United States Patent [19]

Brown et al.

[11] **3,878,422**

[45] **Apr. 15, 1975**

[54] **DISPLAY OF TIME-DEPENDENT VECTOR INFORMATION**

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

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[52] **U.S. Cl.** .... **313/220**; 313/486; 315/169 TV

[51] **Int. Cl.** **H01j 7/30**

[58] **Field of Search** ...... 315/169 TV, 169; 313/108, 313/109, 220, 484, 485, 486, 487; 340/166

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[57] **ABSTRACT**

There is disclosed a gaseous discharge phosphor panel containing an ionizable gaseous medium and at least one phosphor, such that radiation from the gas discharge excites the phosphor, and wherein the visual color output of the gas discharge is different from that of the phosphor and wherein the luminescence rise or decay time of the phosphor is substantially longer than the rise or decay time of the radiation emission of the gas discharge such that when one discharge site formed by a pair of electrodes is initiated and a previously initiated discharge site is erased, the newly initiated site has the color of the gas discharge, the erased site has the color of the decaying phosphor, and those sites-which have been previously initiated and have been in the on state for a period of time longer than the rise time of the phosphor-exhibit a color which combines the output of both the phosphor and the gas discharge, whereby time-dependent vector information is displayed as color difference by the panel.

20 Claims, 6 Drawing Figures

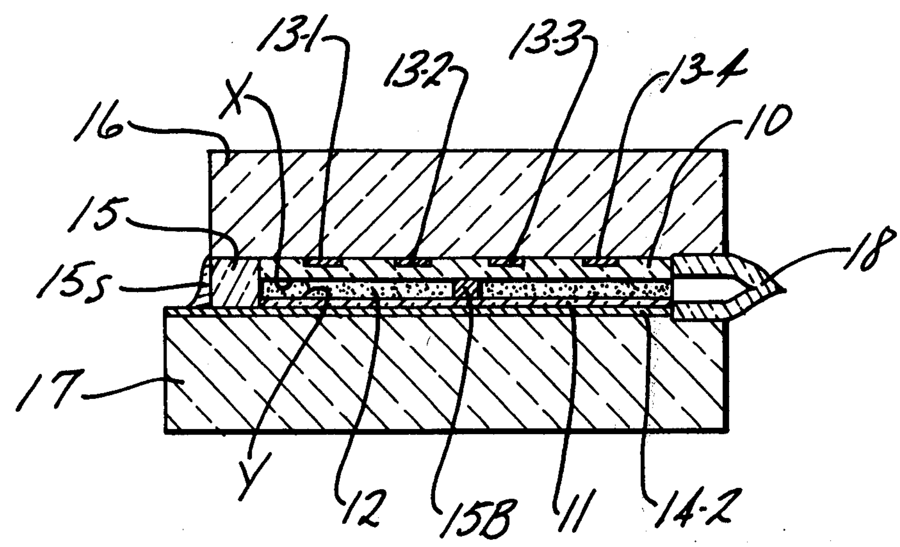


FIG. 2

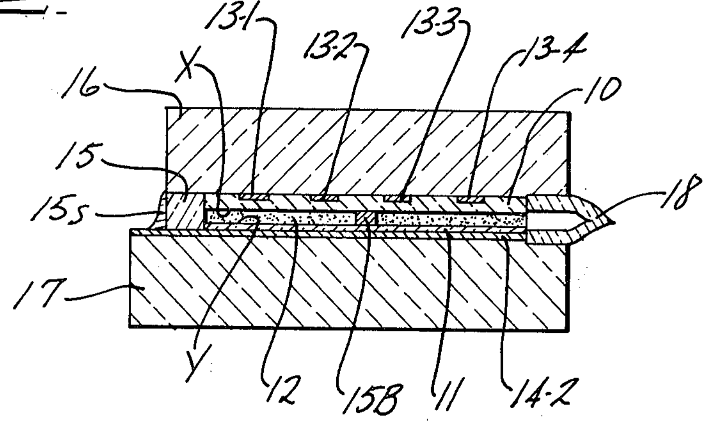

16
X
13-1
13-2
13-3
13-4
10
15
15s
18
17
Y
12
15B
11
14-2

FIG. 1

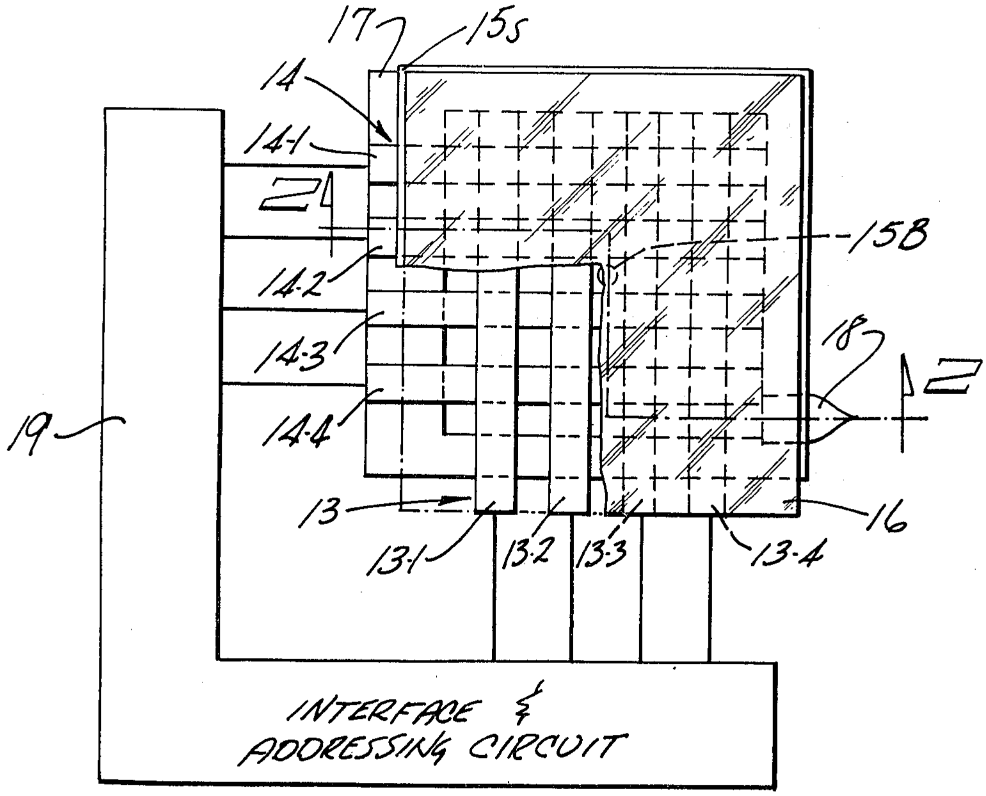

17
15s
14
14-1
2
14-2
15B
14-3
18
2
19
14-4
13
13-1
13-2
13-3
13-4
16
INTERFACE &
ADDRESSING CIRCUIT

FIG. 3

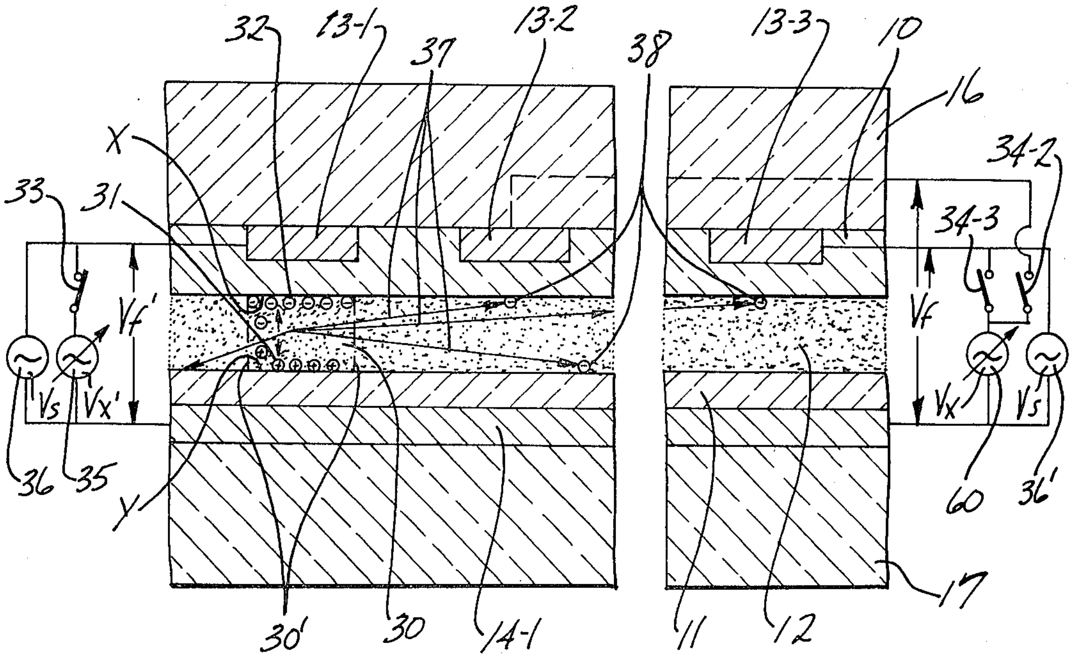
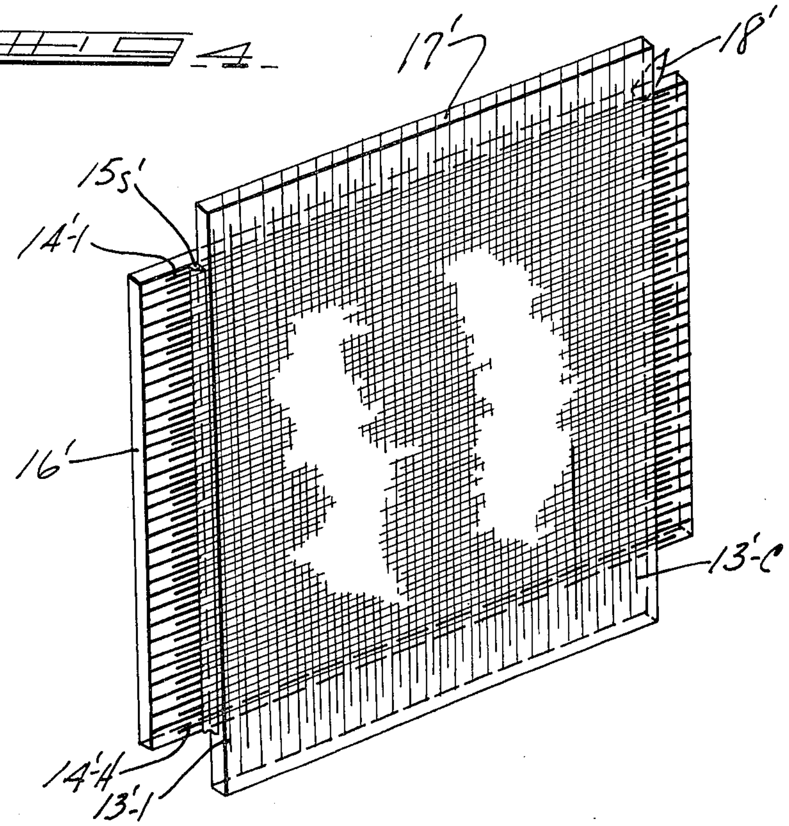

