# United States Patent [19]

**Fein et al.**

[11] **3,833,832**

[45] **Sept. 3, 1974**


[54] **ELECTRONIC CONDITIONING OF GAS DISCHARGE PANELS BY INVERSION INTERNAL EXTENSION**


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



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[52] **U.S. Cl.** ...... **315/169 R,** 315/166, 315/169 TV, 340/324 M, 315/174

[51] **Int. Cl.** .......... **H05b 41/29**

[58] **Field of Search** ......... 315/166, 169 R, 169 TV, 315/174; 313/108 B; 340/324 M


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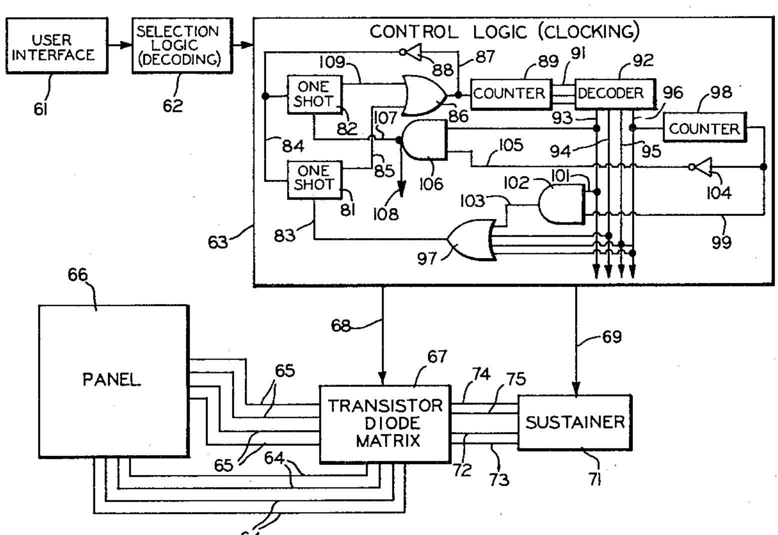
*Assistant Examiner*—Eugene R. LaRoche
*Attorney, Agent, or Firm*—Donald Keith Wedding


[57] **ABSTRACT**


The conditioning or priming of multicelled gas discharge display-memory panels, of the type in which a discharge in a hermetically enclosed ionizable gas generates charges alternately collectable on pairs of discrete areas of spaced dielectric surfaces which are backed by conductors of first and second conductor arrays to define a plurality of discharge cells, is enhanced and their operation made more reliable by periodically inverting the state of all cells in the panel. Extension of the interval of inversion of the discharge state of the panel beyond the half period of a normal sustainer voltage cycle increases the probability that the cells normally in the "off state" will be transferred to the "on state." This improvement permits less frequent inversions of discharge state without detriment to the cell writing reliability of the panel thereby enhancing the contrast ratio between "on" cells and "off" cells. A clocking circuit for regular sustainer voltage cycles and for a regular, periodic, extended interval device inverting sustainer voltage is shown with a number of sustainer wave form constructions for the inverting condition.


