voltage pulse applied to the corresponding conductors in the arrays 22 and 24.

During a given half-cycle of the operating potential, the gas discharge extinguishes but now charges have accumulated on the surfaces of the dielectric members 32 and 34 and are available for facilitating the discharge during the next half-cycle. These accumulated charges and the electric field assistance they provide enable the next discharge to be initiated with a lower applied potential. For instance, if a peak-to-peak voltage of 400 volts is required to start the first discharge, the additional electrons and ion available after the first discharge enables subsequent discharges to be maintained with a 300-350 volts peak-to-peak sustaining voltage. Consequently, if a write-in voltage of 50 volts is added to a 350 volt sustaining voltage, information can be written-in to generate the first discharge. Thereafter, the write-in voltage can be removed and the written-in information will continue to be displayed with the application of 350 volt sustaining voltage, alone. This enables the panel 10 to serve as a memory.

Since panel operating frequencies of about 50 to 500 KC are generally used, the extinguishing of the glow during each half-cycle will not be discernable by the human eye, but will appear as a continuous glow.

As can be appreciated for a visual display to be adequate during all operating conditions, i.e., whether the panel 10 is to be used in high or low ambient light environment, it is necessary that the gaseous mixture and the operating parameters of the panel 10 be selected to always provide adequate light emission. This, as discussed, requires compromises in the selection of operating parameters and gaseous mixtures which could otherwise be selected to provide a panel with optimum firing and memory capabilities. For this reason, the FIG. 3 panel 10 includes a luminescent material, such as an electroluminescent phosphor of some kind, e.g., zinc sulphide with copper added as an activator. The phosphor can be added as a continuous film or as particles in an inorganic binder. In either form the phosphor can be added to the panel 10 as a series of elements, such as lines or dots on the conductors of one or both of the arrays 22 and 24. Also, the phosphor can be combined with the dielectric material of the dielectric members 32 and 34. In FIG. 3, the phosphor is shown as dots 40 on the array 22 conductors, which would preferably be transparent. These dots 40 would be located proximate the cross-points 26 and can have virtually any geometry desired. Also, as well understood by those versed in the art, the phosphors can be selected to provide different colors, e.g., some of the phosphor dots 40 can be made with a material that would provide red and other of a material that would provide a green or blue, or, of course, a combination.

To explain the operation of the FIG. 3 panel 10, reference is made to the FIG. 7 equivalent circuit for

panel 10. In FIG. 7, the chamber 30 and the dielectric members 32 and 34 are all depicted as capacitors arranged in series with the driving and addressing circuit 28. The phosphor dot 40 is considered slightly capacitive and hence a part of the total capacitance presented by the dielectric member 32. Consequently, when the discharge occurs in the chamber 30, approximately half of the breakdown voltage is suddenly applied across the dielectric member 32 and the phosphor dot 40. A relatively high electric field will be applied to the selected dots 40 and will cause electroluminescence. Hence, the dots 40 will emit light at the corresponding cross-points 26. Relating this to FIG. 1, each of the cross-points 26 in the letter H will emit light to form the glowing spots 14 on the panel face 12. Therefore, when there is no breakdown within the chamber 30, a reduced voltage will appear across the phosphor dots 40 and the spots 14 will not glow. But when the gaseous mixture breaks down, the suddenly increased voltage will produce the glowing spots 14. Since the light emission from the discharge is not used for viewing, the dielectric member 32 does not have to be transparent. Whether or not the dielectric member 34 is transparent will be determined by the type of readout.

To erase the panel 10, the power from the circuit 28 is turned off. This removes the sustaining voltage, and consequently, all discharges will terminate. Also erasure can be done by applying from a separate source or the circuit 28, erase pulses of such a phase and magnitude as to terminate the discharges. These erase pulses are so timed so to be out of phase with the discharges. Hence, they interfere with the memory mechanism and cause the extinguishment.