32
13-1
37
13-2
38
13-3
10
16
X
33
31
34-2
34-3
Vf'
Vf
Vs
Vx'
Vx
Vs
36
35
60
36'
Y
30'
30
14-1
11
12
17

FIG. 4


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

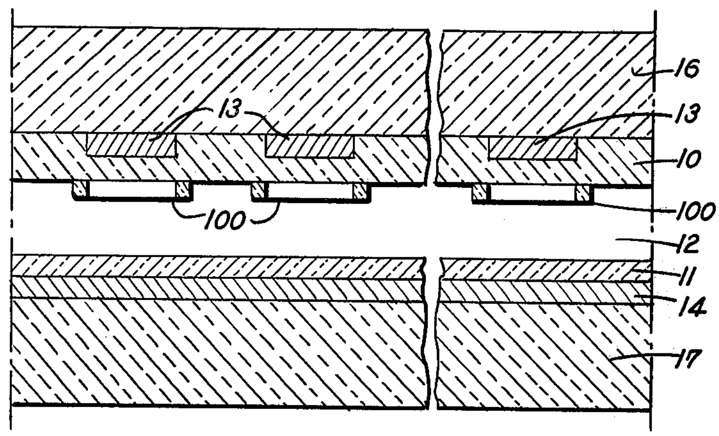


FIG. 5

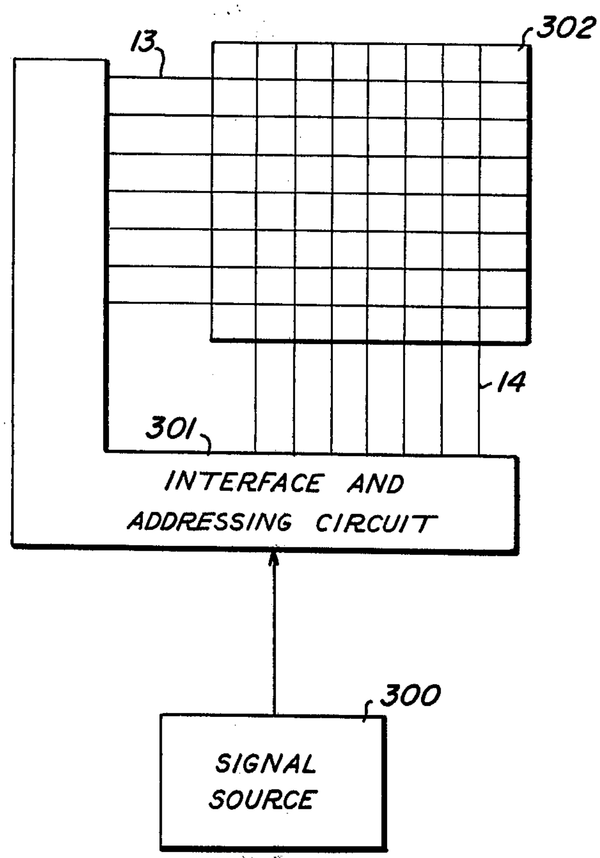

13
302
14
301
INTERFACE AND
ADDRESSING CIRCUIT
300
SIGNAL
SOURCE

FIG. 6

DISPLAY OF TIME-DEPENDENT VECTOR INFORMATION

BACKGROUND OF THE INVENTION

This invention relates to gas discharge phosphor-containing 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, air-craft displays, binary words, educational displays, etc.

Multiple gas discharge display and/or memory panels of one type with which the present invention is especially 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 or space between a pair of opposed dielectric charge storage members which are backed by conductor (electrode) members, the conductor members backing each dielectric member typically being appropriately 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 structures 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 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," Procedding of the Fall Joint Computer Conference, IEEE, San Francisco, Calif., Nov. 1966, pp. 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 × 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, e.g., at least one insulated electrode.

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 discussed 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

$$M.M. = V_f - V_E / V_f / 2$$

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 not containing dielectric members and wherein the electrodes are in direct contact with an ionizable gas medium. Such direct contact devices are wellknown 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 gas discharge devices of the aforementioned types, phosphors may be appropriately positioned within the device so as to be activated by radiation from the gas discharge of the device. For example, in a charge storage device of the Baker et al type, phosphors can be positioned on or be embedded in one or more charge storage dielectric surfaces.

The features and advantages of the invention will be better understood by reference to the following detailed description when considered in connection with the accompanying drawings. FIGS. 1–4 and the description of these figures are from the above mentioned Baker et al. U.S. Pat. No. 3,499,167.