**22 Claims, 8 Drawing Figures**



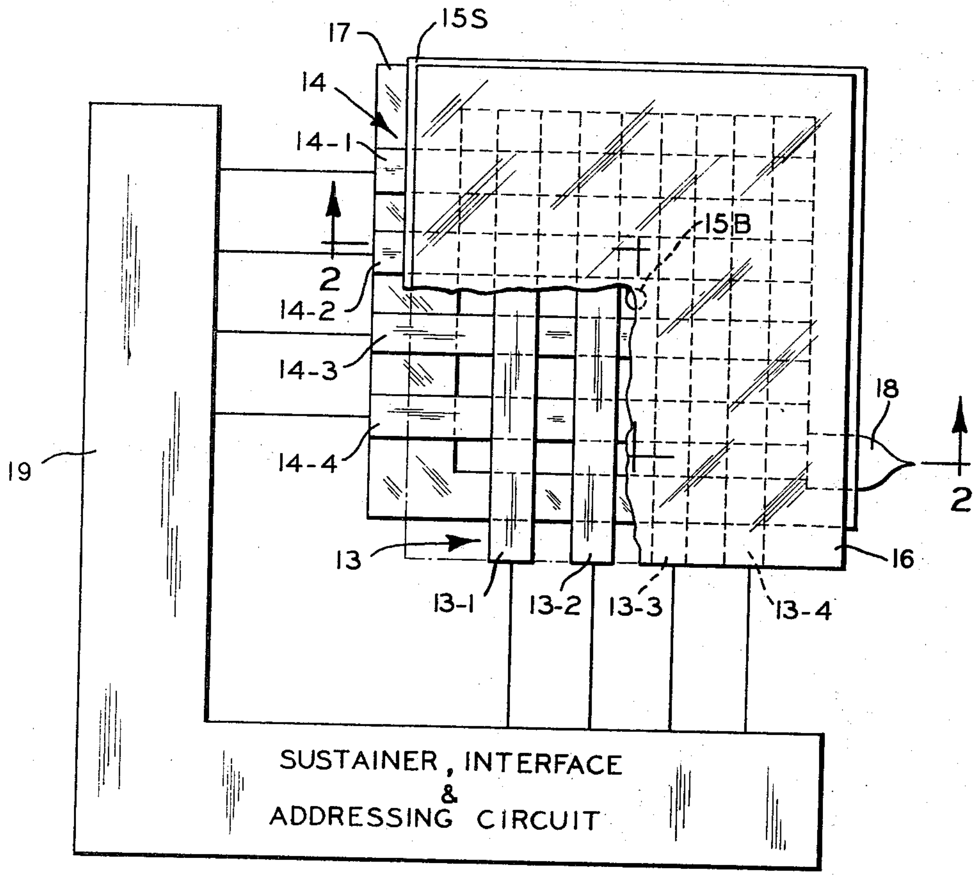

17
15S
14
14-1
15B
2
14-2
14-3
18
14-4
19
2
16
13
13-1
13-2
13-3
13-4
SUSTAINER, INTERFACE & ADDRESSING CIRCUIT

FIG. 1

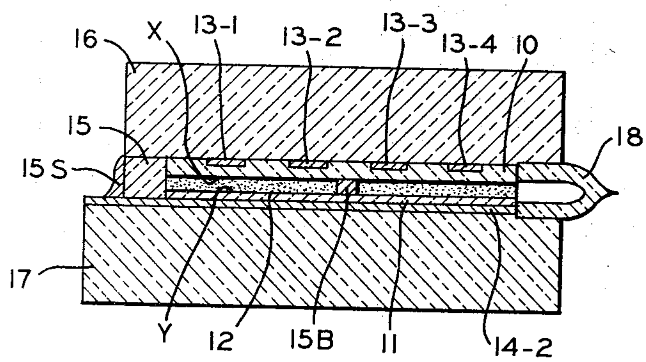

16
X
13-1
13-2
13-3
13-4
10
15
18
15S
17
Y
12
15B
11
14-2

FIG. 2

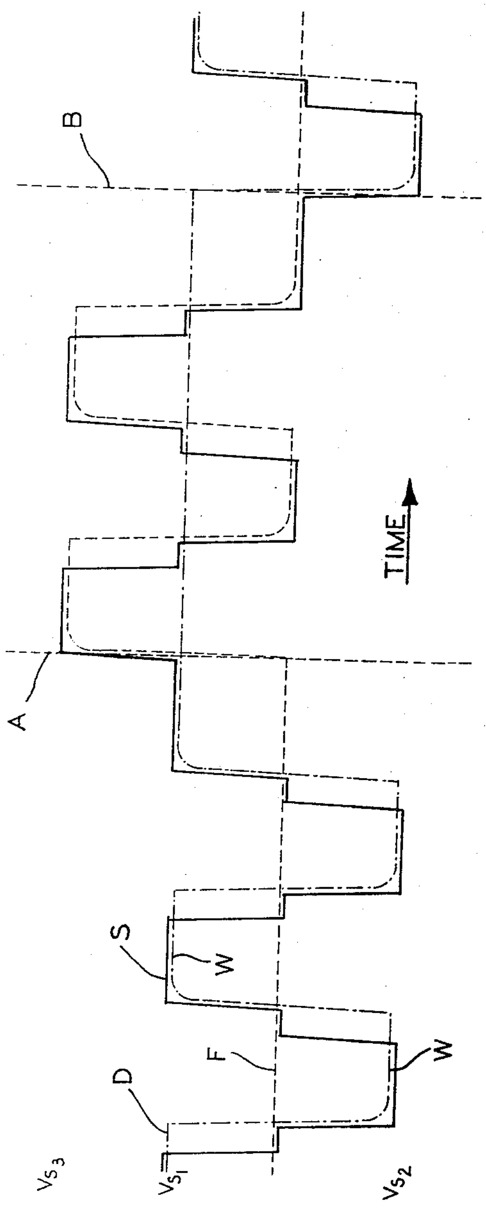

A
B
S
W
D
F
W
$V_{S_3}$
$V_{S_1}$
$V_{S_2}$
TIME

FIG. 3

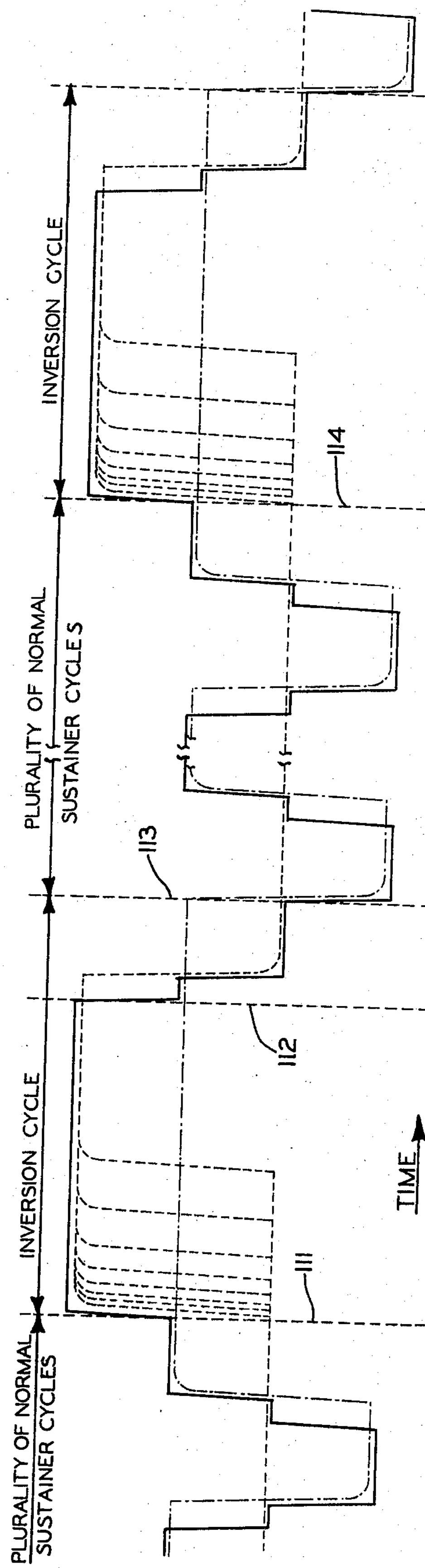

INVERSION CYCLE
PLURALITY OF NORMAL SUSTAINER CYCLES
INVERSION CYCLE
PLURALITY OF NORMAL SUSTAINER CYCLES
111
112
113
114
TIME

FIG. 8

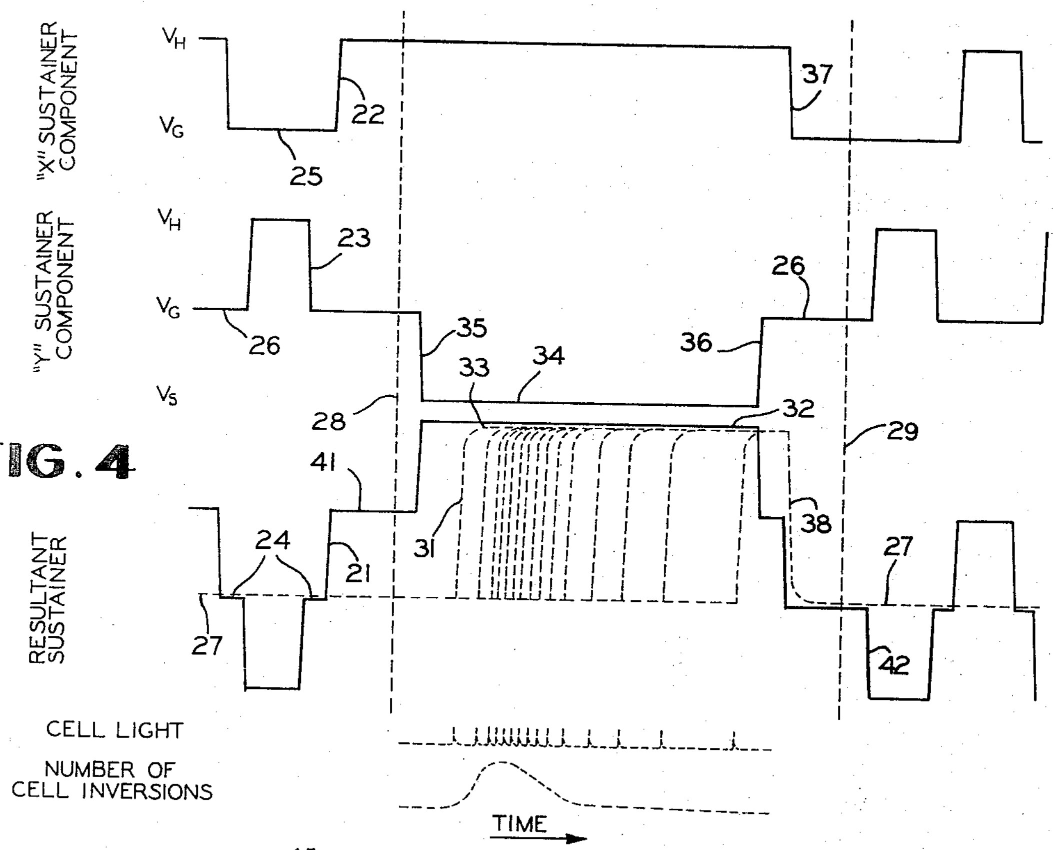

"X" SUSTAINER COMPONENT
"Y" SUSTAINER COMPONENT
RESULTANT SUSTAINER
$V_H$
$V_G$
$V_S$
22
25
23
26
35
33
34
36
26
37
28
41
21
24
27
31
32
38
29
27
42
CELL LIGHT
NUMBER OF CELL INVERSIONS
TIME

FIG. 4

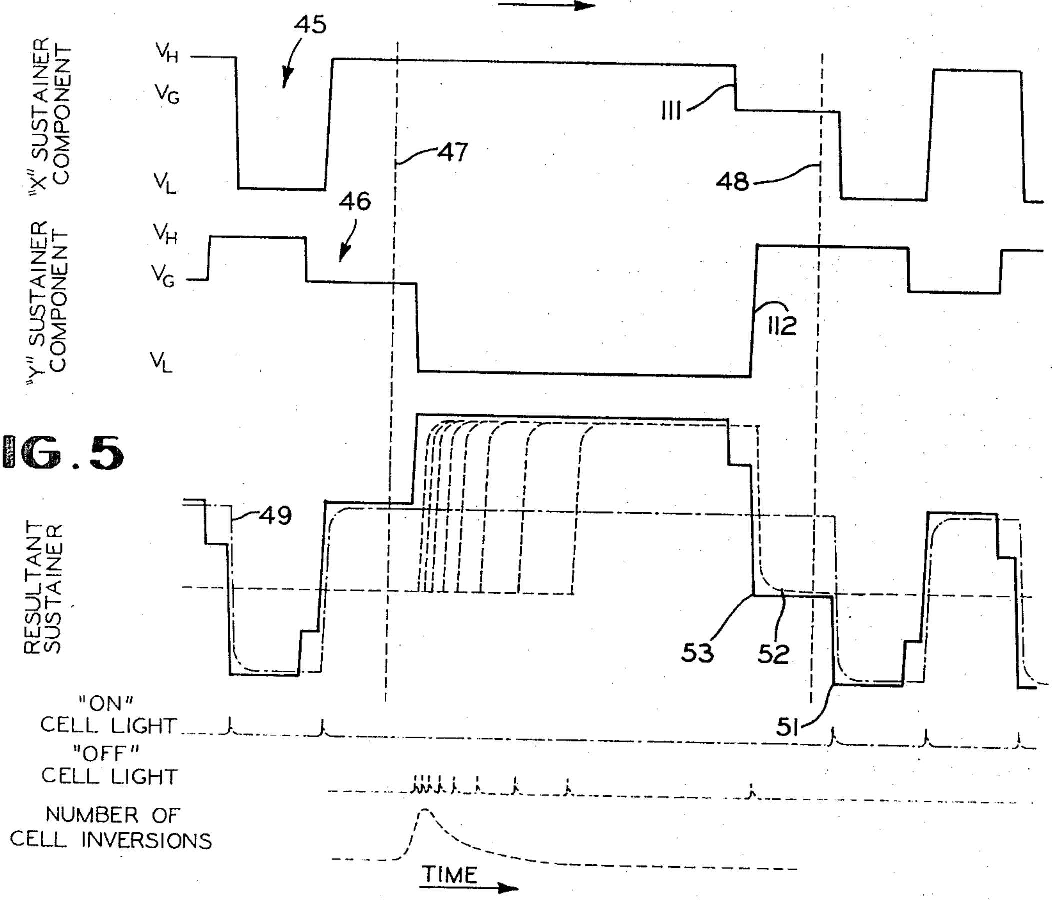

"X" SUSTAINER COMPONENT
"Y" SUSTAINER COMPONENT
RESULTANT SUSTAINER
$V_H$
$V_G$
$V_L$
45
46
47
48
111
112
49
53
52
51
"ON" CELL LIGHT
"OFF" CELL LIGHT
NUMBER OF CELL INVERSIONS
TIME

