United States Patent

Slottow et al.

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[45] **Apr. 4, 1972**

[54] METHODS AND APPARATUS FOR OBTAINING VARIABLE INTENSITY AND MULTISTABLE STATES IN A PLASMA PANEL

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[73] Assignee: **University of Illinois Foundation,** Urbana, Ill.

[22] Filed: **Oct. 29, 1970**

[21] Appl. No.: **85,160**

[52] **U.S. Cl.** .....**178/7.3 D,** 178/75 D, 315/169 TV

[51] **Int. Cl.** **H04n 5/66**

[58] **Field of Search** .....315/167, 168, 169, 189; 178/6.7 A, 6, 7.3 D, 7.5

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Assistant Examiner—Richard P. Lange
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[57] **ABSTRACT**

Techniques for providing multiple states and variable intensity in a gaseous discharge device known in the art as "plasma panel" or "plasma display panel." A method and apparatus for imparting information to a plasma display panel to produce an image of several intensity levels, and the preserving of this image on the panel until new information is received by the panel. The information that controls the intensity at a given cell is imparted in the form of a voltage but at a selected time creates a control discharge at the selected cell. The discharge creates a wall voltage at the cell that at the time of the discharge is characteristic of a particular stable sequence of discharges, and of an average intensity that is produced by this sequence. Several different discharge sequences each with a characteristic intensity are possible, and each can be initiated by setting the appropriate wall voltage at the appropriate time.

11 Claims, 13 Drawing Figures

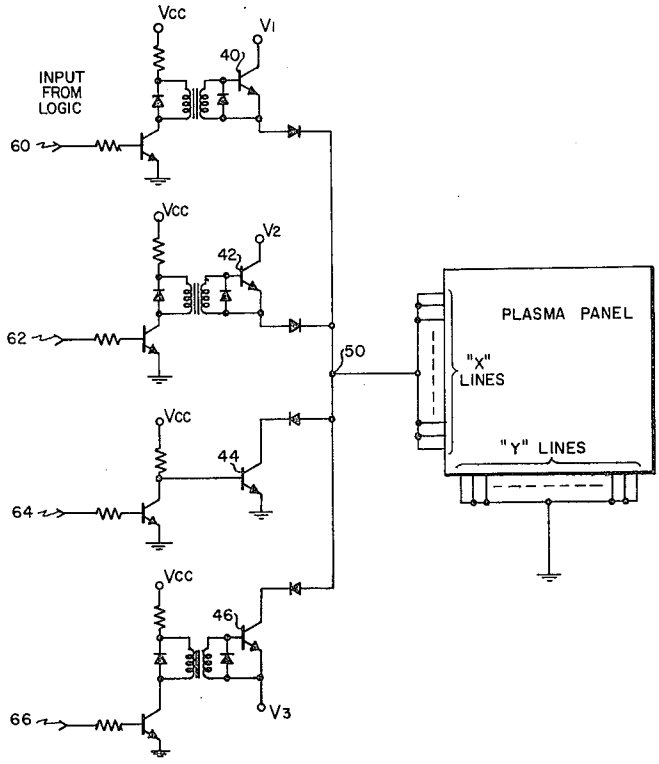


FIG. 1

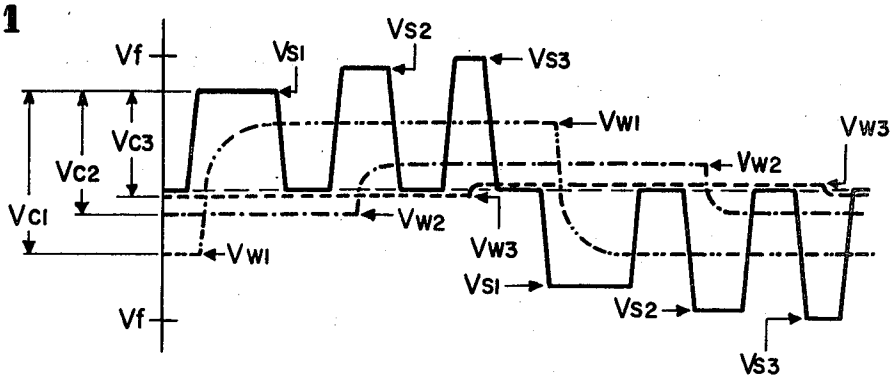


FIG. 2(b)

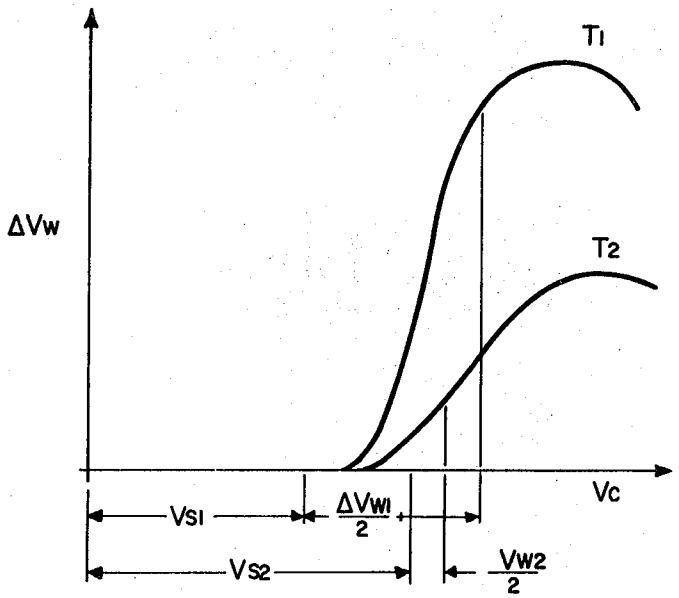
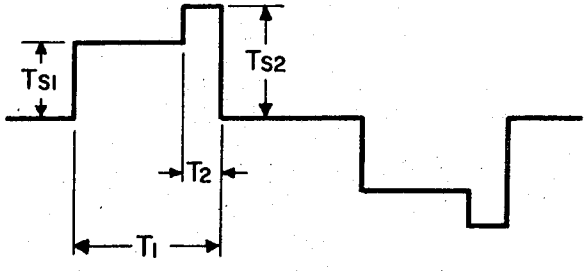