The panels in FIGS. 4, 5 and 6 have been assigned the numerals 10', 10'' and 10''' respectively. When the panels have parts similar to those in the FIG. 3 panel 10, they have been assigned the same number.

Considering first FIG. 4, the panel 10' has on the chamber side a light absorbing dielectric layer 42 in place of or in addition to the dielectric member 32 in the panel 10. This can be a black low melting point glass and will provide a black background for improved light contrast during high ambient lighting conditions when the phosphor dots 40 luminesce in the aforescribed way. Whether or not the other dielectric member 34 is also made of light absorbing material is optional.

The FIG. 5 panel 10'' has the conductor arrays 22 and 24 arranged instead of on the chamber side of the support plates 18 and 20, on the side opposite the chamber 30. Between the conductor arrays 22 and 24 and the chamber 30 and extending laterally through the support plates 18 and 20, there is successively arranged at the cross-points 26, phosphor dots 40 and a series of pins 44. These pins 44 provide a conductive path through the electrically inert support plates 18 and 20 between the external conductor arrays 22 and 24 and the chamber 30.

An insulating layer 46 of dielectric material similar to that suggested for dielectric members 32 and 34 may be added to the support plates 22 and 24. The layers 46 would be used if the pin material was adversely affected by the gaseous mixture. Also, although charges will accumulate at the phosphor dots 40 to provide the memory mechanism, if not adequate, the layers 46

could facilitate this charge accumulation. With the conductor array 22 on the outside of the panel 10'' a protective optically transparent member 48 can be installed on the viewing face 12 of the support plate 18. This member 48 can be made of the same material as the support plates 18 and 20. The face 15 of the support plate 20 with the exposed conductor array 24 enables the readout device 16 to be positioned closer to the phosphor dots 40. In fact, if the read-out is to be made unto a photosensitive sheet of material used by the printer, the sheet can be in direct contact with the face 15. This eliminates the need for intermediate optical coupling provision. The operation of the panel 10'' is the same as that of the panels 10 and 10', i.e., when the discharge occurs in the chamber 30, the resultant high electric field will cause the phosphor dots 40 to emit light which can be viewed at the face 12.

In the FIG. 6, the panel, which is assigned the numeral 10''' has phosphor layers 50 and 52 respectively on the chamber sides of the support plates 18 and 20. Therefore, not only are the layers 50 and 52 subjected to the high electric field at discharge to initiate electroluminescence but also the layers 50 and 52 provide both cathodoluminescence due to the bombardment from the electrons and ions and photoluminescence assuming the wave lengths of the exciting light from the discharge is proper. Otherwise, the operation is the same as the panels 10, 10' and 10''.

It should be kept in mind that each of the foregoing panels may have the phosphor on one side only or both. Also, if the readout is to be entirely internal, the support plate 18 would not have to be optically transparent nor would the dielectric member 34 if used.

In addition to having the readout device 16 with contact or close to the panels, it can be remotely positioned as illustrated in FIG. 4 by using fiber optic elements 54. The fiber optic elements 54 would have their input ends arranged by the plate 56, which could be attached or moveably positioned next to the face 15 of the panel 10' so as to sense the illumination from each cross-point 26. The output ends of the elements 54 would be connected to the remote readout device 16. As has been suggested the readout could also be done internally by including an appropriate electronic readout circuit 58 as shown in FIG. 3. This circuit 58 could be some part of a line scan or random access system.

From the foregoing, it will be appreciated that by utilizing luminescent materials in the described way that visual displays can be achieved without concern for the light emission abilities of the gaseous mixture used in the gas discharge chamber. Therefore, the panels can be optimized for firing and memory capabilities. Furthermore, the visual display can be multicolored.

This invention is to be limited only by the following claims.