FIG. 5

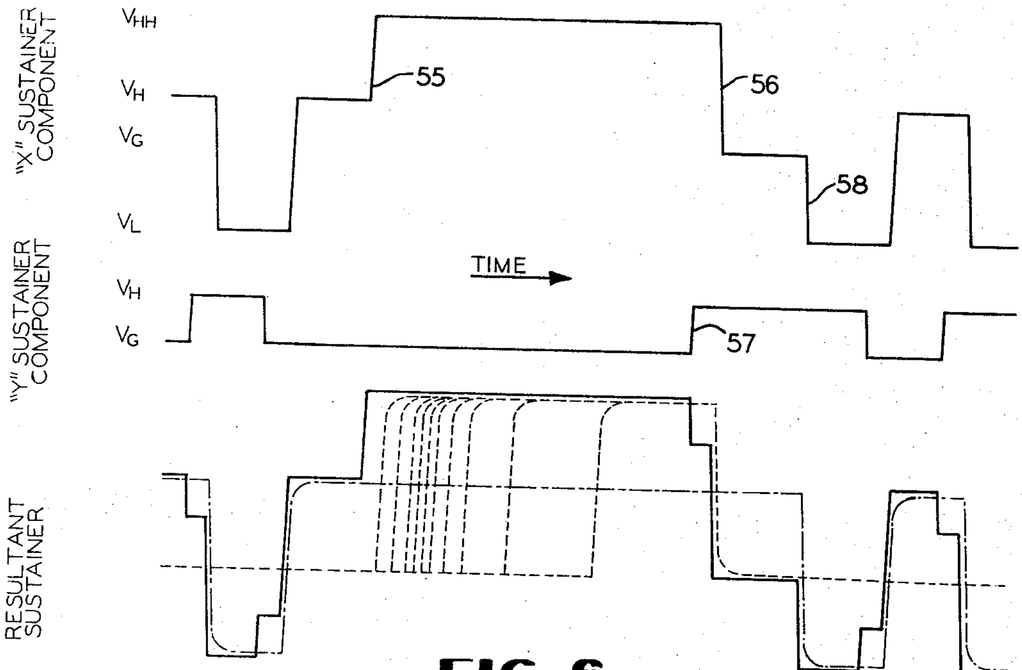

"X" SUSTAINER COMPONENT
$V_{HH}$
$V_H$
$V_G$
$V_L$
55
56
58
TIME
"Y" SUSTAINER COMPONENT
$V_H$
$V_G$
57
RESULTANT SUSTAINER

FIG. 6

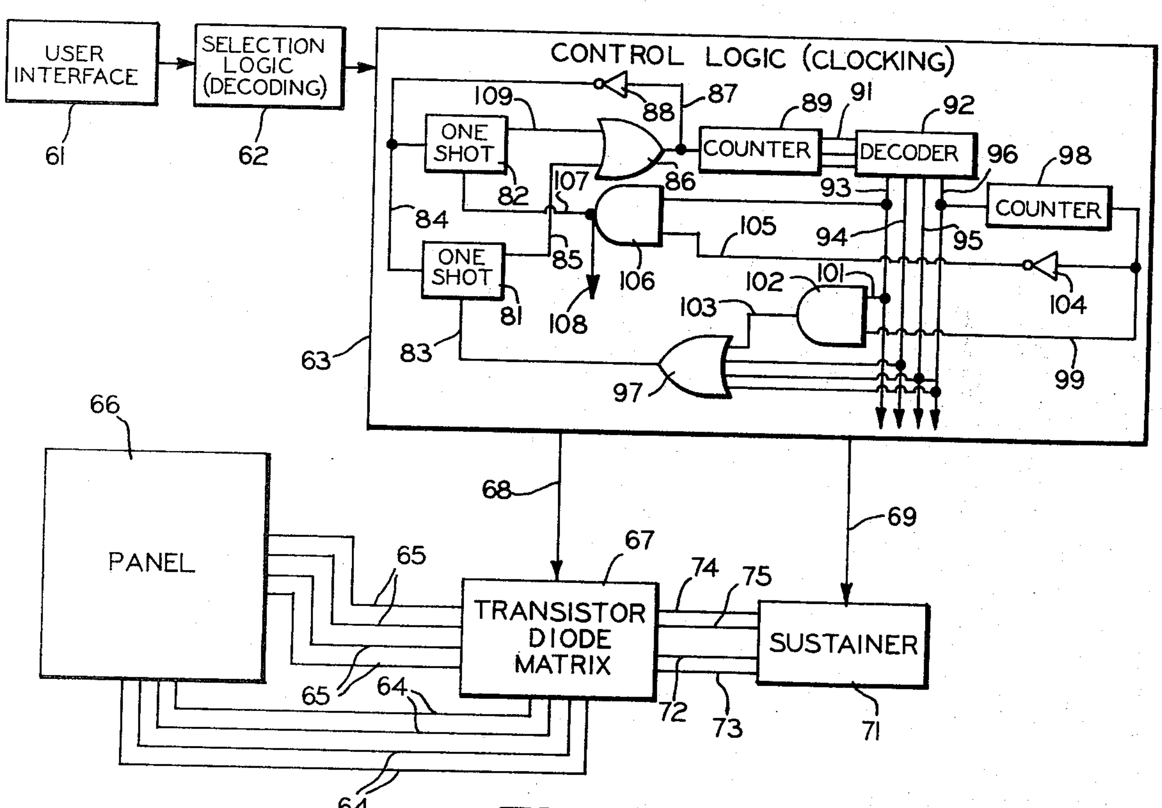

USER INTERFACE
61
SELECTION LOGIC (DECODING)
62
CONTROL LOGIC (CLOCKING)
63
ONE SHOT
ONE SHOT
COUNTER
DECODER
COUNTER
81
82
83
84
85
86
87
88
89
91
92
93
94
95
96
97
98
99
101
102
103
104
105
106
107
108
109
66
PANEL
68
69
67
TRANSISTOR DIODE MATRIX
SUSTAINER
65
65
64
64
74
75
72
73
71

FIG. 7

# ELECTRONIC CONDITIONING OF GAS DISCHARGE PANELS BY INVERSION INTERNAL EXTENSION

## RELATED APPLICATIONS

This application is related to applications for U.S. Pat., Ser. No. 372,553 entitled "Method of Driving and Addressing Gas Discharge Panels by Inversion Techniques" (Case S–12513) and U.S. Pat. Ser. No. 372,549 entitled "Circuits for Driving and Addressing Gas Discharge Panels by Inversion Techniques" (Case S–13030) both of which were filed herewith in the name of Jerry D. Schermerhorn.

## BACKGROUND OF THE INVENTION

### 1. FIELD OF THE INVENTION

This invention relates to gas discharge devices of the multiple discharge display/memory type which have an electrical memory and which are capable of producing a visual display or representation of data and more particularly to methods of priming or conditioning such devices for the institution of selective discharges.

### 2. DESCRIPTION OF THE PRIOR ART

Heretofore, multiple gas discharge display and/or memory panels have been proposed in the form of a pair of opposed dielectric charge storage members which are backed by electrodes, the electrodes being so formed and oriented with respect to an ionizable gaseous medium as to define a plurality of discrete gas discharge units or cells. The cells have been defined by surrounding or confining physical structure such as the walls of apertures in a perforated glass plate sandwiched between glass surfaces and they have been defined in an open space between glass or other dielectric backed by conductive electrode surfaces by appropriate choices of the gaseous medium, its pressure and the electrode geometry. In either structure, charges (electrons and ions) produced upon ionization of the gas volume of a selected discharge cell, when proper alternating operating voltages are applied between the opposed electrodes, are collected upon the surface of the dielectric at specifically defined locations and constitute an electrical field opposing the electrical field which created them so as to reduce the voltage and terminate the discharge for the remainder of the cycle portion during which the discharge producing polarity remains applied. These collected charges aid an applied voltage of the polarity opposite that which created them so as that they aid in the initiation of a discharge by imposing a total voltage across the gas sufficient to again initiate a discharge and a collection of changes. This repetitive and alternaing charge collection and ionization discharge constitutes an electrical memory.

An example of a panel structure containing nonphysically isolated or open discharge cells is disclosed in U.S. Pat. No. 3,499,167 issued to Theodore C. Baker, et al. Physically isolated cells have been disclosed in the article by D. L. Bitzer and H. G. Slottow entitled "The Plasma Display Panel — A Digitally Addressable Display With Inherent Memory" Proceeding of the Fall Joint Computer Conference, IEEE, San Francisco, California, November 1966, pp 541–547 and in U.S. Pat. No. 3,559,190.

One construction of a memory/display panel includes a continuous volume of ionizable gas confined between a pair of dielectric surfaces backed by conductor arrays typically in parallel lines with the arrays of lines orthogonally related to define in the region of the projected intersections, as viewed along the common perpendicular to each array, a plurality of opposed pairs of charge storage areas on the surfaces of the dielectric bounding or confining the gas. Many variations of the individual conductor form, the array form, their relationship to each other and to the dielectric and gas are available, hence the orthogonally related, parallel line arrays are discussed herein merely as illustrative.

In prior art, a wide variety of gases and gas mixtures have been utilized as the ionizable gaseous medium, it being desirable that the gas provide a copious supply of charges during discharge, be inert to the materials with which it comes in contact, and where a visual display is desired, be one which produces a visible light or radiation which stimulates a phosphor. Preferred embodiments of the display panel have utilized at least one rare gas, more preferrably at least two, selected from helium, neon, argon, krypton or xenon.

In an open cell Baker etal. type panel, the gas pressure and the electrical field are sufficient to laterally confine charges generated on discharge within elemental or discrete dielectric areas confined generally to a region in proximity to the registering projections of opposed electrodes through the dielectric layers and gas. 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 charged particles so as to condition at least one elemental volume other than the elemental volume in which the photons originated.

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 potential imposed, 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 spacing or discharge volumes and gas 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. devices.