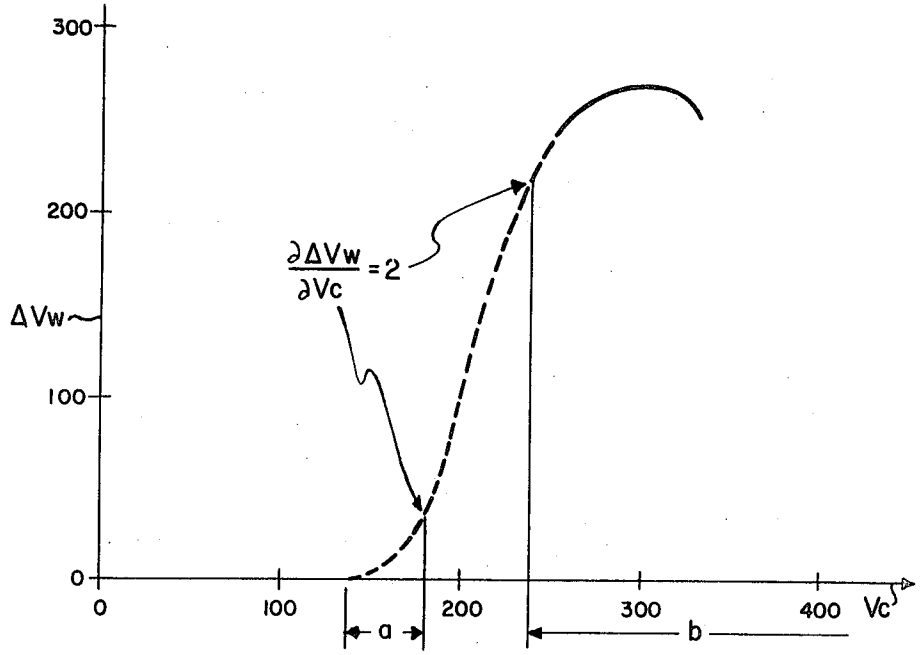
FIG. 2(a)



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FIG. 3



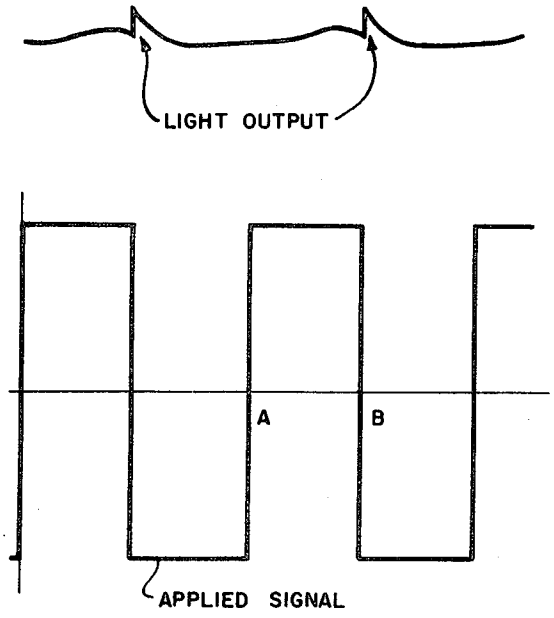


FIG. 4

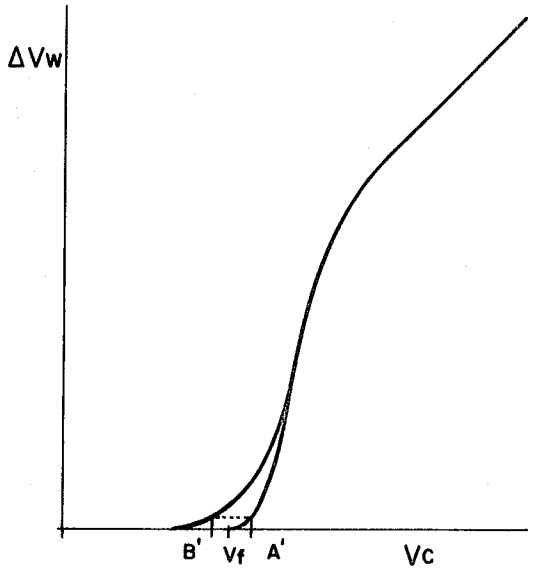


FIG. 5

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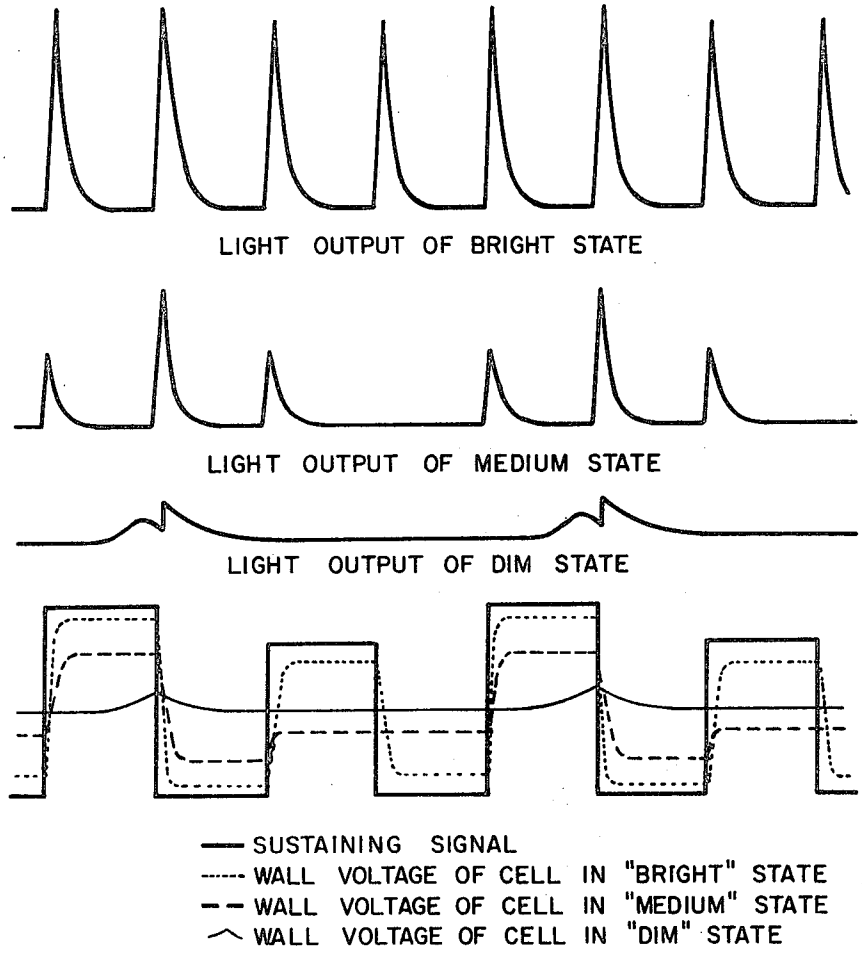