FIG. 1 is a partially cut-away plan view of a gaseous 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 the lines 2—2 of FIG. 1,

FIG. 3 is an explanatory partial cross-sectional view similar to FIG. 1 (enlarged, but not to proportional scale),

FIG. 4 is an isometric view of a larger gaseous discharge display/memory panel, and

FIG. 5 is an explanatory partial cross-sectional view similar to FIG. 3 showing an embodiment of the present invention, and

FIG. 6 is a schematic drawing of the invention in use.

The invention utilizes a pair of dielectric films or coatings **10** and **11** separated by a thin layer or volume of a gaseous discharge medium **12**, said medium **12** producing a copious supply of charges (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 nongas-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 under **10** mils and preferably about 5 to 6 mils, dielectric layers **10** and **11** (over the conductors at the elemental or discrete X and Y areas) is between 1 and 2 mils thick, and conductors **13** and **14** about 8,000 angstroms thick (tin oxide). However, support members **16** and **17** are much thicker (particularly 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 although for purposes described later herein it is preferred that one of the support members and members formed thereon be transparent to or pass ultraviolet radiation.

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 commerical 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, McGraw-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 bead like solder glass spacers such as shown at **15B** may be located between conductors 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 30 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 3,000 ohms per line. 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 1,000 v. and be electrically homogeneous on a microscopic 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. However, a supply of free electrons for conditioning gas **12** for the ionization process may be provided by inclusion of a radioactive material within the glass or gas space. A preferred range of thickness of dielectric layers **10** and **11** overlying the conductor arrays **13** and **14** is between 1 and 2 mils. 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 5 to 6 mils with conductor arrays **13** and **14** having center to center spacing of about **30** 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. However, 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.

One mode of initiating operation of the panel will be described with reference to FIG. **3,** which illustrates the condition of one elemental gas volume **30** having an elemental cross-sectional area and volume which is quite small relative to the entire volume and cross-sectional area of gas **12.** The cross-sectional area of volume **30** is defined by the overlapping common elemental areas of the conductor arrays and the volume is equal to the product of the distance between the dielectric surfaces and the elemental area. It is apparent that if the conductor arrays are uniform and linear and are orthogonally (at right angles to each other) related each of elemental areas X and Y will be squares and if conductors of one conductor array are wider than conductors of the other conductor array, said areas will be rectangles. If the conductor arrays are at transverse angles relative to each other, other than 90°, the areas will be diamond shaped so that the cross-sectional shape of each volume is determined solely in the first instance by the shape of the common area of overlap between conductors in the conductor arrays **13** and **14.** The dotted lines **30′** are imaginary lines to show a boundary of one elemental volume about the center of which each elemental discharge takes place. As described earlier herein, it is known that the cross-sectional area of the discharge in a gas is affected by, inter alia, the pressure of the gas, such that, if desired, the discharge may even be constricted to within an area smaller than the area of conductor overlap. By utilization of this phenomena, the light production may be confined or resolved substantially to the area of the elemental cross-sectional area defined by conductor overlap. Moreover, by operating at such pressure charges (ions and electrons) produced on discharge are laterally confined so as to not materially affect operation of adjacent elemental discharge volumes.

In the instant shown in FIG. **3**, a conditioning discharge about the center of elemental volume **30** has been initiated by application to conductor **13-1** and conductor **14-1** firing potential V_x' as derived from a source **35** of variable phase, for example, and source **36** of sustaining potential V_s (which may be a sine wave, for example). The potential V_x' is added to the sustaining potential V_s as sustaining potential V_s increases in magnitude to initiate the conditioning discharge about the center of elemental volume **30** shown in FIG. **3.** There, the phase of the source **35** of potential V_x' has been adjusted into adding relation to the alternating voltage from the source **36** of sustaining voltage V_s to provide a voltage V_f', when switch **33** has been closed, to conductors **13-1** and **14-1** defining elementary gas volume **30** sufficient (in time and/or magnitude) to produce a light generating discharge centered about discrete elemental gas volume **30.** At the instant shown, since conductor **13-1** is positive, electrons **32** have collected on and are moving to an elemental area of dielectric member **10** substantially corresponding to the area of elemental gas volume **30** and the less mobile positive ions **31** are beginning to collect on the opposed elemental area of dielectric member **11** since it is negative. As these charges build up, they constitute a back voltage opposed to the voltage applied to conductors **13-1** and **14-1** and serve to terminate the discharge in elemental gas volume **30** for the remainder of a half cycle.

During the discharge about the center of elemental gas volume **30**, photons are produced which are free to move or pass through gas medium **12**, as indicated by arrows **37**, to strike or impact remote surface areas of photoemissive dielectric members **10** and **11**, causing such remote areas to release electrons **38**. Electrons **38** are, in effect, free electrons in gas medium **12** and condition each other discrete elemental gas volume for operation at a lower firing potential V_f which is lower in magnitude than the firing potential V_f' for the initial discharge about the center of elemental volume **30** and this voltage is substantially uniform for each other elemental gas volume.