In operation of the display/memory device an alternating voltage is applied, typically, by applying a first periodic voltage wave form to one array and applying a cooperating second wave form, frequently identical to and shifted on the time axis with respect to the first wave form, to the opposed array to impose a voltage across the cells formed by the opposed arrays of electrodes which is the algebraic sum of the first and second wave forms. The cells have a voltage at which a discharge is initiated. That voltage can be derived from externally applied voltage or a combination of wall charge potential and externally applied voltage. Ordinarily, the entire cell array is excited by an alternating voltage which, by itself, is of insufficient magnitude to ignite gas discharges in any of the elements. When the walls are appropriately charged, as by means of a previous discharge, the voltage applied across the element will be augmented, and a new discharge will be ignited. Electrons and ions again flow to the dielectric walls extinguishing the discharge; however, on the following half cycle their resultant wall charges again augment the applied external voltage and cause a discharge in the opposite direction. The sequence of electrical discharges is sustained by an alternating voltage signal that, by itself, has been designated $V_s$.

In addition to the sustaining voltage there are manipulating voltages or addressing voltages imposed on the opposed electrodes of a selected cell or cells to alter the state of those cells selectively. One such voltage termed a "writing voltage" transfers a cell or discharge site from the quiescent to the discharging state by virtue of a total applied voltage across the cell sufficient to make it probable that on subsequent sustaining voltage half cycles the cell will be in the "on state." A cell in the "on state" can be manipulated by an addressing voltage termed an "erase voltage" which transfers it to the "off state" by imposing sufficient voltage to draw off the surface or wall charges on the cell walls and cause them to discharge without being collected on the opposite cell walls so that succeeding sustainer voltage transitions are not augmented sufficiently by wall charges to ignite discharges.

A common method of producing writing voltages is to superimpose voltage pulses on a sustainer wave form in an aiding direction and cumulatively with the sustainer voltage, the combination having a potential of enough magnitude to fire an "off state" cell into the "on state." Erase voltages are produced by superimposing voltage pulses on a sustainer wave form in opposition to the sustainer voltage to develop a potential sufficient to cause a discharge in "on state" cells and draw the charges from the dielectric surfaces such that the cell will be in the "off state." The wall voltage of a discharged cell is termed an "off state" wall voltage and frequently is midway between the extreme magnitude limits of the sustainer voltage, 2 $V_s$. These manipulating signals are applied in a timed relationship with the alternating sustaining voltage, and through control of discharge intensity, accomplished selective state transitions by changing the wall voltage of only the cell being addressed.

Cells are transferred to the "on state" by applying a portion of the manipulating signal superimposed on the sustaining voltage termed a "select signal" on each of two opposed electrodes which constitute the cell. Conventionally, like sustaining signals are imposed on each electrode array so that half the sustaining voltage is imposed on each array and half the select signal is imposed on the addressed cell electrode in each electrode array at a time when the sum of the applied voltages is sufficient to ignite a discharge. Further, the partial select signals on each electrode are limited to a value which will not impose a "turn on" potential across other cells defined in part by that electrode and not selected. A typical write signal for a cell is developed by applying half select voltages to the addressed electrodes of the cell to be placed in the "on state") at a time the sustaining voltages are developing a pedestal potential somewhat below the maximum sustaining voltage. Typically, a write signal is imposed on each opposed electrode of the cell during the terminal portion of a sustain voltage half cycle when any wall charging which may result from the prior sustainer transient is substantially completed. The manipulating signal thus ignites a single, and unique, cell at the intersection of the selected two opposed electrodes. This ignited discharge thus establishes the cell in the "on state" since a quantity of charge is stored in the cell such that on each succeeding half cycle of the sustaining voltage, a gaseous discharge will be produced.

In order to erase a cell or transfer it to the "off state" the charge stored in the cell is discharged at a time when the sustaining voltage is imposing a voltage in opposition to the wall charge voltage. As for writing, the erase manipulation is facilitated if the sustaining voltage is at a pedestal level below the level providing the maximum applied voltage so that the erase half select voltages are at a convenient level. Typically an erase signal is imposed on each opposed electrode of the cell during the terminal portion of a sustain voltage half cycle, when the wall charging from the prior sustainer discharge is substantially completed, but preceeding the next half cycle alternation by enough time so that the wall discharge of the selected cell is substantially stabilized.

In the operation of a multiple gaseous discharge device, of the above described type, it is necessary to condition or prime the discrete elemental gas volume of each discharge cell by supplying at least one free electron thereto such that a gaseous discharge can be initiated when the cell is addressed with an appropriate voltage signal.

One such means of panel conditioning comprises periodically applying an electronic conditioning signal or write pulse to all of the panel discharge cells. However, electronic conditioning is self-conditioning and is only effective after a discharge cell has been conditioned previously; that is electronic conditioning involves periodically discharging a cell. Accordingly, one cannot wait too long between the periodically applied conditioning pulses since there must be at least one free electron present in order to discharge and condition a cell.

External radiation can be employed to condition a panel, as by flooding part or all of the gaseous medium of the panel with ultraviolet radiation. This is sometimes inconvenient since external radiation may not be available to the panel and at best, requires auxiliary equipment.

A frequently employed conditioning termed "internal conditioning" comprises using internal radiation such as from a radioactive material.

Photon conditioning where photons excite electrons as by impingement upon the dielectric surface of the cells is utilized by providing one or more pilot discharge cells maintained in the "on state" for the generation of photons. This is particularly effective in an open cell construction as disclosed by Baker et al. where 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 panel gas space so as to condition other elemental volumes of other discharge units. In addition to or in lieu of the pilot cells, other sources of photons internal to the panel may be used.

Internal photon conditioning may be unreliable when a given discharge unit to be addressed is remote in distance relative to the conditioning source. Accordingly, multiplicity of pilot cells may be required for the conditioning of a panel having a large area. In one highly convenient arrangement, the panel matrix border is comprised of a plurality of such pilot cells.

The priming or conditioning mechanism for the gaseous discharge devices involves metasable atoms, photons and electrons all of which can impinge upon the cell walls to generate additional starter electrons and/or collide with atoms in the gas of the cell to generate such electrons.

It has been suggested from observation of the operation of multicelled gaseous discharge display/memory devices that the reliability of transfer of selected cells from an "off state" of discharge to an "on state" is a function of the number of charged particles available in the cell site at the time a "turn on" signal is imposed on that cell. Even though the firing potential of the cell is imposed, conventionally as a signal addressed to the individual opposed conductors whose shadow region generally defines the discharge site of the cell to superimpose a voltage upon the sustainer voltage wave, not all cells so addressed will be turned "on." The probability of turn on is enhanced by the spatial proximity of an "on state" cell and the time proximity of that "on state" to the application of a firing voltage. Thus, cells widely spaced from an "on cell" or cells which have not either been in the "on state" or had nearby cells in the "on state" shortly before the application of a firing voltage will have less likelihood of responding to an imposed firing voltage than cells which have a nearby "on" cell or were recently exposed to an "on discharge state."

The observed reliability of transfer as a monotonically decreasing function of distance from a particle source suggests that the most reliable conditioning method is to periodically place each cell in the "on state" of discharge whereby conditioning particles are generated and maintained in its vicinity. Periodic electronic inversion of panels has been proposed for this purpose since such inversion conditions all "off" cells to an "on state" at regular intervals and, where the inversion interval is brief, those normally "on" cells are only briefly in an "off state" and are returned to the "on state" as the panel is reinverted.

Prior art electronic inversions have been performed by superimposing a d-c signal level on one or both sustainer components without altering the operating sequences of the sustainer. When employed for conditioning, it has been observed that electronic inversion must be imposed frequently in order to achieve acceptable reliability of cell operation. Since each inversion and reinversion of the panel generates at least two bursts of light from each cell successfully transferred to the "on state," a high rate of repetition of inversions increases the background lighting of the images represented by normally "on" cells and thus reduces the contrast for the display. A compromise has, therefore, been forced upon utilizations of electronic inversion conditioning between reliability and contrast ratio.

Inversion conditioning as disclosed in the aforenoted related patent applications involves periodic, momentary shifting of all cells of the panel which are normally in the "off state" to the "on state" and of all cells which are normally in the "on state" to the "off state" by an interchange of dissimilar sustainer component wave forms applied to the opposed conductor arrays of the device. In this manner the conditioning sources are distributed over the panel field and thus are proximate to all cells in the field and conditioning over the field is accomplished without loss of memory since upon reinversion of the panel the cells which are normally "on" will be returned to the "on state" and those normally "off" will be returned to the "off state." Also as disclosed in the related applications the inversion conditioning of the panel can be combined with pilot cell or panel matrix border conditioning.

It is desirable that all cells of a panel matrix have the requisite number of free electrons available at all times so that upon imposition of a firing voltage across the cell it transfers to an "on" discharge state. This suggests a relatively high frequency of inversions of the panel where inversion is the mechanism supplying free electrons. However, each change of discharge state in a cell involves the emission of light. A burst of light is generated for an "on" cell with each sustainer half cycle and when it is erased or transferred to the "off state" a light burst is issued during its discharge to the "off state" wall voltage level. As a result, if inversion conditioning were employed for a single sustainer cycle every other sustainer cycle, all cells would appear equally illuminated since they would issue an equal number of light bursts of like intensities for their respective transfers of state. No useful display for visual observation would result at the frequencies of sustainer employed.