FIG. 6

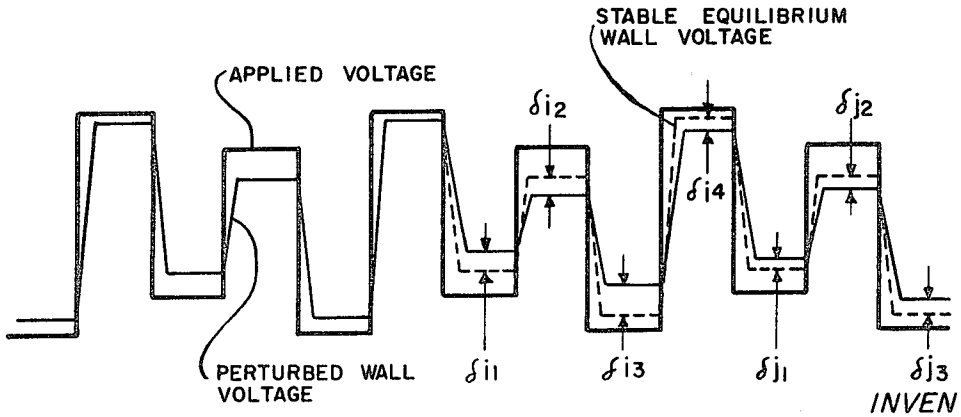


FIG. 7

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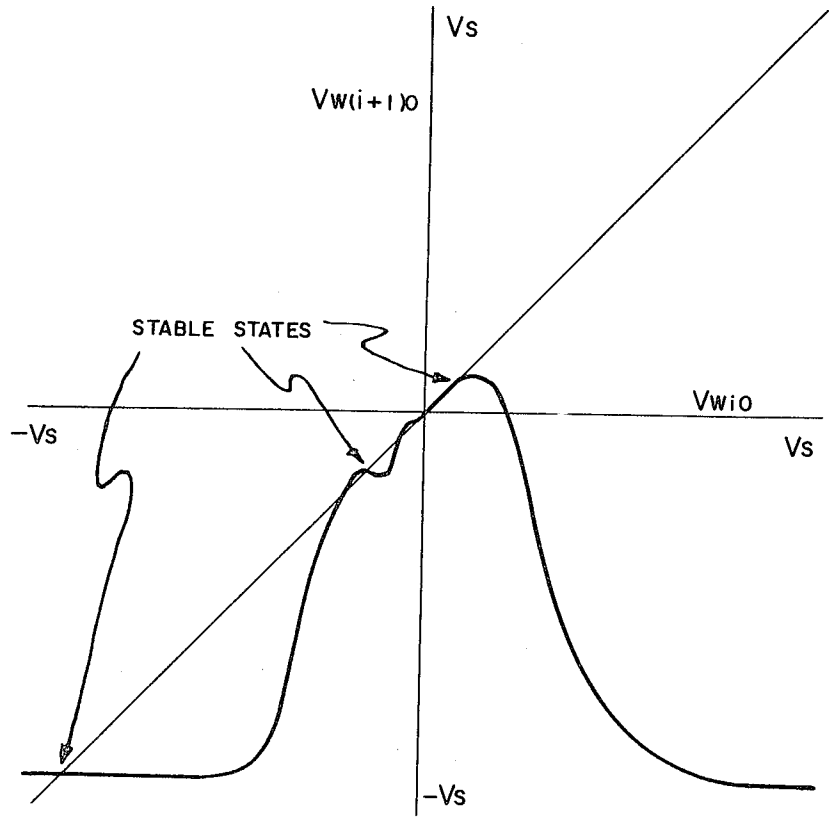
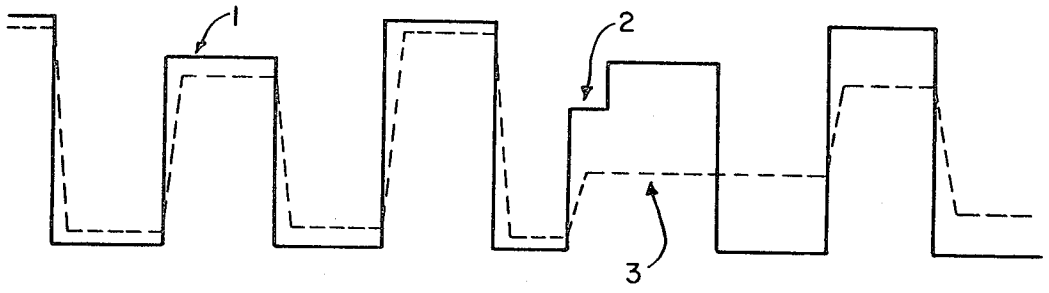


FIG. 8



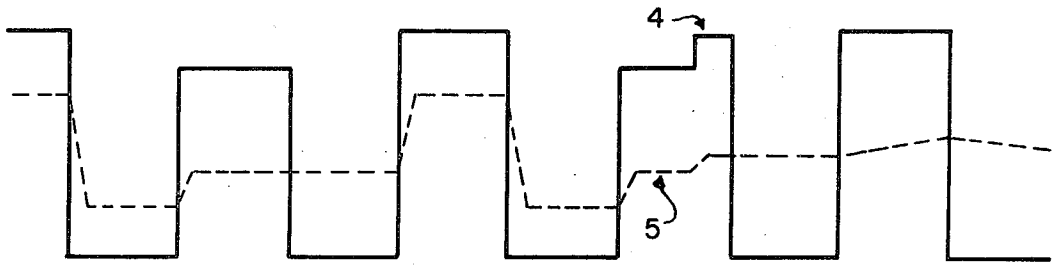
APPLIED VOLTAGE AT THE SELECTED CELL
WALL VOLTAGE OF THE SELECTED CELL

APPLIED CELL VOLTAGE TO ACHIEVE BRIGHT-TO-MEDIUM TRANSITION

FIG. 9(a)

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APPLIED VOLTAGE AT SELECTED CELL
WALL VOLTAGE OF SELECTED CELL

APPLIED CELL VOLTAGE TO ACHIEVE MEDIUM-TO-DIM TRANSITION

FIG. 9(b)