Thus, elimination of physical obstructions or barriers between discrete elemental volumes, permits photons to travel via the space occupied by the gas medium **12** to impact remote surface areas of dielectric members **10** and **11** and provides a mechanism for supplying free electrons to all elemental gas volumes, thereby conditioning all discrete elemental gas volumes for subsequent discharges, respectively, at a uniform lower applied potential. While in FIG. **3** a single elemental volume **30** is shown, it will be appreciated that an entire row (or column) of elemental gas volumes may be maintained in a "fired" condition during normal operation of the device with the light produced thereby being masked or blocked off from the normal viewing area and not used for display purposes. It can be expected that in some applications there will always be at least one elemental volume in a "fired" condition and producing light in a panel, and in such applications it is not necessary to provide separate discharge of generation of photons for purposes described earlier.

However, as described earlier, the entire gas volume can be conditioned for operation at uniform firing potentials by use of external or internal radiation so that there will be no need for a separate source of higher potential for initiating an initial discharge. Thus, by radiating the panel with ultraviolet radiation or by inclusion of a radioactive material within the glass materials or gas space, all discharge volumes can be operated at uniform potentials from addressing and interface circuit **19**.

Since each discharge is terminated upon a build up or storage of charges at opposed pairs of elemental areas, the light produced is likewise terminated. In fact, light production lasts for only a small fraction of a half cycle of applied alternating potential and depending on design parameters, is in the nanosecond range.

After the initial firing or discharge of discrete elemental gas volume **30** by a firing potential V_f', switch **33** may be opened so that only the sustaining voltage V_s from source **36** is applied to conductors **13-1** and **14-1**. Due to the storage of charges (e.g., the memory) at the opposed elemental areas X and Y, the elemental gas volume **30** will discharge again at or near the peak of negative half cycles of sustaining voltage V_s to again produce a momentary pulse of light. At this time, due to reversal of field direction, electrons **32** will collect on and be stored on elemental surface area Y of dielectric member **11** and positive ions **31** will collect and be stored on elemental surface area X of dielectric member **10**. After a few cycles of sustaining voltage V_s, the times of discharge become symmetrically located with respect to the wave form of sustaining voltage V_s. At remote elemental volumes, as for example, the elemental volumes defined by conductor **14-1** with conductors **13-2** and **13-3**, a uniform magnitude or potential V_x from source **60** is selectively added by one or both of switches **34-2** or **34-3** to the sustaining voltage V_s, shown as **36'**, to fire one or both of these elemental discharge volumes. Due to the presence of free electrons produced as a result of the discharge centered about elemental volume **30**, each of these remote discrete elemental volumes have been conditioned for operation at uniform firing potential V_f.

In order to turn "off" an elemental gas volume (i.e., terminate a sequence of discharge representing the "on" state), the sustaining voltage may be removed. However, since this would also turn "off" other elemental volumes along a row or column, it is preferred that the volumes be selectively turned "off" by application to select "on" elemental volumes a voltage which can neutralize the charges stored at the pairs of opposed elemental areas.

This can be accomplished in a number of ways, as for example, varying the phase or time position of the potential from source **60** to where that voltage combined with the potential from source **36'** falls substantially below the sustaining voltage.

It is apparent that the plates **16–17** need not be flat but may be curved, curvature of facing surfaces of each plate being complementary to each other. While the preferred conductor arrangement is of the crossed grid type as shown herein, it is likewise apparent that where an infinite variety of two dimensional display patterns are 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 device shown in FIG. **4** is a panel having a large number of elemental volumes similar to elemental volume **30** (FIG. **3**). In this case more room is provided to make electrical connection to the conductor arrays **13'** and **14'**, respectively, by extending the surfaces of support members **16'** and **17'** beyond seal **15S'**, alternate conductors being extended on alternate sides. Conductor arrays **13'** and **14'** as well as support members **16'** and **17'** are transparent. The dielectric coatings are not shown in FIG. **4** but are likewise transparent so that the panel may be viewed from either side.

In accordance with the practice of this invention, there is provided a gas discharge phosphor device capable of displaying time-dependent vector information as color differences.

More particularly, there is provided a gaseous discharge panel containing an ionizable gaseous medium, at least one phosphor and a plurality of electrodes, with radiation from the gas discharge exciting the phosphor, the improvement wherein the visual color output of the gas discharge is different from that of the phosphor and wherein the luminescence rise or decay time of the phosphor is substantially longer than the rise or decay time of the radiation emission of the gas discharge, such that when one discharge site formed by at least two electrodes is initiated and a previously-initiated discharge site is erased, the newly initiated site has the color of the gas discharge, the erased site has the color of the decaying phosphor, and those cells — which have been previously initiated and have been in the on state for a period of time longer than the rise time of the phosphor — exhibit a color which combines the output of both the phosphor and the gas discharge, whereby time-dependent vector information is displayed as color difference by the panel.

In the practice of this invention, it is contemplated using any suitable luminescent phosphor. In the preferred embodiment, the phosphor is photoluminescent. The term "photoluminescent phosphor" includes quite generally all solid and liquid, inorganic and organic materials capable of converting an input of absorbed photons into an output of photons of different energy, the output comprising visible light of a brightness and intensity of sufficient for visual display.

Typical photoluminescent phosphors contemplated include, not by way of limitation, both activated and non-activated compounds, e.g., the sulfides such as zinc sulfides, zinc-cadmium sulfides, zinc-sulfoselenides; the silicates such as zinc silicates, zinc beryllo-silicate, Mg silicates; the tungstates such as calcium tungstates, magnesium tungstates; the phosphates, borates, and arsenates such as calcium phosphates, cadmium borates, zinc borates, magnesium arsenates; and the oxides and halides such as self-activated zinc oxide, magnesium fluorides, magnesium flyorogermanate. Typical activators include, not by way of limitation, Mn, Eu, Ce, Pb, etc.