It has been observed, when inversion of display panels is employed for conditioning employing regular periods of normal and inverted operation, that a single inversion interval of the regular sustainer period does not place all normally "off" cells in an "on state." These erratically operating cells then do not transfer to an "on" state when subjected to normal write select signals or when the call matrix has its discharge state inverted and cannot be turned "on" by erasure during an inversion when operated according to invert-erase writing technique of the aforenoted co-filed patent applications. This marginal operation can be reduced or even eliminated by increasing the frequency of the conditioning inversions although such increase decreases the visual contrast ratio of the display such that a doubling of the conditioning inversions essentially makes the image of the "on" cells half as bright relative to the background illumination.

In order to develop a visual contrast between "on" and "off" cells it has been proposed that the frequency of inversion be reduced. Ratios of four normal sustainer cycles to one inverted cycle and of 16 to 1 have been employed with acceptable visual contrast ratios for certain utilizations although a background glow is evident. Further, as the higher ratios are employed cell writing becomes marginal since the long intervals between conditioning inversions may result in erratic changes in discharge state from cell to cell.

An object of the present invention is to enhance the write reliability of cells in a multicelled discharge panel.

Another object is to enhance the contrast ratio of a display panel.

A third object is to extend the interval between discharge panel inversions where inversion conditioning is employed.

## SUMMARY OF THE INVENTION

This invention involves apparatus for and a method of operating multiple gas discharge display/memory devices conditioned by panel inversion. More particularly it involves extending the inversion interval beyond the normal sustainer voltage period whereby the opportunity for "off" cells to achieve an "on discharge state" during the inversion conditions is enhanced.

A feature of the invention is to apply the sustainer voltage which induces inversion of the panel in the initial sustainer excursion from a normal sustainer wave form for an interval substantially greater than a normal half sustainer cycle period. This extended interval preferrably is of a length sufficient to insure that all cells normally in the "off state" fire to the "on state." The succeeding half cycle of the inversion can be of normal sustainer half cycle duration.

Another feature is a sustainer clocking control which extends the conditioning inversion interval at regular intervals throughout the application of a normal sustainer wave form applied to a multiple gas discharge display/memory device.

## DESCRIPTION OF THE DRAWINGS

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

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

FIG. **3** is a plot of sustainer voltage applied across a display panel and of "on" and "off" cell wall voltage for that panel presented on a time base and illustrating two regular sustainer periods of the sustainer voltage shifted to a level causing panel inversion followed by a sustainer voltage shift to reinvert the panel to the normal or preponderant sustainer voltage form;

FIG. **4** is a generalized sustaining voltage wave form applied across a panel, typical cell wall voltages for such a wave form, and the component wave forms making up the resultant sustainer wave form; illustrating a resultant wave form comprised of two similar component sustainer wave forms, the production of a panel inverting condition by application of d-c voltage levels to the wave forms, the cell wall voltage, and light emitted all as a function of time;

FIG. **5** is a sustaining voltage wave form utilizing dissimilar component wave forms on the opposed arrays of conductors of the panel and including a means of shifting the resultant wave form by interchange of the components on the arrays to cause an inversion of discharge states in the panel for conditioning according to this invention and illustrating the distribution of the transfer of "off" cells to an "on state" with the time during the inversion both as changes in wall charge and bursts of light for the condition where none of cells in the panel were "on" during the normal sustainer cycles;

FIG. **6** is a sustaining voltage resultant wave form and its components utilizing dissimilar component wave forms and a superimposed direct current level on one component as the means of producing an inversion of the panel for conditioning;

FIG. **7** is a block diagram of a system applying the invention and including a detailed logic diagram for clocking the sustainer for an inversion conditioning cycle of extended length at regular intervals; and

FIG. **8** is a plot of sustainer voltage applied across opposed conductor arrays of a display/memory device and of "on" and "off" cell wall voltages all as a function of time to illustrate the cyclic extended inversion cycles between regular sustainer cycle intervals which can be of greater length than has been practiced theretofore.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

The method of conditioning multicelled, gaseous discharge display/memory devices according to this invention is applicable to various forms of such devices and can be accomplished by various techniques. Particular emphasis will be placed on the method as applied to display panel devices having two opposed spaced essentially planar parallel arrays of conductors each with their proximate surfaces covered with a dielectric and each supported on an individual spaced substrate. However, it is to be appreciated that the conditioning method can be applied to other forms of display/memory devices including those which have a single substrate to sustain opposed arrays having dielectric overlays and defining in their regions of proximity discrete discharge sites or cells. Further the techniques of altering the sustainer wave form to cause inversions in the discharge states of the cells will be discussed in detail with respect to wave forms and controls therefor wherein the change is by an interchange between the conductor arrays of the display/memory device of dissimilar sustainer component wave forms. Alternative wave forms will be discussed briefly, it being understood that the conditioning by discharge state inversion is accomplished by maintaining a long inversion interval relative to the interval of a normal sustainer half cycle for any of the techniques of sustainer voltage manipulation.

One form of multicelled gas discharge display/memory device to which the invention is applicable as illustrated in FIG. **1**, utilizes a pair of dielectric films **10** and **11** separated by a thin layer or volume of a gaseous discharge medium **12**, the medium 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 array on non-gas contacting sides of the dielectric members, each dielectric member presenting large open surface areas and a plurality of pairs of elemental X and Y areas. While the electrically operative structural members such as the dielectric members **10** and **11** and conductor arrays **13** and **14** are all relatively thin (being exaggerated in thickness in the drawings), they are formed on and supported by rigid non-conductive support members **16** and **17** respectively.

One or both non-conductive support members **16** and **17** pass light produced by discharges in the elemental gas volumes unless only the memory function is utilized, in which case they can be opaque. Advantageously, they are transparent glass. Members **16** and **17** essentially define the over-all thickness and strength of the panel. They serve as heat sinks for heat generated by discharges and thus minimize the effect of temperature on operation of the device. For example, the gas layer **12** is usually under 10 mils and typically about **4** to **6** mils in thickness as determined by spacer **15.** Dielectric layers **10** and **11** (over the conductors at the elemental or discrete X and Y areas) are usualy between 1 and 2 mils thick. Conductors **13** and **14** are about 8,000 angstroms thick and may be of transparent, semi-transparent, or opaque conductive material such as tin oxide, gold or aluminum.

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 member to form a bakeable hermetic seal enclosing and confining ionizable gas volume **12.** 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 for filling that space with the ionizable gas. For large panels, small beadlike solder glass spacers **15B** may be located between conductor intersections and fused to dielectric members **10** and **11** to aid in withstanding stress on the panel and maintain uniformity of thickness of gas volume **12.**

Conductor arrays **13** and **14** may be formed in situ on support members **16** and **17,** typically as parallel lines of about 3 mils width spaced 17 mils center to center and having a resistance less than about 1,000 ohms per linear inch of conductor line and usually less than 50 ohms per inch.

Dielectric layer members **10** and **11** are formed of an inorganic material and are preferrably formed in situ as an adherent film or coating which is not chemically or physically affected 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 of certain soda-lime glasses suitable, when in plate form, for support members **16** and **17.** Dielectric layers **10** and **11** must be smooth and have a dielectric strength of about 1,000 volts per mil and be electrically homogeneous on a microscopic scale (i.e., no cracks, bubbles, crystals, dirt, surface films or other irregularities). Also, the surfaces of dielectric layers **10** and **11** should be good photo-emitters of electrons. Alternatively, dielectric layers **10** and **11** may be overcoated with materials designed to produce good electron emission, as in U.S. Pat. No. 3,634,719, issued to Roger E. Ernsthausen. Where an optical display is desired, at least one of the dielectric layers and any overcoats should pass light.

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 external circuitry generically termed the "sustainer, 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 sustainer, interface and addressing circuitry **19.**

In normal usage of a multicelled gaseous discharge device as a display panel having memory, the preponderance of the cells is in one state of discharge to form a field upon which selected cells are in an opposite state of discharge. For example, the cells of the field are normally in an "off state" while the selected cells are in an "on state" to represent a desired bright image on a dark background. As represented on the left side of FIG. **3,** for two cycles of alternation of the sustainer voltage S the selected "on cells" have a wall charge voltage represented by the dot-dash line D which follows the major sustainer voltage transitions to values W. The values W approach the sustainer voltage levels and are of a polarity tending to neutralize the sustainer voltage. Electrons accumulate on the cell wall, the surface of dielectric **10** or **11** at the interface with gas **12,** at the area overlying the conductor of the cell upon which the sustainer voltage imposes the more positive potential while ions accumulate on the area overlying the conductor which has the more negative sustainer imposed potential. Upon reversal of the relative polarity of the sustainer voltage applied to the conductor arrays the cell wall voltage of "on" cells augments the sustainer sufficiently to cause those cells to again institute a gaseous discharge at instant T and emit a burst of light. At the frequency of alternations of a normal sustainer, typically 50 kilohertz, the eye integrates these bursts of light as a continuous glow localized to the cell area.

"Off" cells have a wall charge and a wall voltage resulting therefrom which is between the extreme excursions of the sustainer voltage as shown by the dashed line F and where the positive and negative excursions are equal is centered between those extremes as an essentially level value.