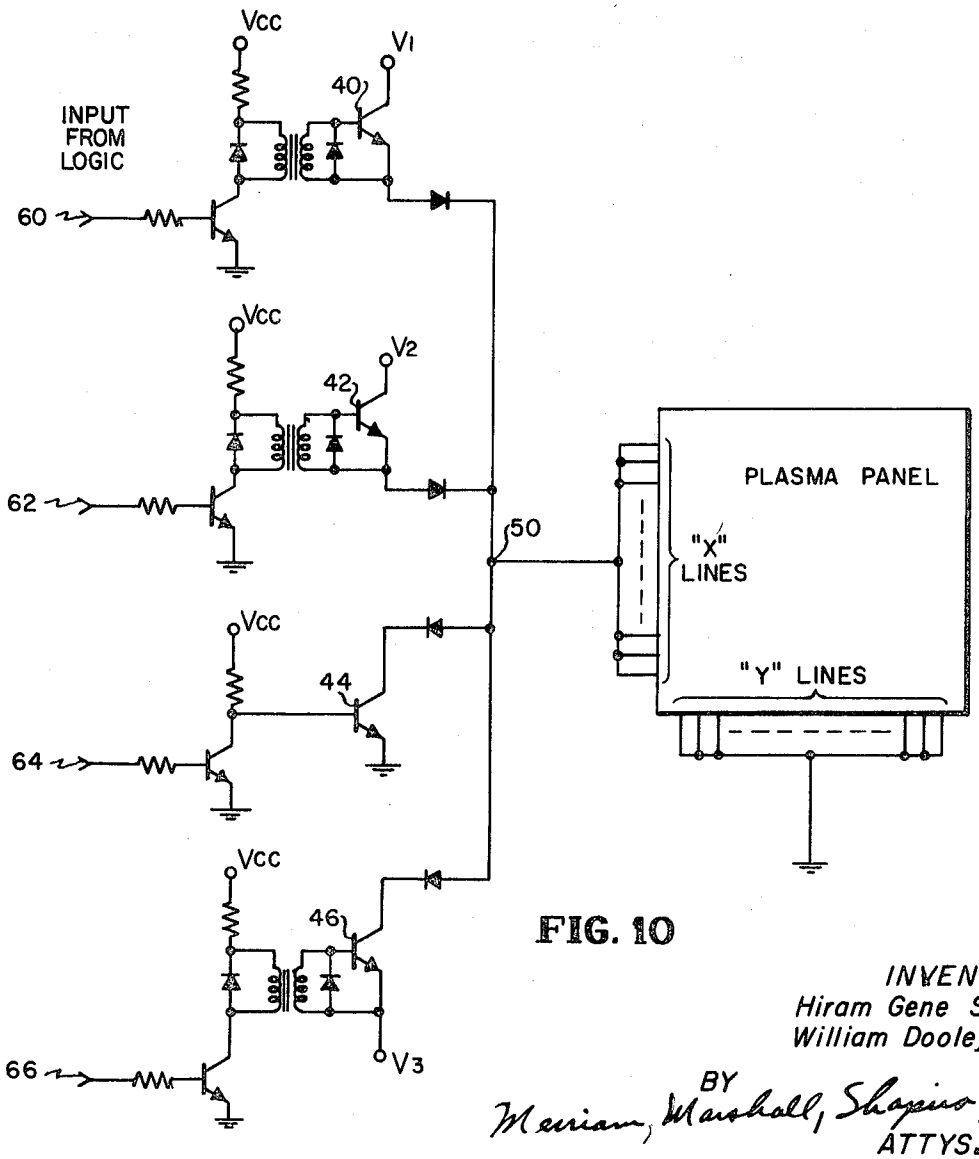


FIG. 10

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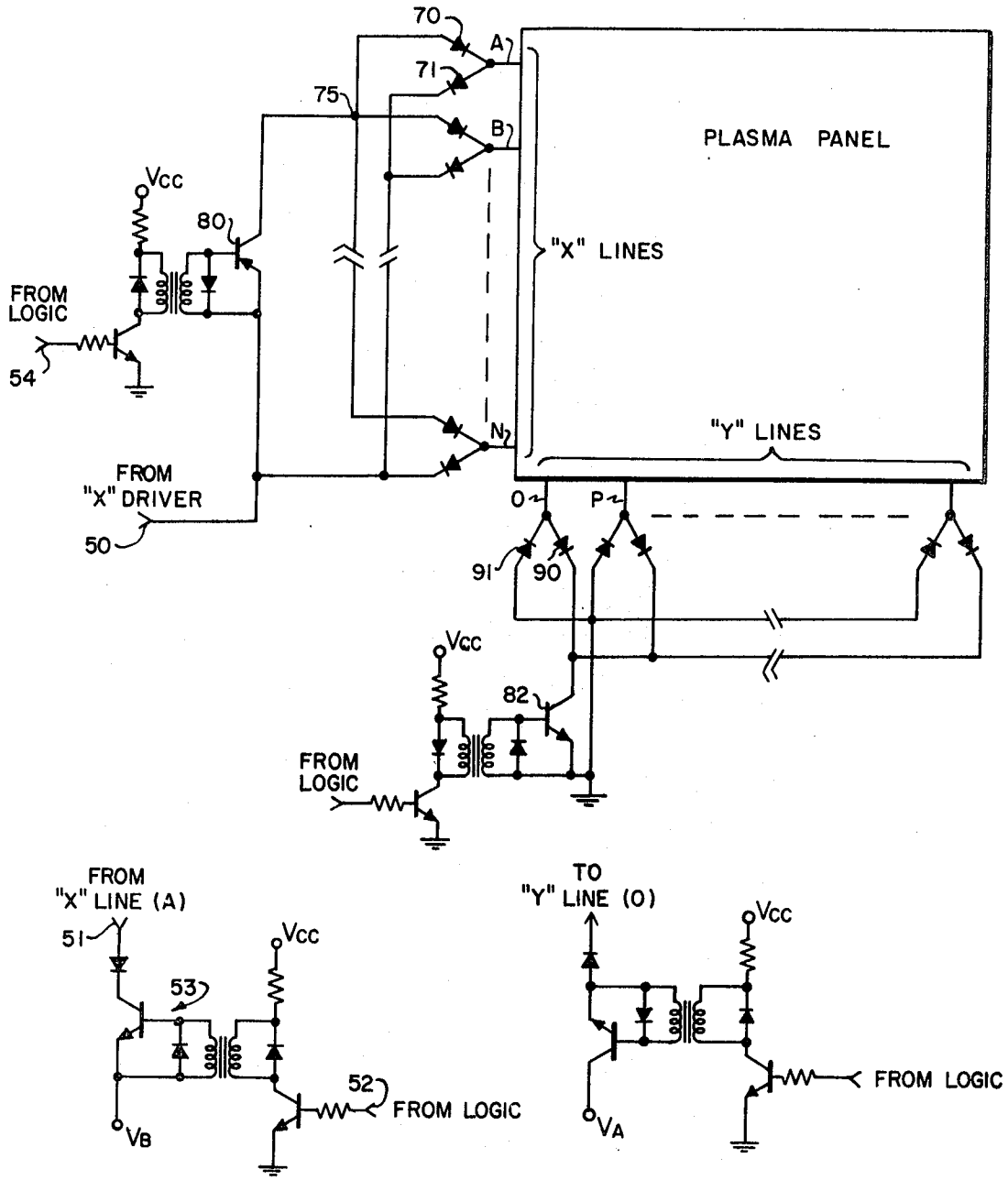