What is claimed is:

1. A gas discharge display/memory device comprising, in combination, a sealed gas chamber, a pair of conductor arrays arranged one on each of the opposite sides of the gas chamber each array including at least one conductor having transverse relative orientation to the other array so as to provide one or more cross-points between the conductors in the opposite arrays

across which discharges occur when an operating potential is supplied thereto, dielectric means having surfaces thereof defining at least a portion of the gas chamber, and electroluminescence means capable of emitting light when subjected to an electric current flow, said conductors, dielectric means, gas chamber and electroluminescence means being arranged in series at each cross-point to provide a current path therethrough, said electroluminescence means providing capacitance in each current path and being arranged relative to the chamber and one of the conductor arrays so as to, in response to an electric field generated by a gaseous discharge at a selected cross-point, emit light at the selected cross-point.

2. A gas discharge display/memory device as described in claim 1, wherein the dielectric means includes light absorbing means between the chamber and the electroluminescence means to prevent detection of light emitted by a gaseous discharge and for providing a dark background for the electroluminescent means when emitting light.

3. A gas discharge display/memory device as described in claim 1, including a series of conductor members arranged relative to the electroluminescence means and the chamber so as to provide a current path therebetween.

4. A gas discharge display/memory device as described in claim 1, wherein the electroluminescence means is arranged within the gas chamber.

5. A gas discharge display/memory device as described in claim 1, wherein the electroluminescence means includes a layer of phosphor material arranged between the conductor arrays.

6. A gas discharge display/memory device comprising, in combination, a pair of spaced apart members formed of a dielectric material and defining therebetween a sealed gas chamber, a pair of conductor arrays arranged one on each of the opposite sides of the gas chamber and respectively spaced therefrom by the members, the arrays being in transverse relative orientation so as to provide a series of cross-points therebetween, the electroluminescence means capable of emitting light when subjected to an electric current flow, said conductor arrays, dielectric means, gas chamber and electroluminescence means being arranged in series at each cross-point to provide a current path therethrough, said electroluminescence means providing capacitance in each current path and being arranged relative to one of the conductor arrays and the gas chamber so as to, in response to an electric field generated by a gaseous discharge at a selected cross-point, emit light at the selected cross-point.

7. A gas discharge display/memory device as described in claim 6, wherein the electroluminescence means includes a phosphor material combined with the material of one of the members.

8. A gas discharge display/memory device as described in claim 6, wherein one of the dielectric members includes a light absorbing material to prevent viewing of light emitted by said gaseous discharge and for providing a contrast for the light emission by the electroluminescent means.

9. A gas discharge display/memory device as described in claim 6, wherein the electroluminescence means includes a phosphor layer on the chamber side of one of the members.

10. A gas discharge display/memory device comprising, in combination, a sealed gas chamber, a pair of members arranged one on each side of the chamber and having confronting faces defining at least a portion of the chamber and opposite external faces, each opposite face having a conductor array arranged thereon, each array including at least one conductor having transverse orientation relative to the other array so as to provide one or more cross-points between the conductors in each array, a dielectric member arranged on the confronting face of one of the support members so as to define at least a portion of the chamber, a series of conductor elements extending laterally through the one support member at the cross-points and a series of phosphor elements capable of emitting light when subjected to an electric current flow and positioned one at each cross-point between the associated conductors and conductor elements, said conductors, conductor elements, dielectric member, gas chamber and phosphor elements being arranged in series at each cross-point to provide a current path therethrough, said phosphor elements providing capacitance in each current path so as to emit light when an electric field generated by a gaseous discharge is applied thereto.

11. A gas discharge display and memory system comprising, in combination, a gas discharge panel having a sealed gas chamber, a pair of members arranged one on each side of the chamber and having confronting faces defining at least a portion of the chamber and opposite external faces, a pair of conductor arrays each array being arranged relative to one of the external faces, the arrays each including at least one conductor oriented relative to the other array so as to provide one or more cross-points between the conductors in the opposite arrays, electroluminescence means capable of emitting light when subjected to an electric current flow, said conductors, gas chamber and electroluminescence means being arranged in series at each cross-point to provide a current path therethrough, said electroluminescence means providing capacitance in each current path and being arranged relative to the gas chamber and one of the conductor arrays so as to, in response to an electric field generated by a discharge at a selected cross-point, emit light at the selected cross-point, write-in means connectible to the arrays so as to selectively energize the arrays and cause a discharge at the selected cross-point, readout means operative in response to the emission of light from the selected cross-point to develop a corresponding output, and erase means for extinguishing the discharge.