The discharge state of the cells in a display panel can be interchanged by shifting the sustainer voltage whereby the relationship of the wall charge levels to the sustainer voltage levels are interchanged. This interchange has been termed "panel inversion." Consider the sustainer wave form which is preponderant as the "normal" wave form which dictates the "normal" cell states. The sustainer voltage levels can be shifted as shown at the time instant A in FIG. **3** so that one excursion of that sustainer voltage is approximately $2V_s$ from the normal "off" cell wall voltage at N and no excursion of that shifted sustainer voltage from the normal "on" on cell wall voltage is great enough to achieve a discharge starting or sustaining value when the sustaining voltage is augmented by the normal "on" cell wall voltage. In the example the symmetrical wave form of the sustainer placed the "off" cell wall voltage at N half way between the extremes of the excursions $V_{s1}$ and $V_{s2}$ above and below N so that a shift of the sustainer to alternate between the values N and $V_{s3}$, a value **2** $V_s$ from N, places the value $V_{s1}$ half way between the extremes of the excursions. Since the value $V_{s1}$ is essentially the wall voltage level of a normally "on" cell, cells with that wall voltage at the time of the sustainer voltage shift are at the "off state" cell wall voltage for the shifted sustainer voltage and discharges will not occur in the normally "on" cells during sustainer transitions while the shifted sustainer is imposed upon those normally "on" cells. Further, since the sustainer excursion to the value $V_{s3}$ is $2V_s$ from the N level, the full sustainer voltage is augmented by the cell wall voltage previously established for the "off" cells during the normal cycles to cause those cells to have discharges during each sustainer transition while the shifted sustainer is imposed.

FIG. **3** illustrates a shift of the sustainer voltage for two cycles preceded and followed by normal sustainer cycles. The normally "on" cells having the wall voltage, wave form D, are in an "off state" for the interval between A and B as evidenced by the constant level wall charge during that interval. Normally "off" cells are transferred to an "on state" with the first transition of their wall charge shown for curve F at time A and are continued in that state for three additional transitions whereby at the time B they are at the wall charge voltage N.

At time B the sustainer is illustrated as returned to the normal levels and the panel is reinverted such that the cells which were "off" during the inversion interval have a wall charge voltage which is essentially 2 $V_s$ from the excursion of the sustainer to $V_{s2}$. This wall charge is sufficient to augment the sustainer voltage to institute a discharge in those cells. The cells which were "on" during the shift of the sustainer voltage for panel inversion are returned to the "off state" since their wall charge level at N offers insufficient augmentation of the sustainer transitions to sustain their discharges.

It is to be appreciated that while the inversion illustrated was by a positive going shift of the sustainer, panel inversion can be accomplished by a negative going shift, as, in fact, was the case at instant B in FIG. 3. Further, it should be recognized that while it is convenient to operate at or near ground external of the panel as the reference value from which the sustainer voltage makes positive and negative excursions, so far as the internal potentials imposed on the panel are concerned the reference level can be at any convenient level such that both the negative and positive going excursions of the sustainer voltage can be at positive or negative levels relative to external ground.

A generalized resultant sustainer wave form **21** showing an extended half cycle which tends to invert the state of cells in the panel to which it is applied is set forth in FIG. **4.** That resultant sustainer is made up of components **22** and **23** applied to the conductors **13–1** . . . **13–4** of the *x* array and to conductors **14–1** . . . **14–4** of the *y* array respectively. Each component has a magnitude of $V_s$ so that when combined in phase opposition they impose 2 $V_s$ or a sustaining voltage across the cell to which they are applied, typically about 220 volts. By definition this sustaining voltage is below the firing voltage of the panel cells yet is of such magnitude as to maintain a cell in the "on state" of discharge once it is placed in that state.

The resultant sustainer includes pedestals **24** developed by restricting excursions from the reference levels **25** and **26** of the *x* and *y* components to less than a half period, as illustrated for about 135°. Manipulation of the discharge state of individual cells is accomplished by superimposing signals addressed to the cells on the sustainer components to augment the sustainer and increase the voltage across the cells above their firing voltage in the case of a "write" or "turn on" manipulation and to oppose the sustainer and draw off the wall charge of the cell without collecting an opposite wall charge in the case of an "erase" or "turn off" manipulation (all by well-known means, not shown).

FIG. **4** represents a sustainer applied to a panel having all cells in the "off state" as evidenced by the common "off state" wall charge level **27** shown in dashed lines on the resultant wave form. During normal sustainer cycles, as represented prior to the instant **28** and subsequent to the instant **29,** the wall charge of all cells in the "off state" remains approximately midway between the extremes in the excursion of the resultant sustainer.

Since it is the voltage across the gas **12** which is significant in determining the state of discharge of the cells, and the excursions of the sustainer voltage in the resultant wave form from the "off state" wall charge level of "off" cells is one half of the value required to sustain an "on state" for the cells, a shift of the sustainer to a value of 2 $V_s$ from the "off state" wall voltage will place the normal "off state" wall charge voltage level **27** at a value which augments the sustainer sufficiently to exceed the voltage required to initiate a discharge in the cells. This firing of the cells of the panel matrix is represented in FIG. **3** by excursions **31** of the wall charge level from the normal "off state" **27** toward the displaced level **32** as at **33.** In the example, the sustainer voltage shift is accomplished by superimposing a negative d-c level of $V_s$ on the *y* sustainer component (illustrated to level **34** beginning at time **35)** while maintaining the magnitude of the *x* sustainer component **22** at $V_H$. When the *y* sustainer component is reduced to the reference voltage level $V_G$, illustrated at **26** at time **36,** and shortly thereafter the *x* sustainer component **22** is shifted from level $V_s$ to its reference level **25** at time **37,** a voltage which is effectively 2 $V_s$ augmented by the wall charge level **33** is imposed across the cell and it is discharged to the opposite polarity as at **38.** At this wall charge level, a return to the normal sustainer voltage wave form by removal of the $V_s$ d-c level will place the wall charge at the normal "off state" wall charge level **27** and terminate the "on state" of discharge established during the application of that supplemental voltage.

The shift in sustainer resultant wave form during imposition of the $V_s$ d-c level provides a transition condition from "on" to "off" for the wall charge levels of cells which are in the "on state" normally. Thus an "on" cell would have a wall charge level (not shown) at or near the sustainer level **41.** Upon the shift of the sustainer by a value $V_s$ the level **41** is at the midpoint of the displaced sustainer excursions effectively placing the normal "on state" wall charge at the neutral level for the shifted sustainer levels. As a result, the normally "on" cells have a wall charge during the inverting interval which does not augment the sustainer alternations to the cell firing potential and the cells are in the "off state" with reference to the shifted wave form. Upon return to the normal wave form at time **29,** the wall charge level of the cells which were "off" during inverting conditions is retained and is therefore again at a level which augments the sustainer transition at **42** sufficiently to impose the firing potential across those cells and return them to the "on state."

The sustainer wave depicted is generated by clocking a group of switches to the voltage levels on the sustainer component wave forms such that each array is subjected to a pull up signal to $V_H$ followed in a given interval by a pull down signal to the reference level, typically ground or a slight offset from ground $V_G$ followed by a repetition of the cycle. According to the present invention reliable conditioning can be achieved where the normal sustainer alternations are imposed for intervals of about a millisecond provided the inversion producing interval is of the order of 40 microseconds. Typically, a 50 kilohertz sustainer can have 50 cycles of normal wave form between inversion cycles (a single inversion cycle is illustrated between times **28** and 29 of FIG. 4). It is to be appreciated that the values given here are exemplary and that enhanced reliability of conditioning of the cells is realized as a function of the increasing length of the inversion producing interval.

The time relationships appear to be a function of the frequency of conditioning. More frequent inversion producing intervals in a panel having no normally "on" cells cause the cells to transfer to an on state earlier in the inversion producing interval and to have their times of transfer more bunched along the time axis than for the same cell operated with widely spaced inversion producing intervals. Since the inversion producing interval (the time from 28 to 29 in FIG. 4) should be of sufficient length to insure that all cells in the panel are inverted under the most adverse conditions of operation, with no cells "on" during the preceding normal sustainer interval (the time from 29 to 28 of the next inversion interval) a relationship between normal sustainer interval length and inversion producing interval length exists dictating that the inversion interval should be increased as the sustainer interval is increased.

FIG. 4 illustrates a broad spread of the distribution of cell discharges during the initial excursion period of the inversion producing interval between the transitions at 35 and 36 which is typical of a long interval of normal sustainer cycles preceding each inversion producing interval. It will be noted that in the absence of discharged cells during the interval of normal sustainer cycles a delay is experienced before cells begin to discharge, the greatest density of inversions is about a half a normal sustainer period after the sustainer transition, and the density gradually decays in a generally exponential form over the remainder of the interval. The discharges are illustrated in FIGS. 4 and 5 in a qualitative but not quantitative manner hence they should be interpreted only as illustrative of general operating characteristics for a panel. While the illustrations will contemplate a 50 kilohertz sustainer having 20 microsecond periods with an operating cycle of 50 normal sustainer cycles, a 40 microsecond inversion producing interval, a 10 microsecond half cycle of alternation of the sustainer to discharge all cells which have been placed in the "on state" to the opposite polarity, and a return to the normal sustainer, it is to be understood that sustainer frequency can be changed over a wide range. The inversion producing interval can be changed within lower limits of achieving the shift in discharge state for essentially all cells and upper limits which are imposed in practice by system interfacing constraints and brightness considerations. Further, the second half cycle of the inverting sustainer voltage need not be at the normal sustainer frequency although use of such frequency is convenient.