FIG. 11

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METHODS AND APPARATUS FOR OBTAINING VARIABLE INTENSITY AND MULTISTABLE STATES IN A PLASMA PANEL

This invention relates to gaseous discharge devices, and in particular to techniques for providing multiple states and variable intensity in a gaseous discharge device known in the art as "plasma panel" or "plasma display panel".

The subject matter of the present invention is related to apparatus disclosed in a copending application of Donald L. Bitzer, H. Gene Slottow and R. H. Willson, U.S. Ser. No. 613,693, filed Dec. 22, 1966, now U.S. Pat. No. 3,559,190, and entitled "Gaseous Display and Memory Apparatus." In the disclosure of this prior copending application which is incorporated herein in its entirety, there is described a panel incorporating gaseous discharge cells of a unique pulsing discharge type, wherein the presence or absence of suitably formed wall charges in the cells imparts information. Such a gaseous discharge panel has become known in the art as the "-plasma panel," and when utilized for display purposes is commonly referred to as the "plasma display panel." Reference may also be had to the following publications disclosing the type of plasma panel related to the present invention, such publications being incorporated herein in their entirety:

1. Bitzer, D. L. and Slottow, H. G. "The Plasma Display Panel—A Digitally Addressable Display with Inherent Memory," *Proceedings of the Full Joint Computer Conference*, San Francisco, California, November 1966.
2. Arora, B. M., Bitzer, D. L., Slottow, H. G. and Willson, R. H., "The Plasma Display Panel—A New Device for Information Display and Storage," *Proceedings of the Eighth National Symposium of the Society for Information Display*, May, 1967.
3. Bitzer, D. L. and Slottow, H. G. "The Plasma Display Panel—A New Device for Direct View of Graphics," *Conference on Emerging Concepts in Computer Graphics*, University of Illinois, November 1967, to be published by Benjamin Publishing Company, New York.
4. Bitzer, D. L. and Slottow, H. G., "Principles and Applications of the Plasma Display Panel," *Proceedings of the OAR Research Applications Conference*, Office of Aerospace Research, Arlington, Va., March 1968. (Also published in the *Proceedings of the* 1968 *Microelectronics Symposium*, I.E.E.E., June 1968.

It is to be understood that the terms "plasma panel" or "-plasma display panel" is defined by and is characterized by the gaseous discharge panel as described in the previously mentioned copending application and the above listed publications.

In a copending application of Bitzer, Slottow and Petty, U.S. Ser. No. 765,939, now U.S. Pat. No. 3,601,531, entitled "-Plasma Display Panel Apparatus Having Multi-Level Stable States for Variable Intensity", there is described apparatus and a method for providing a variable intensity technique for the plasma display panel—which technique is based on a stability theory for the plasma display panel which is discussed therein. The present application is based on an extension of that theory and provides an alternative method and apparatus to those described in the above application.

SUMMARY OF THE INVENTION

In accordance with the principles of the present invention there is provided a method and apparatus for imparting information to a plasma display panel to produce an image of several intensity levels, and the preserving of this image on the panel until new information is received by the panel. The information that controls the intensity at a given cell is imparted in the form of a voltage but at a selected time creates a control discharge at the selected cell. The discharge creates a wall voltage at the cell that at the time of the discharge is characteristic of a particular stable sequence of discharges, and of an average intensity that is produced by this sequence. Several different discharge sequences each with a characteristic intensity are possible, and each can be initiated by setting the appropriate wall voltage at the appropriate time.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1–6** are schematic illustrations of various waveforms useful in the description and maintenance of stable sequences;

FIGS. **7–9** are schematic illustrations of waveforms and sustaining and selective addressing circuits for providing the same in the initiation and maintenance of stable sequences and corresponding levels of variable intensity for a plasma display panel; and

FIGS. **10–11** illustrate plasma panel apparatus constructed in accordance with the principles of the invention.

DETAILED DESCRIPTION

THE DESCRIPTION AND MAINTENANCE OF STABLE SEQUENCES

One form of implementation is illustrated by the drawing of FIG. **1** which represents the wall voltages V_{w1}, V_{w2}, and V_{w3} of three cells in a plasma display panel of the type having a plurality of x and y panel electrodes in a matrix array, and each cell being defined at intersections of the x–y electrodes. These wall voltages can be set by initiating signals that correspond to the desired intensity levels.

When the first pulse, with amplitude V_{s1}, is applied to the panel, only the cell with wall voltage V_{w1} responds. Since the system is in a sustaining mode, and therefore in equilibrium, the wall voltage change is $2V_{w1}$ as shown in FIG. **1**. The second pulse, with amplitude V_{s2}, creates a discharge only in the cell with wall voltage V_{w2}. The total cell voltage for the third cell ($V_{s2} + V_{w3}$) is less than the firing voltage, V_f, and no discharge takes place in the third cell at this time. Similarly, because of the phase of the voltage on the first cell, the cell voltage is too low to ignite a discharge. Finally, when the third pulse, V_{s3} is applied, only the third cell responds. The entire sequence is repeated once each half cycle until it is interrupted by the introduction of new intensity information.