12. A gas discharge display and memory system as described in claim 11, wherein the readout means contacts one of the external faces.

13. A gas discharge display and memory system as described in claim 11 further including a pair of support members each one engaging one of the external faces.

14. A gas discharge display and memory system as described in claim 11 wherein the read-out means is remotely positioned relative to the panel and further including a series of light conducting elements associated with each cross-point for transferring the illumination therefrom to the read-out means.

15. A gas discharge display/memory device comprising, in combination, a sealed gas chamber, a pair of conductor arrays arranged one on each of the opposite

sides of the gas chamber, each array including at least one conductor having transverse relative orientation to the other array so as to provide one or more cross-points between the conductors in the opposite arrays across which discharges occur when an operating potential is supplied thereto, and electroluminescence means capable of emitting light when subjected to an electric current flow, said conductor, gas chamber and electroluminescence means being arranged in series at each cross-point to provide a current path therethrough, said electroluminescence means providing capacitance in each current path and being arranged relative to the chamber and one of the conductor arrays so as to, in response to an electric field generated by a gaseous discharge at a selected cross-point, emit light at the selected cross-point.

16. A gas discharge display/memory device as described in claim 1 wherein said electroluminescence means is combined with said dielectric means.

17. A gas discharge display/memory device as described in claim 1 further comprising means insulating the light emitted by said gaseous discharge from the light emitted by said electroluminescence means, whereby only the light emitted by said electroluminescence means is detected.

18. A gas discharge display/memory device as described in claim 6 wherein said electroluminescence means is combined with said dielectric material.

19. A gas discharge display/memory device as described in claim 6 further comprising means insulating light emitted by said gas discharge from light emitted by said electroluminescence means, whereby only said light emitted by said electroluminescence means is detected.

20. A gas discharge display/memory device as described in claim 10 further comprising means insulating light emitted by said gaseous discharge from light emitted by said phosphor elements, whereby only said light emitted by said phosphor elements is detected.

21. A gas discharge display/memory device as described in claim 10 wherein the dielectric member includes light absorbing means between the chamber and the phosphor elements to prevent detection of light emitted by a gaseous discharge and for providing a dark

background for the phosphor elements when emitting light.

22. A gas discharge display/memory system as described in claim 11 further comprising dielectric means on the confronting faces of said pair of members.

23. A gas discharge display/memory device as described in claim 22 wherein said electroluminescence means is combined with said dielectric means.

24. A gas discharge display/memory device as described in claim 22 further comprising means insulating light emitted by said gaseous discharge from light emitted by said electroluminescence means, whereby only said light emitted by said electroluminescence means is detected.

25. A gas discharge display/memory device as described in claim 23 wherein said dielectric means includes light absorbing means between the chamber and the electroluminescence means to prevent detection of light emitted by a gaseous discharge and for providing a dark background for the electroluminescence means when emitting light.

26. A gas discharge display/memory device as described in claim 15 further comprising dielectric means on the confronting faces of said pair of members.

27. A gas discharge display/memory device as described in claim 26 wherein said electroluminescence means is combined with said dielectric means.

28. A gas discharge display/memory device as described in claim 26 further comprising means insulating light emitted by said gaseous discharge from light emitted by said electroluminescence means, whereby only said light emitted by said electroluminescence means is detected.

29. A gas discharge display/memory device as described in claim 26 wherein said dielectric means includes light absorbing means between the chamber and the electroluminescence means to prevent detection of light emitted by a gaseous discharge and for providing a dark background for the electroluminescence means when emitting light.

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