FIG. 5 shows another combination of sustainer component wave forms which produces a resultant sustainer of the same effective form as that of FIG. 4 including a time extended first half cycle of an inversion producing shift of the resultant sustainer. The sustainer components in this instance are of the form set forth in the aforenoted co-pending patent applications where they are dissimilar. Typically, the $x$ component 45 normally shifts between a value $V_H$ above a reference level $V_G$ (ground) and a value $V_L$ below the reference level an amount at least equal to $|V_H|$ and preferrably about twice $|V_H|$, and the $y$ component 46 shifts between $V_H$ and $V_G$. Inverting conditions are imposed by an interchange of the wave forms on the arrays at times 47 and 48 so that the $x$ component shifts between $V_H$ and $V_G$ and the $y$ component shifts between $V_H$ and $V_L$. The inversion producing interval effectively shifts the resultant sustainer an amount $V_s$ so that the "off state" cell wall voltage for the previously imposed sustainer is at the "on state" cell wall voltage relative to the new sustainer level and the "on state" cell wall voltage for the previously imposed sustainer is at the "off state" cell wall voltage relative to that new sustainer level.

FIG. 5 also represents a panel having cells in the "on state" during the normal sustainer interval. The wall charge 49 of those normally "on" cells is shown in dot-dash lines. It involves a transition with each normal alternation of the sustainer to a value approaching the extreme of the flat topped sustainer. Each such transition is accompanied by a burst of light, as illustrated in dot-dash lines, utilized in the display function of the panel. Upon shift of the sustainer to the inversion inducing state, the conditioning effect of the cells which were "on" during the normal sustainer quickly initiates discharges of the nromally "off" cells. The distribution of discharges in this instance is more peaked and tends toward completion earlier in the inversion producing interval.

FIGS. 4 and 5 illustrate that the ranges of distribution and speed of shift of "off" cells to the "on state" are a function of the time proximity of "on state" cells in the panel to the inversion producing interval. While it typically requires about a half sustainer period (10 microseconds) for the density of inverting cells to peak and may require 40 microseconds to essentially invert all cells in the panel where no cells were in the "on state" and no auxiliary conditioning is applied, when cells in significant numbers and general distribution over the panel are "on" at the time the inversion producing signal is imposed, the cells in large measure respond within the normal operating speeds of regular sustain manipulations. This produces a distribution of discharges sharply peaked within a few microseconds of the sustainer shift and essentially complete inversion of the panel in 10 to 20 microseconds.

A convenient feature of the wave form of FIG. 5 is electronic exchange symmetry on the $x$ and $y$ arrays. Each can be controlled by normally open transistor switches having emitter-collector circuits coupled between sources of the desired voltage levels and busses for the display connector lines to the arrays. Such circuits are shown in the aforenoted co-pending applications so that the $x$ and $y$ arrays each have a pull-up to $V_H$ circuit, a pull to ground $V_G$ circuit, and a pull-down to $V_L$ circuit. The regular operation of these circuits can be accomplished by conventional TTL logic wherein clocking functions are performed by one-shot multivibrators. In the illustrated wave form of FIG. 5 the extended interval can be achieved by extending the interval between the turn on of the pull to $V_L$ and the turn on of the pull to $V_H$ circuits on the $y$ component, in the example for 40 microseconds, while holding the pull to ground $V_G$ in abeyance on the $V_H$ level imposed on the $x$ component during that interval. The second half of the cycle for cell inversion is at the regular sustainer half cycle period following which the sustainer components are shifted back to their normal states. This returns the normally "on" cells which have been "off" during the inversion to an "on state" since their wall charge is at an "on" level and augments the sustainer sufficiently at **51** to cause a discharge. Conversely, at this time the normally "off" cells have their wall charge transferred to a level **52** on the second half cycle of the inversion producing sustainer at **53** so that with the return to a normal sustainer, the level coincides with the normal "off state" level and the cells are returned to their normally "off state."

Another wave form construction is considered in FIG. **6**. The sustainer components for FIG. **6** are normally those employed for FIG. **5**. However, inversion is accomplished by superimposing a higher level on the *x* component as to level $V_{HH}$, at time **55** while the *y* component is held at $V_G$. The *y* component is raised at **57** to $V_H$ and the *x* component is pulled to ground at **56** for the second half of the inversion cycle. After the reverse discharge of the "on state" cells has had an opportunity to stabilize, the sustainer can be reinverted at **58** by shifting the *x* component to $V_L$ and in due course switching the *y* component from $V_H$ to $V_G$, from which condition the regular sustainer sequence can be continued.

A general block diagram with an extended inversion interval clocking means is shown in FIG. **7**. Signals for manipulating the individual cells of the panel between their "on" and "off" discharge states for useful display/memory purposes are derived at a user interface **61** which can be a typewriter, a computer or even a direct image source. The signals are decoded by means of selection logic **62** to identify the row and column electrodes of the *y* and *x* array which define the cells to be manipulated. Control logic **63** provides the clocking of the signals for the sustainer components and synchronized therewith the addressed "write" and "erase" pulses which augment or oppose the sustainer components at appropriate times to place the selected cells in an "on" or "off" state. Selection signals from the selection logic **62** control the manipulating signals which are directed to the *x* and *y* display lines **64** and **65** of panel **66** and are routed through a transistor-diode matrix **67** as determined by signals on leads **68**. Sustainer sequencing signals are passed from control logic **63** on leads **69** to the sustainer signal source and switch controls **71** from which sustainer signal levels are issued to the transistor-diode matrix **67** on a pull-up and pull-down buss for the *x* array **72** and **73** and similar busses **74** and **75** for the *y* array. The sustainer **71** and the transistor-diode matrix **67** are shown in greater detail in the co-pending aforementioned patent application entitled "Circuits For Driving and Addressing Gas Discharge Panels By Inversion Techniques" to produce wave forms as particularly set forth in FIG. **5**.

The logic circuit for clocking the sustainer components is shown in a generalized form within the control logic **63**. It essentially comprises a normal interval defining one shot **81** gated to an on condition except during the extended inversion producing interval defined by a long interval one shot **82**. Each of the one-shots is self-triggering. Assume that one-shot **81** operates on a 2.5 microsecond interval and that it has a gating signal on lead **83** and a triggering signal is imposed on trigger lead **84**. Upon expiration of 2.5 microseconds a pulse is issued on output lead **85** to OR **86** which issues another trigger signal to **87** inverter **88** and trigger input **84** for another cycle from **81**. OR **86** also issues a pulse to counter **89**. Count on counter outputs **91** enters decoder **92** from which decoded signals issued on leads **93, 94, 95** and **96** in the sequence appropriate to turn on the normally open transistor switches of the several pull-up, pull-down and pull-to-ground circuits for the sustainer wave form generating sequence. The output of the decoder is ored in OR **97** to gate **83** of one shot **81** to maintain its operations for a number of wave form cycles between the inversion producing cycle as determined by counter **98**. Where 50 cycles are desired, counter **98** issues on output **99** a signal in response to every fiftieth completion of a normal sustainer cycle. The cycle completion is signified by the signal on lead **96** to counter **98**. When an output issues on lead **99**, it inhibits the transmittal of the gating signal from lead **93** through lead **101** and AND **102** to input **103** for OR **97**. The output signal on lead **99** is inverted to an enable signal at inverter **104** and passed on lead **105** to AND **106**. AND **106** is also subject to the gating signal on lead **93** so that the signal inhibited in AND **102** is enabled in AND **106**. One shot **82** is thus gated by the signal on output lead **107** from AND **106** and is triggered from lead **84** to begin its long interval defining the initial long inversion producing interval. The signal at **107** also turns on the *y* array pull-down to $V_L$ switch at output **108** to develop the inversion producing sustainer level.

When one shot **82** times out, after 40 microseconds in the example, it issues a signal at output **109** to OR **86** whereby a triggering signal is passed on lead **87** through inverter **88** and trigger input **84** and one shot **81**. That timed signal is also passed to the gate lead **83** for one shot **81** since the inhibiting signal from counter **98** does not persist beyond the 2.5 microseconds of the next clocked pulse issued on lead **93** of decoder **92** and subsequent pulses are ORed through **97** to lead **83**.

Decoder is thus pulsed at the clocking rate of one shot **81** for all but the first inversion producing shift of the sustainer. That is one shot **81** clocks the second half of the inversion interval as determined in the decoder to pull the *x* component down to $V_G$ at **111** of FIG. **5**, then pull the *y* component up to $V_H$ at **112**, then pull the *x* component down to $V_L$ as it initiates its regular routine for defining the next 50 normal sustainer cycles.

The logic diagram is merely illustrative of a clocking arrangement including means to regularly clock a predetermined number of normal sustainer cycles, means to shift the sustainer to a cell inversion producing condition for a long interval relative to a normal sustainer half cycle, means to shift the polarity of the inversion producing condition, and means to reinvert to the normal sustainer form to initiate a repetition of the routine. Many other arrangements can be utilized to produce the wave form of FIG. **5** and the techniques illustrated can also be adopted for production of wave forms as shown in FIGS. **4** and **6**.

FIG. **8** represents the applied sustainer voltage levels for portions of three intervals in which normal sustainer trains of alternations have inverting sustainer cycles interposed between each train. Prior to instant **111**, a 50 cycle train of 50 kilohertz sustainer cycles (i.e., an application of such a train for a millisecond) is imposed on the display/memory device. The first half of the inversion cycle between instant **111** and instant **112** represents an extension of the time interval in which the excursion of the inverting sustainer in the direction augmenting the inverting shift (a positive going excursion for this example) is imposed which is several times the period of a normal sustainer positive going excursion. The second half of the inversion cycle between instant **112** and **113** corresponds in its duration to the duration of a negative going half cycle of the normal sustainer. The wave form between instants **113** and **114** is shown broken away for convenience of illustration and is ordinarily a train of another 50 cycles of normal sustainer followed at time **114** by an extended inversion cycle of the same form as that between instants **111** and **113** for conditioning the device. This sequence of plural cycle trains of normal sustainer voltage cycles with interposed extended inversion sustainer cycles can be repeated throughout operation of the display/memory device to maintain it conditioned for reliable write operations.