A variation of this procedure is to hold the voltage level of each pulse until the beginning of the succeeding pulse. The corresponding sustaining voltage is shown in FIG. **2**(*a*) for two states. If the charge generated by each discharge is completely drawn to the wall before the termination of each pulse in FIG. **1** the effect of the panel for these two sustaining signals should be identical (except of course that for the wave form of FIG. **2**(*a*) there are only two states). If this is not true, there should be some reversal of charge flow after each of the pulses of FIG. **1**, and the change in wall voltage must be accounted for. This system has been implemented for two states on a small experimental panel fabricated at the Coordinated Science Laboratory of the University of Illinois, and also on a standard Owens-Illinois Digivue panel.

We note that the successive levels in each phase become narrow in time as well as greater in voltage. This insures that each successive discharge in a group is less intense than its precedessor. The process depends on the fact that the change in wall voltage at a discharge depends not only on the amplitude of the applied pulse, but also on the pulse duration. Thus, for each of the voltage pulses corresponding to changes in level of the sustaining signal shown in FIG. **1** and **2** (*a*) there is a unique dependence of change in wall voltage on cell voltage, and the terminal characteristics of the cell for this complex wave form must be described by a family of curves. An important advantage of this entire approach to variable intensity is that these functional relationships can be measured.

FIG. **2**(*b*) shows two members of a family of curves as they relate to the wave form of FIG. **2**(*a*). The upper curve labeled **T1** shows the voltage transfer curve for an applied voltage with time duration **T1**. Similarly the curve labeled **T2** corresponds to an applied voltage with duration **T2**. The effect of the second step in each half-cycle on a discharge created by the first step is usually small, but its influence, if any, simply changes the detailed character of the curve.

In the bright state the switching across the cell at the time of discharge is the sum of V_{s1}, the sustaining voltage, and $\Delta V_{w1}/2$, the wall voltage. The resulting change in wall voltage is ΔV_{w1}. Similarly for the discharges of the dim states, the cell voltage of that discharge is the sum of V_{s2} and the wall voltage $\Delta v_{w2}/2$. The resulting change in wall voltage is in this case ΔV_{w2}. These changes are indicated in the transfer curves of FIG. 2(*b*).

This procedure for obtaining variable intensity is based in part on recent advances in the theoretical understanding of the plasma display technique. The essential concept is that, under proper conditions, the wall voltage associated with the discharge sequences stabilizes at two precise levels, one for the positive half-period and one for the negative half-period. Any small perturbation in wall voltage affects the succeeding discharge in a way that decreases the magnitude of perturbation. The process is described by the equation

$$\delta_{it1}=(-1+d(\Delta V_w)/dV_c)\ \delta_i;$$

where V_w is the actual change in wall voltage at a discharge and V_c is the actual voltage across the plasma display cell (the sum of the wall voltage and the applied voltage) at the time of the discharge. The condition for stability therefore is that

$$0 \quad d(\Delta V_w)/dV_c \leq 2.$$

In another form more useful for comparison in a more generalized case the condition for stability is

$$-1 \leq (-1+d(\Delta V_w)/dV_c) \leq 1.$$

We assume that all of the wall voltages characteristic of the wave forms shown in FIGS. 1 and 2 correspond to stable equilibrium states. This stability theory and its implications have been described in part in the previously mentioned copending patent application of Bitzer, Slottow and Petty.

Typical measurements in the change in wall voltages of a function of actual cell voltage (voltage transfer curves) indicate a stable region corresponding to a large change in wall voltage, an unstable region of somewhat smaller, but more sensitive, change in wall voltage and another stable region for very small wall voltage changes. These regions are indicated in FIG. 3 in which a change of wall voltage ΔV_w is plotted against V_c, the actual cell voltage. This curve suggests the existence of two stable states for the same applied voltage V_s, an intense state that is the commonly observed "on" state for a plasma display cell, and a new dim state. An attempt to observe this dim state was made and has been successful. The discharges, however, as indicated by the light pulses of FIG. 4 are unsymmetrical.

It appears that the explanation rests on an understanding of the physics of the discharges. We assume that at time A there is essentially no charge in the volume of the cell with the wall voltage and with the sustaining voltage as indicated in FIG. 4 the condition for voltage breakdown is satisfied, and the light pulse shows a growth curve that is characteristic of growing avalanches. Before the discharge becomes very intense, however, the sustaining voltage changes abruptly at time B. For this cell at this time, the breakdown condition is not met. However, there are electrons and ions in the volume and a sequence of avalanches in successfully decreasing intensity develops. There is, therefore, an initial increase of current and light, followed by an exponential decreasing current and light. This interpretation is consistent with the oscilloscopic measure of light intensity.

This explanation requires a change in the lower part of the voltage transfer curves of FIGS. 2 and 3. The modified curve of FIG. 5 shows two branches for small ΔV_c. The right hand branch corresponds to the conditions for which there is little charge in the volume. The left hand branch, which extends to the left of the firing voltage, V_f represents a condition for which charge is in the volume of the cell at the time the voltage V_f is applied. Conditions for times A and B of FIG. 4 are represented in FIG. 5 by the points A′ and B′. Note that the change in wall voltage, V_w is the same—otherwise charge would accumulate on the walls.

If the applied voltage is less than V_f and there is little charge in the volume, the right hand branch is effective and there will be no discharge. This provides an "off" state to go with the dim and bright states described below.

In a generalization of this technique the dim and bright states have been combined with a third "on" state by sustaining an Owens-Illinois Digivue plasma display panel with the voltage wave-form shown in FIG. 6. The third state involves three discharges per period, two changes of voltage in one direction for every single change in voltage in the other. These three states have been introduced into adjacent sections of the same panel and have been maintained simultaneously by the voltage wave-form of FIG. 6.

All of these modes represents stable sequences of discharges in which, again, the state information is held at the cell itself. The stability theory, however, for the generalized case must be extended. For the simple case, all discharges, in equilibrium, are essentially alike, and for a stable sequence a perturbation must decrease with each successive discharge. The condition for this to be true has been stated above in terms of limits on $d(\Delta V_w)/dV_c$. For the more general case the discharges are different from one another and this requirement is not necessary. FIG. 7 illustrates a hypothetical case in which the sequence is composed of groups each of which contains four discharges. The perturbations in this example do not decrease for each discharge within the group. They do, however, diminish from group to group, and in particular, the perturbation associated with a particular discharge in a group must diminish with each corresponding discharge in the following group. In FIG. 7, for example, the perturbation δ_{i1} is followed by three perturbations of which δ_{i3} is larger than δ_{i1}. The corresponding perturbations δ_{j1} is however less than $_{i1}$Similarly, δ_{j2} is less than δ_{i2}, δ_{j3} is less than δ_{i3}, and δ_{j4} is less than δ_{i4}. Since for each discharge in the group, the perturbation associated with that discharge diminishes from group to group the process illustrated is stable. The mathematical statement of the condition for stability in this case is that

$$-1 \leq \pi_{k=1}^{4}\{-1+[d(\Delta V_w)/dV_c]_k\} \leq 1.$$

The term $[d(\Delta V_w)/dV_c]_k$ is the slope of the voltage transfer curve for the k^{th} equilibrium discharge in the group. Of course in the general case where there are n different discharges in each group, the stability condition involves a product of n factors instead of the four shown in the above example. This condition reduces in the simple case to the condition for stability stated earlier in which the perturbation decreases discharge by discharge to zero. Thus, we see that the condition on the term $(-1+d(\Delta V_w)/dV_c)$ in the simple case becomes in the general case the limit on the product of similar terms.