In one highly preferred embodiment, there is utilized a phosphor Pl as defined by JEDEC Electrode Tube Council, Publication No. **16A** of January 1966, revised February 1969 Pl is manganese activated zinc silicate (Zn_2SiO_4; Mn).

In another preferred embodiment hereof as shown in FIG. **5**, there is utilized a gas discharge display/memory device containing at least one dielectric charge storage surface **10** or **11**, the phosphor **100** being appropriately applied to such dielectric.

In such embodiment, the phosphor may be applied to the dielectric by way of any convenient method including, not by way of limitation, vapor deposition; vacuum deposition; chemical vapor deposition; wet spraying or settling upon the dielectric a mixture or solution of the phosphor suspended or dissolved in a liuqid, followed by evaporation of the liquid; silk screening; dry spraying of the phosphor upon the dielectric; electron beam evaporation; plasma flame and/or arc spraying and/or deposition; thermal evaporation; laser evaporation; RF or induction heating evaporation; sputtering target techniques; and/or attachment of the phosphor to the dielectric as disclosed in the copending U.S. Patent Application Ser. No. 101,433, filed Dec. 24, 1970 by Robert N. Clark, and assigned to the assignee of the instant patent application.

In accordance with the broad practice of this invention, it is contemplated applying the phosphor to the dielectric (surface or sub-surface) in any suitable geometric shape, pattern, or configuration, symmetrical or asymmetrical as disclosed for example in the copending U.S. Patent Application Ser. No. 98,846, filed Dec. 16, 1970 by Felix H. Brown and Robert F. Schaufele, and assigned to the assignee of the instant patent application.

In the practice of this invention, it is contemplated using radiation from any suitable gas discharge to excite the phosphor.

In the 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 flyoride; 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; radio active gases; and the rare or inert gases.

In one embodiment hereof, the gaseous medium comprises at least one rare gas selected from neon or argon, and at least one other rare gas selected from argon, xenon, or krypton.

In another embodiment, the gaseous medium comprises about 80% to about 99.9% atoms of neon and about 20% to about 0.1% atoms of at least one member selected from argon, xenon, or krypton.

In another embodiment, the gaseous medium comprises one or more rare gases selected from argon, xenon, or krypton.

Beneficial amounts of other additives, such as mercury and/or helium, may also be present in the gaseous medium.

It is desirable in many applications to display moving and stationary targets or bodies in a manner which enhances the difference between them. CRT displays exist which accomplish this by means of brightness or color. This requires that something recognize that a target is moving and instruct the CRT to display it differently than it does other targets.

Utilizing a multiple gaseous discharge display/memory panel rather than a CRT, it is possible to produce color difference between stationary and moving targets without the need for the recognition and instruction functions, thereby making the system cheaper, smaller, and less complex. If a phosphor, having a definite risetime for visible luminescence is placed in the panel and the target is moving fast enough so that it activates a new cell before the phosphor in the previous cell has reached visible brightness, the moving target will appear the color of the discharging gas whereas stationary or more slowly moving targets will be the color of the discharge plus the luminescence of the phosphor. For example, a green luminescing phosphor in a Neon/Argon panel will show a target moving more rapidly than some minimum speed as red and stationary or more slowly moving targets as yellow (Neon red plus phosphor green). Thus, in the practice of this invention it is possible to tag a moving body by color without computer processing.

The threshold speed depends upon the choice of phosphor and it is possible to have a series of panels each displaying a different speed range in color, or to do it in one panel at the cost of resolution. The effect is independent of the mechanism of phosphor excitation.

If the number of gas discharge cells comprising the moving target is great enough, the body of the target will appear in the color of the discharge plus phosphor luminescence, while the leading edge will appear in the color of the discharge alone. This not only indicates that a target is moving, but instantaneously gives the direction of motion because the leading edge only is emphasized by color difference.

The moving target may be a large body such as an automobile, airplane, or sea-going vessel (as in traffic control) or a smaller target as in a home, laboratory, or factory.

The electrical system utilized to initially detect the target and/or provide information signals for display may be of the type conventionally used in a radar, sonar, television system, etc., including signals synthesized by a computer.

The signals are then appropriately forwarded to the panel electrode arrays by any suitable addressing circuitry.

In FIG. **6** there is schematic arrangement comprising a signal source **300** which is fed to an X-Y interface and addressing circuit **301** for addressing X-axis electrodes **13** and Y-axis electrodes **14** in a multiple gaseous display panel **302.** Although an X-Y electrode pattern is shown, other electrode patterns may be utilized. Examples of suitable interface and addressing circuitry which may be utilized include U.S. Pats. Nos. 3,618,071 to Johnson et al. and 3,614,739 to Johnson.