It is not intended that limits be set on the interval length or number of normal sustainer cycles between the inversion producing intervals or upon the length of the inversion producing intervals other than that one interval, advantageously the first, is of a length greater than the normal sustainer wave half period. With increase in the length of this invention producing interval the probability that a discharge will occur is improved for each cell so that less frequent keep-alive inversions are required, resulting in a greater contrast ratio for display panels, and so that more reliability is achieved in addressing the cells to turn them to an "on state." The technique of inversion interval extension is of particular advantage in maintaining a sufficient metastable level at every cell in the panel so that conditioning by remote cells, the pilot or border cells, is not necessary. This extension of the interval an inverting sustainer level is maintained appears to allow time for conditioning of every cell of the panel. The extended interval presumably has this effect for two reasons. First of all, if the metastable density in an "off" cell has decayed to the point where metastable action generates starting electrons infrequently, the longer interval increases the probability that one of these starting electrons will be effective during the interval in initiating a discharge. Secondly, the long interval allows for the propagation of conditioning from those cells which fire early in the interval to others which fire later either by photon conditioning or by step-by-step transfer of charged or excited particles from each to its neighbors.

It is contemplated that a display device or panel can be conditioned by an extended inversion time interval at regular intervals each of which occurs between successive trains of normal sustainer voltage cycles of a predetermined number of cycles. The conditioning can also be performed by inversion intervals the length of time spacing of application of which is adjusted according to the interval or normal pulse train length between the transfer of substantial numbers of cells to the "on state," such transfers occurring, for example, where the inversion-erase-writing technique of the aforenoted patent application disclosures is employed.

In view of the variants available in the practice of this invention it is to be understood that the above disclosure is to be read as illustrative and not in a limiting sense.

What is claimed is:

**1.** The method of operating a gas discharge display/-memory panel of the type in which a discharge in an enclosed ionizable gas generates charges alternately collectible on pairs of discrete areas of spaced dielectric surfaces which are backed by conductors of first and second conductor arrays respectively to define a plurality of discharge cells, each including a pair of opposed discrete charge storage areas comprising:

applying trains of a plurality of cycles of a first alternating sustaining voltage wave form having a regular cycle period across the first and second conductor arrays;

selectively interposing between said trains a second alternating sustaining voltage wave form having levels displaced from the first sustaining voltage to apply voltages across the first and second conductor arrays tending to invert the discharge states of all cells comprised of conductors of the first and second conductor arrays from the discharge states established for those cells during application of the first sustaining voltage; and

extending the time interval of application of an excursion of the second sustaining voltage in the direction of the displacement of the second sustaining voltage from the first sustaining voltage for a time interval exceeding the time interval of an excursion in that direction of the regular cycle of the first sustaining voltage wave form.

**2.** The method according to claim **1** including the step of maintaining each train of the first alternating sustaining voltage wave form for a long interval relative to the interval of application of the second alternating sustaining voltage wave form.

**3.** The method according to claim **1** wherein the step of extending the excursion of the second sustaining voltage is during the initial excursion of the second sustaining voltage in the direction of the displacement of the second sustaining voltage from the first sustaining voltage.

**4.** The method according to claim **2** wherein the length of the extended interval of excursion is a direct function of the length of the interval the train of cycles of the first sustaining voltage is maintained between applications of the second sustaining voltage wave form.

**5.** The method according to claim **2** wherein the interval the train of cycles of the first sustaining voltage wave form is applied is of the order of a millisecond.

**6.** The method according to claim **1** wherein the regular period is of the order of 20 microseconds and wherein the extension of the excursion of the second sustaining voltage is of the order of 40 microseconds.

**7.** The method of operating a gas discharge display/-memory panel of the type in which a discharge in an enclosed ionizable gas generates charges alternately collectible on pairs of discrete areas of spaced dielectric surfaces which are backed by conductors of first and second conductor arrays respectively, each pair of opposed discrete charge storage areas comprising a discharge cell, comprising:

imposing trains of a plurality of cycles of a first alternating sustainer voltage wave form having a regular cycle period between the first and second conductor arrays to develop a first "off" cell wall voltage for cells in the "off" discharge state and a first "on" discharge state periodic alternating wall voltage for cells in the "on" discharge state having charges alternately collectible on the dielectric surfaces;

between each train of the first alternating voltage shifting the sustainer voltage level applied between the first and second conductor arrays to an inversion level which has an inversion "off" cell wall voltage for cells in the "off" discharge state which is essentially at the cell wall voltage level of the first "on" discharge state cell wall voltage and which has an inversion "on" cell wall voltage for cells in the "on" discharge state which is essentially at the cell wall voltage level of the first "off" discharge state cell wall voltage, whereby those cells in the "off" discharge state during imposition of the first sustainer voltage tend to be shifted to the "on" discharge state during imposition of the inversion level voltage and those cells in the "on" discharge state during imposition of the first sustainer voltage tend to be shifted to the "off" discharge state during imposition of the inversion level voltage;

maintaining the sustainer voltage shift for a time interval exceeding half the time interval of a regular period of the first sustainer voltage wave form to facilitate the transfer of cells which were in the "off" discharge state during imposition of the first sustainer voltage to the "on" discharge state during the period of said shift; and

shifting the sustainer voltage level to a level near the first "off" cell wall voltage whereby the cells transferred to the "on" state during the maintained shift of sustainer level have a cell wall voltage level near the first "off" cell wall voltage.

**8.** The method according to claim **7** including the step of maintaining the first alternating sustainer voltage wave form for a long interval relative to the interval the shift of the sustainer voltage level to the inversion level is maintained.

**9.** The method according to claim **8** wherein the length of the interval of the shift of the sustainer voltage level to the inversion level is a direct function of the length of the interval the alternating sustainer voltage wave form is maintained.

**10.** The method according to claim **8** wherein the interval the first alternating sustainer voltage wave form is maintained is of the order of a millisecond.

**11.** The method according to claim **7** wherein the regular period is of the order of twenty microseconds and wherein the maintained interval is of the order of 40 microseconds.

**12.** The method according to claim **7** wherein the shift of the sustainer voltage level near the first "off" cell wall voltage is maintained for an interval of the order of one half the regular period.

**13.** The method according to claim **7** wherein the interval the sustainer voltage level is shifted to the inversion level is of the order of 40 microseconds.

**14.** The method according to claim **7** wherein the first alternating sustainer voltage is produced by:

alternately shifting the component of the sustainer applied to a first array of conductors between a reference voltage and a first small voltage displaced from the reference voltage;

alternately shifting the component of the sustainer applied to a second array of conductors between a second small voltage of the general magnitude and direction from the reference voltage of said first small voltage and a third voltage at least equal to the second voltage in magnitude and in a direction from the reference voltage opposite the second voltage;

wherein the shift to said inversion level is produced by shifting the component applied to the second array to the second small voltage and shifting the component applied to the first array to a fourth voltage displaced from the reference voltage opposite the first voltage and of a value of the general magnitude of the third voltage; and

wherein the shift to the first "off" cell wall voltage is produced by shifting the component applied to the second array to the reference voltage level and shifting the component applied to the first array to the fourth voltage level.



**15.** The method according to claim **14** wherein the first voltage equals the second voltage and the third voltage equals the fourth voltage.

**16.** In a circuit for maintaining a distribution of starting charge particles in a gas discharge display/memory panel of the type in which a discharge in an enclosed ionizable gas generates charges alternately collectible on pairs of discrete areas of spaced dielectric surfaces which are backed by conductors of first and second conductor arrays respectively to define a plurality of discharge cells each including a pair of opposed discrete charge storage areas comprising, means for applying successive trains of cycles of a first level sustaining voltage across said first and second conductor arrays alternating at regular cycle periods; means effective between successive trains for selectively shifting said sustaining voltage to a second-level to apply voltages across said first and second conductor arrays tending to invert the discharge state of all cells comprised of conductors of said first and second conductor arrays; and means to extend the time interval of an excursion of the shifted sustaining voltage in the direction augmented by said shifted level for an interval exceeding the interval of such excursion during a regular period for said first level sustaining voltage.

**17.** The circuit according to claim **16** wherein said extending means defines an interval which is at least several times said excursion during a regular period.

**18.** The circuit according to claim **16** wherein said extending means is operated during the initial excursion of said shifted sustaining voltage.

**19.** The circuit according to claim **16** including means to actuate said shifting means in response to the application of a predetermined number of alternations of the first level sustaining voltage by said applying means.

**20.** The circuit according to claim **18** wherein said shifting means includes means for applying one cycle of alternation of the sustaining voltage at the second level; means to terminate application of the sustaining voltage at the second level and to apply the first level sustaining voltage upon the completion of one cycle of alternation of the sustaining voltage at the second level.

**21.** The circuit according to claim **16** wherein said applying means includes a first clock means having a given period which establishes the regular periods of the sustaining voltage alternations; and wherein said shifting means includes a second clocking means having a second given period at least several times said first mentioned given period.

**22.** The circuit according to claim **16** including means to generate an excursion of the shifted sustaining voltage in the direction opposite the shifted level for an interval equal to the interval of an excursion in said direction of a regular period of the sustaining voltage.

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