In equilibrium the perturbations are zero, and the wall voltage following a particular discharge from one group is identical with the wall voltage following the same discharge in the next group. Since the memory is in the wall voltage, there must be a different stable equilibrium wall voltage at any time for each stable state. FIG. 8 which plots the wall voltage after a discharge against the wall voltage after the corresponding discharge in the previous group indicates five points (or regions) in which the wall voltage associated with a particular discharge remains the same from group to group. For two of these points the graph shows that these perturbations grow and that these two points represent unstable conditions. Two other points represent stable conditions and these correspond to two stable "on" states. There also exists a region in which there are no perturbations. This region corresponds to the range of wall voltages for which there are no wall charges. This is an "off" state.

The above theory describes only states for which the memory is entirely in the wall voltage. It does not consider the case, found experimentally, and discussed above, in connection with FIGS. 4, 5 and a portion of 6 in which the state information resides to some extent in charges in the volumes.

INITIATION OF MULTISTATES

To initiate a state the wall voltage of particular cells must be set for instance to the particular states or levels, V_{w1}, V_{w2} and V_{w3} as illustrated in FIG. 1. The change in cell wall voltage can be made by applying an appropriate initiating pulse of ap-

propriate amplitude and width to affect the particular cell as shown by the charge transfer curves of FIG. 2(*b*). In the laternative the wall change setting techniques described in the previously mentioned copending application of Bitzer, Slottow and Petty can be used.

More generally, instead of initially setting the wall voltages directly to the three states, the wall voltage at each cell can be incrementally adjusted from one state to another until the desired state is achieved. As an example, all of the cells in the plasma panel can be discharged and sustained at the normal bright level as is already known, and the levels or states for particular cells can be derived therefrom. Of course in any system in which off is a state, the transition from off to another state must also be considered. Furthermore it must be realized that the cell wall voltage need not be set precisely since any deviation in terms of perturbations from the desired stable equilibrium wall voltage will damp out during sequential sustaining as described above.

In addressing a panel with n states, a total of n (n–1) transitions are possible. However, if a multi-step addressing scheme is used, any state change can be achieved with n or less state transitions. Thus for a three state display, six transitions are possible, for instance, the bright to medium, bright to dim, medium to dim, medium to bright, dim to bright, dim to medium (however only three transitions are necessary to complete addressing, for example, bright to medium, medium to dim, dim to bright). Addressing is then accomplished by cyclically addressing the desired cells through the three transitions terminating with the desired state. In one demonstration of this the bright state can be chosen as the initial state.

The transition of a cell from one state to another is accomplished by incrementing the wall voltage at a specified time in the discharge sequence such that the resulting discharges achieve a stable equilibrium sequence different from the first. One technique of incrementing the wall voltage is through the use of a controlled discharge. FIG. 9 shows some possible waveforms used to achieve this. When the cell is in the bright state and the sustaining signal (1) is pulsed at the proper time (2) the resulting discharge will raise the wall voltage (3) to such a level that on successive cycles of the sustaining signal the cell will fire in the medium state. A pulse (4) can be applied to a cell in the medium state which will result in a discharge raising the wall voltage (5) so that the cell will be in the dim state on subsequent cycles of the sustaining signal. The waveforms shown appear on a cell and thus represent the difference between the voltage applied to the x and y line whose intersection marks the cell. The x and y correspond to the matrix array of panel electrodes. The voltages appearing across all other cells that are common to the selected x line or y line are too small to change the state at these other cells.

Since the waveforms of FIGS. 1, 2, 4 and 6 are all made up of sections of discrete voltage levels, these control discharge waveforms can be produced simply by switching the appropriate panel conductors at appropriate times to the correct voltage levels. One way of doing this is illustrated by the sustaining signal generator circuit in FIG. 10 which provides four levels—V_1, V_2, V_3, and ground through transistor switches 40, 42, 44 and 46 respectively to the x lines connected to one set of matrix panel electrodes on the schematically illustrated plasma panel. The other set of matrix panel electrodes are connected to ground through the corresponding y lines. By referring to x line and y line hereinafter it is to be understood also to refer to the corresponding panel electrodes.

For convenience in illustration, the plasma panels shown in Figures 10 and 11 are to be understood to be of the type concerned with the present subject matter and art as set forth in the aforementioned co-pending application of Bitzer, Slottow and Willson, and the listed publications relating thereto. Such plasma panels contain a plurality of cells containing a gaseous medium, and in which wall charges are formed relating to the entry of information. The information is maintained by applying a sustaining signal to the respective intersecting electrodes associated with the cell to cooperate with the initial wall charge so as to initiate a discharge of the gaseous medium and form wall charges in the cell of reversed polarity—the sustaining cycle being repeated by reversals of the sustaining signal.

Due to the information of the reversed polarity wall charges which now oppose the applied sustaining signal, the discharge is rapidly quenched. For this reason, the cell is sometimes operatively to as a "pulsing discharge cell" or "minicell" to distinguish it from the prior well known glow discharge devices. As is known, the prior glow discharge devices operate with charges in the volume and it is therefore desirable to maintain such charges in the volume rather than on the cell walls to maintain (rather than extinguish) the discharge.

The above summary of operation of the plasma panel and its individual cells is given here merely for convenience in understanding the present invention which is concerned with providing variable intensity and multistates in the plasma panel. A more detailed description is of course presented in the publications and the aforementioned copending application.

In FIG. 10, the transistor switches are turned on one at a time in accordance with signals on lines 60, 62, 64 and 66 from suitable logic circuits. The square wave of FIG. 4 of course requires only two levels and the waveform of FIG. 6 requires three. Since the waveforms of FIG. 2(*a*) and FIG. 1 require five levels and seven levels respectively, additional modular circuits could be added to the point 50 in FIG. 10 to provide the additional voltage levels required.