We claim:

1. In a process for operating a gaseous discharge display/memory device comprising a multiplicity of gas discharge cells, an ionizable gaseous medium, a phosphor at each cell with radiation from the gas discharge exciting the phosphor, a plurality of electrodes, and means connected to said plurality of electrodes for addressing said electrodes in sequence at varying rates to display a moving target,

the improvement which comprises displaying time-dependent vector information as color difference by the device by selecting a gaseous medium and phosphor wherein the visual color output of the gas discharge is different from that of the phosphor and wherein the luminscence rise or decay time of the phosphor is substantially longer than the rise or decay time of the radiation emission of the gas discharge, such that when one discharge site formed by at least two electrodes is initiated and a previously-initiated discharge site is erased, the newly initiated site has the color of the gas discharge, the erased site has the color of the decaying phosphor, and those cells — which have been previously initiated and have been in the ON state for a period of time longer than the rise time of the phosphor — exhibit a color which combines the output of both the phosphor and gas discharge, and the color of a fast moving target is that of the gas during discharge and the color of a slower moving or stationary target is the resultant color of the gas during discharge plus the color of the phosphor during luminescence.

2. The invention of claim **1** wherein the phosphor is a photoluminescent phosphor.

3. The invention of claim **2** wherein the phosphor is selected from activated or non-activated zinc sulfide, zinc-cadmium sulfide, zinc-sulfo-selenide, zinc-silicate, zinc-beryllo-silicate, magnesium silicate, calcium tungstate, magnesium tungstate, calcium phosphate, cadmium borate, zinc borate, magnesium arsenate, zinc oxide, magnesium fluoride, and magnesium flyorogermanate.

4. The invention of claim **1** wherein the phosphor is a manganese activated zinc silicate.

5. The invention of claim **3** wherein the gaseous medium comprises at least one rare gas.

6. In a gaseous discharge display/memory device comprising a multiplicity of gas discharge cells, an ionizable gaseous medium, and a phosphor at each cell, radiation from a gas discharge at a cell exciting the phosphor at said cell, and means connected to each of said multiplicity of gas discharge cells for addressing predetermined of said electrodes in sequence at varying rates to display a moving target, the improvement wherein the visual color output of the gas discharge is different from that of the phosphor and wherein the luminescence rise or decay time of the phosphor is substantially longer than the rise or decay time of the radiation emission of the gas discharge, such that when one discharge cell is initiated and a previously initiated discharge cell is erased, the newly initiated cell has the color of the gas discharge, the erased cell has the color of the decaying phosphor, and those cells which have been previously initiated and have been in the ON state for a period of time longer than the rise time of the phosphor exhibit a color which combines the output of both the phosphor and the gas discharge, whereby vector information is displaved as color difference by the device, the color of a fast moving target being that of the gas during discharge and the color of a slower moving or stationary target being the resultant color of the gas during discharge plus the color of the phosphor during luminescence.

7. The invention of claim **6** wherein the phosphor is a photoluminescent phosphor.

8. The invention of claim **7** wherein the phosphor is selected from activated or non-activated zinc sulfide, zinc-cadmium sulfide, zinc-sulfo-selenide, zinc-silicate, zinc-beryllo-silicate, magnesium silicate, calcium tungstate, magnesium tungstate, calcium phosphate, cadmium borate, zinc borate, magnesium arsenate, zinc oxide, magnesium fluoride, and magnesium flyorogermanate.

9. The invention of claim **6** wherein the phosphor is a manganese activated zinc silicate.

10. The invention of claim **9** wherein the gaseous medium comprises at least one rare gas.

11. In the operation of a gaseous discharge display/-memory device characterized by an ionizable gaseous medium in a gas chamber formed by a pair of dielectric material members having opposed charge sotrage surfaces which dielectric material members are respectively backed by a series of parallel-like electorde members, the electrode members behind one dielectric material member being transversely oriented with respect to the electrode members behind the opposing dielectric material member so as to define a plurality of discrete discharge volumes, each constituting of a discharge site, a phosphor on at least one of said dielectric material members at each discharge site, and means connected to said plurality of electrode members for addressing said electrode members in sequence at varying rates to display a moving target, the improvement which comprises displaying time-dependent vector information as color difference by selecting a gaseous medium and phosphor wherein the visual color output of the gas discharge is different form that of the phosphor and wherein the luminescence rise or decay time of the phosphor is substantially longer than the rise or decay time of the radiation emission of the gas discharge, such that when one discharge site formed by at least two electrodes is initiated and a previously-initiated discharge site is erased, the newly initiated site has the color of the gas discharge, the erased site has the color of the decaying phosphor, and those cells — which have been previously initiated and have been in the ON state for a period of time longer than the rise time of the phosphor — exhibit a color which combines the output of both the phosphor and gas discharge, and the color of a fast moving target is that of the gas during discharge and the color of a slower moving or stationary target is the resultant color of the gas during discharge plus the color of the phosphor during luminescence.

12. The invention of claim **11** wherein the phosphor is a photoluminescent phosphor.

13. In a gaseous discharge display/memory device comprising an ionizable gaseous medium in a gas chamber formed by a pair of opposed dielectric material charge storage members backed by a plurality of electrode members, the electrode members behind one dielectric material member being transversely oriented with respect to the electrode members behind the opposing dielectric material member so as to define a plurality of discharge volumes each constituting a discharge cell, a phosphor on at least volumes, of said dielectric material members at each discharge cell, radiation from a gas discharge at a discharge cell exciting the phosphor at said cell, and means connected to each of said plurality of electrode members for addressing said electrode members in sequence at varying rates to display a moving target, the improvement wherein the visual color output of the gas discharge is different from that of the phosphor and wherein the luminescence rise or decay time of the phosphor is substantially longer than the rise or decay time of the radiation emission of the gas discharge, such that when one discharge cell is initiated and a previously initiated discharge cell is erased, the newly initiated cell has the color of the gas discharge, the erased cell has the color of the decaying phosphor, and those cells which have been previously initiated and have been in the ON state for a period of time longer than the rise time of the phosphor exhibit a color which combines the output of both the phosphor and the gas discharge, whereby vector information is displayed as color difference by the device, the color of a fast moving target being that of the gas during discharge and the color of a slower moving or stationary target being the resultant color of the gas during discharge plus the color of the phosphor during luminescence.

14. The invention of claim **13** wherein the phosphor is a photoluminescent phosphor.

15. In a process for the manufacture of a gaseous discharge display/memory device wherein a gas chamber is formed by assembling a pair of opposed dielectric material charge storage members in spaced and sealed relationship and a plurality of electrode members behind each dielectric material charge storage member, the electrode members behind one dielectric material member being transversely oriented with respect to the electrode members behind the opposing dielectric material member so as to define a plurality of discharge volumes, each constituting a discharge cell, and means connected to said electrode members is provided for addressing said electrode members in sequence at varying rates to display a moving target, the improvement which comprises filling the gas chamber with an ionizable gaseous medium having one visual color output upon gaseous discharge and applying a phosphor having a different visual color output to at least one of said dielectric material members at each discharge cell, the luminescence rise or decay time of the phosphor being substantially longer than the rise or decay time of the radiation emission of the gas discharge, such that when one discharge cell is initiated and a previously initiated discharge cell is erased, the newly initiated cell has the color of the gas discharge, the erased cell has the color of the decaying phosphor, and those cells which have been previously initiated and have been in the ON state for a period of time longer than the rise time of the phosphor exhibit a color which combines the output of both the phosphor and the gas discharge, whereby vector information is displayed as color difference by the device, the color of a fast moving target being that of the gas during discharge and the color of a slower moving or stationary target being the resultant color of the gas during discharge plus the color of the phosphor during luminescence.

16. The invention of claim **15** wherein the phosphor is a photoluminescent phosphor.

17. A gas discharge display/memory device comprising in combination, a pair of spaced-apart non-conductive support members, a pair of conductor arrays arranged one on each of the confronting surfaces of said support members, the arrays being in transverse relative orientation so as to provide a series of crosspoints therebetween, each defining a discharge cell, a thin dielectric material coating on the confronting surfaces of each of the support members and conductor arrays defining therebetween a sealed gas chamber with said discharge units in open photonic communication, means connected to said conductor arrays for addressing said discharge cells in sequence at varying rates to display a moving target, a phosphor having one visual color output on at least one of said dielectric material members at each discharge cell, and an ionizable gaseous medium having a different visual color output contained in said gas chamber, the luminescence rise or decay time of the phosphor being substantially longer than the rise or decay time of the radiation emission of the gas discharge, such that when one discharge cell is initiated and a previously initiated discharge cell is erased, the newly initiated cell has the color of the gas discharge, the erased cell has the color of the decaying phosphor, and those cells which have been previously initiated and have been in the ON state for a period of time longer than the rise time of the phosphor exhibit a color which combines the output of both the phosphor and the gas discharge, whereby vector information is displayed as color difference by the device, the color of a fast moving target being that of the gas during discharge and the color of a slower moving or stationary target being the resultant color of the gas during discharge plus the color of the phosphor during luminescence.

18. The invention of claim **17** wherein the phosphor is a photoluminescent phosphor.

19. A process for displaying time-dependent vector information as color difference on a multiple gaseous discharge display/memory device containing an ionizable gaseous medium, a plurality of discharge cells, each formed of at least two electrodes, a phosphor at each discharge cell and excitable by radiation from discharge of said gaseous medium, and means connected to said electrodes for addressing said electrode members in sequence at varying rates to display a moving target, said process comprising

a. incorporating a gaseous medium and phosphors in said device, the visual color output of said gaseous medium when discharged being different from that of the phosphors and the luminescence rise or decay time of said phosphors being substantially longer than the rise or decay time of the radiation emission of the gas discharge,

b. initiating discharge of a series of cells in sequence and simultaneously erasing the earliest previously initiated cells in sequence,

c. such that the most recently initiated cell of the series exhibits the color of the gas discharge, the most recently erased cell exhibits the color of the phosphors, and those cells which have been previously initiated and have been in the ON state for a period of time longer than the rise time of the phosphors exhibit a color which is the combination of the output of both the gas discharge and the output of the phosphors.

20. A gaseous discharge display/memory device for displaying time-dependent vector information as color difference and comprising a multiplicity of gas discharge cells, an ionizable gaseous medium, means for addressing said gas discharge cells in sequence at varying rates to display a moving target and a plurality of phosphors excitable by radiation for discharge of said gaseous medium, the visual color output of said gaseous medium when discharged being different from that of the phosphors, and the luminescence rise or decay time of said phosphors being substantially longer than the rise or decay time of the radiation emission of the gas discharge, such that when discharge is initiated in sequence in a series of cells and simultaneously the earliest previously initiated cells are erased in sequence the most recently initiated cell of the series exhibits the color of the gas discharge, the most recently erased cell exhibits the color of the phosphors, and those cells which have been previously initiated and have been in the ON state for a period of time longer than the rise time of the phosphors exhibit a color which is the combination of the output of both the phosphors and the gas discharge.

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