To initiate a state at a given cell signals must be provided selectively at an appropriate x line and y line of the plasma panel. A selection circuit for providing addressing signals in a plasma display panel demonstration mode is shown in FIG. 11. The four level sustaining signal generator in FIG. 10 is connected at point 50 to the point 50 shown in FIG. 11. The selection circuit in FIG. 11 thus replaces the direct connection to the panel shown in the diagram of the sustaining signal generator in FIG. 10.

If electrode line A on the plasma panel is to be selected, it is connected through a switch to the connector 51 which is connected to line A. When the signal from the logic circuits is applied to point 52 the voltage at 51 and at the selected panel electrode marked A is brought to the voltage level V_B. For purposes of illustration, only one circuit 53 is shown in FIG. 11 connected at point 51 to line A. Identical circuits such as circuit 53 can be connected to each of the remaining x lines. Alternatively, the single circuit 53 can be used with suitable multiplexing to connect it to the desired x line.

The lower of the two diodes 70, 71 connected to electrode A will be back biased and will pass no current. At the same time the control signal appears at 52, a similar signal from the logic circuit also appears at 54. This opens the transistor switch 80 from point 75 to the x-driver at point 50 and allows point 75 to follow point A to essentially the voltage level established at V_B. The upper diodes on the remaining lines B to N are open and line A is effectively isolated from all other horizontal lines.

In a similar way a selective y line, such as line O is brought to the control voltage V_A and the combination provides, on a selective basis, the transition shown in FIG. 9 which changed the states of the cells in the plasma display panel.

In the normal sustaining mode when addressing through the selective addressing circuit of FIG. 11 does not take place, current can pass from the x-driver through the switching transistor 80 through the upper diodes 70 on each of the horizontal lines A–N across the panel and through the right hand diodes 90 on each of the vertical y lines and finally through the switching transistor 82 to ground. When current flows in the other direction it flows from ground through the left hand diodes 91 on the horizontal lines and back to the x-driver at point 50. This preserves the low impedance properties of the driving circuits during sustaining periods. The circuits shown in FIGS. 10 and 11 were constructed and are illustrated herein only to demonstrate the feasibility of the variable

intensity concept of the present invention. Those skilled in the plasma panel art can readily construct other circuits in accordance with the teachings herein which will provide the addressing and sustaining waveforms required by the present invention.

The foregoing detailed description has been given for clearness of understanding only, and no unnecessary limitations should be understood therefrom, as modifications will be obvious to those skilled in the art.

What is claimed is:

1. In the method of displaying video information in a gaseous discharge plasma panel having a gaseous medium in said panel, and display points defined by associated paired electrodes said display points including gaseous discharge cells having cell walls for forming wall charges thereon, wherein said information is entered into the panel at selected display points by coupling addressing signals sufficient to discharge the gaseous medium to respective electrodes and form associated wall charges related to said information, the improved step of sustaining said information in said panel at various respective information levels by applying a periodic sustaining signal having a series of pulses in each half cycle which increase in amplitude and decrease in width, each of said pulses corresponding to a different wall voltage.

2. In the method of displaying video information in a gaseous discharge plasma panel having a gaseous medium in said panel, and display points defined by associated paired electrodes, said display points including gaseous discharge cells having cell walls for forming wall charges thereon, wherein said information is entered into the panel at selected display points by coupling addressing signals sufficient to discharge the gaseous medium to respective electrodes and form associated wall charges related to said information, the improved step of supplying a sustaining signal to sustain an individual group of discharges which repeat themselves group by group, such that any perturbation from a stable equilibrium sequence in an individual discharge in a group will be less than the perturbation of the corresponding discharge in the preceding group.

3. The method of displaying information as claimed in claim 2, wherein said sustaining signal sustains several different sequences of discharges each composed of different groups, and each sequence of discharges defining a particular intensity.

4. The method of displaying information as claimed in claim 3, including incrementing the wall voltage of at least one of said display points at a specified time in the discharge sequence to provide a stable equilibrium sequence different from the initial sequence.

5. The method of displaying information as claimed in claim 3, including setting the initial wall charges at each display point in said panel to obtain different sequences of discharges, each corresponding to a particular average light intensity.

6. The method of displaying information as claimed in claim 5, including incrementing the wall voltage of selected display points in said panel to provide a respective different sequence of discharges associated with each of said selected display points to vary the light intensity of said display points.

7. In gaseous discharge plasma display panel apparatus, including a gaseous medium in said panel, and display points defined by associated paired electrodes said display points including gaseous discharge cells having cell walls for forming wall charges thereon, wherein information is transferred into and out of said panel by manipulating wall charges associated with the selective pulsing discharge of the gaseous medium at the display points by coupling suitable exciting signals to the associated paired electrodes, the improvement comprising means for displaying said information at variable intensity levels, including a periodic sustaining signal generator means coupled to said electrodes, said periodic sustaining signal having a series of pulses in each half cycle which increase in amplitude and decrease in width, each of said pulses corresponding to a different wall voltage.

8. In gaseous discharge plasma display panel apparatus, including a gaseous medium in said panel, and display points defined by associated paired electrodes, said display points including gaseous discharge cells having cell walls for forming wall charges thereon, wherein information is transferred into and out of said panel by manipulating wall charges associated with the selective pulsing discharge of the gaseous medium at the display points by coupling suitable exciting signals to the associated paired electrodes, the improvement comprising means for displaying said information at variable intensity levels, including signal generator coupled to said electrodes supplying a sustaining signal to sustain an individual group of discharges which repeat themselves group by group, such that any perturbation from a stable equilibrium sequence in an individual discharge in a group will be less than the perturbation of the corresponding discharge in the preceding group.

9. Display panel apparatus as claimed in claim 8, including incremental signal generator means coupled to said electrodes for incrementing the wall voltage of at least one of said display points at a specified time in the discharge sequence to provide a stable equilibrium sequence different from the initial sequence.

10. Display panel apparatus as claimed in claim 9, including means for setting the initial wall charges at each display point in said panel to obtain different sequences of discharges, each corresponding to a particular average light intensity.

11. Display panel apparatus as claimed in claim 10, including incremental signal generator means coupled to said electrodes for incrementing the wall voltage of selected display points in said panel to provide a respective different sequence of discharges associated with each of said selected display points to vary the light intensity of said display points.

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