ABSTRACT

A.C. plasma display panel interrogating apparatus including coincident addressing means for applying an interrogation signal to selected rows and columns of the panel cells in combination with the sustaining signal which is normally applied thereto such that the resultant signal across the coincident cell remains at the sustaining level while at the non-coincident cells the signal strength decreases below the extinction value. This condition reduces the non-coincident cell outputs to zero with only the coincident cell providing a signal output indicative of its data storage state, thereby enabling readout to be performed with a respective current or photo sensor arranged to receive the signals from individual rows or columns of cells.

14 Claims, 7 Drawing Figures
FIG. 2a

FIG. 2b

FIG. 2c
FIG. 3a.

FIG. 3b.

FIG. 3c.
A. C. PLASMA DISPLAY PANEL INTERROGATING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to A.C. plasma panels and more particularly to means for interrogating or reading out the information stored therein as represented by the instantaneous operating condition of the individual cells comprising the panel.

2. Description of the Prior Art

An A.C. plasma panel typically comprises a two-dimensional array of gas discharge cells formed between two spaced parallel glass plates sealed together about their edges to form a unitary gas-tight structure containing an ionizable gas in the region between the plates. A set of linear parallel electrode elements is formed on the exterior planar surface of each plate, the respective sets being orthogonally oriented relative to one another in a conventional X-Y or row-column format. The individual cells of the array comprise the finite gaseous regions located between the multiplicity of coincident points formed by the crossed electrode configuration. Information storage is conveniently accomplished in accordance with conventional coincident addressing techniques simply by applying appropriate signals to selected row and column electrodes so as to establish an ionizing potential difference at the point of coincidence of the selected electrodes. This produces a localized discharge in the gas at the coincident point, indicative of data storage thereat. Thus, the panel can be used for storing either binary data or symbols or other graphical data represented by correspondingly energized cell patterns.

In operation of the panel, an A.C. sustaining signal is connected to the electrodes to establish a quiescent potential difference across each cell at a level intermediate between extinction and ionizing potentials of the gas. Under this condition all the cells are initially off. Information can be written into selected cells by applying a write pulse to the corresponding pair of electrodes at the proper instant with respect to the sustaining signal. The amplitude of the write pulse is made sufficiently large so that in combination with the sustaining signal it produces an instantaneous voltage level in excess of the ionizing potential, thereby switching the selected cell to an on condition. Ions and electrons flow to the glass plates of the selected cell and accumulate thereon, rapidly providing a sufficient countercarcting electric field which extinguishes the discharge. During the next half cycle of the sustaining signal, the field produced by the ions and electrons briefly reinforces the applied sustaining signal field causing another discharge to occur which also is rapidly extinguished as explained above. Thereafter, with the applied potential maintained at the sustaining level, operation continues in the foregoing manner with discharge current and light pulses being produced in each half cycle of the sustaining signal. However, those cells for which the applied signal amplitude was not momentarily raised above the ionizing potential remain continuously off. A sustaining signal frequency on the order of 50 kilohertz or higher, up to perhaps several hundred kilohertz, is used so that the light output appears continuous without perceptible flicker. Stored data is conveniently erased from the panel simply by applying an erase pulse, similar to the write pulse, but phased differently with the sustaining signal.

Interrogation or readout of the stored data has customarily been accomplished herebefore by temporarily removing the sustaining signal and then selectively reapplying it to the individual cells. This action causes the individual cells to return to their original state, that is, cells that were off prior to removal of the sustaining signal remain off when it is reapplied whereas cells that were previously on switch on again thereby producing current and light pulses indicative of the on condition. Inasmuch as the readout is non-destructive, subsequent application of the sustaining signal simultaneously to all the cells reproduces the panel image in preparation for further reading, erasing and interrogating. The length of time for which the sustaining signal can be removed without deleteriously affecting the reproduced image is, of course, limited and in fact is determined by the life time of the discharge produced charges on the interior walls of the glass plates. In any event, the life time is generally sufficiently long to assure readout without any difficulty.

SUMMARY OF THE INVENTION

The present invention is particularly concerned with improved means for reading out the data stored in an A.C. plasma panel. Specifically, the invention provides for interrogating a panel without the necessity for switching off the sustaining signal. In one embodiment this is accomplished by the provision of X-Y addressing means which applies, to selected row and column arrangements of the panel cells, interrogating signals that are equal in amplitude and frequency to the sustaining signal but 180° phase shifted therefrom. As a result the cell located at the coincident point of the selected row and column has a net signal applied to it which is also equal in amplitude and frequency and 180° phase shifted relative to the sustaining signal. The coincident cell therefore continues to function in the operational mode which it had acquired prior to interrogation. At the non-coincident cells, on the other hand, the interrogating signals cancel the sustaining signal so the resultant voltage is zero and the cells are temporarily turned off. Respective current sensors connected in series with the cells and corresponding columns detect the current pulses representative of an on condition or data storage at the coincident cell. Absence of such current pulses indicates an off condition or zero data storage at the coincident point. Under appropriate control, for example a computer, the interrogation process can continue with each column being addressed sequentially during concurrent addressing of a single row and so on row by row in the manner of a conventional television raster scan. The computer, of course, maintains cognizance of the particular cell which happens to be the coincident one at each instant. It will be readily appreciated, therefore, that the A.C. plasma panel which is normally used for displaying computer information can also be used for conveniently feeding data into a computer under direct computer control.

In another embodiment of the invention the interrogating signals comprise one component having a frequency equal to that of the sustaining signal and another component at twice the sustaining frequency. These signals are applied in the same manner to achieve essentially the same result as the aforesaid embodiment, namely a sustaining level signal at the coincident cell and a signal less than sustaining level at the non-coincident cells. In this case, however, the voltage at the non-coincident cells, although reduced below the level required to sustain the discharge, does not diminish to zero. In addition, the output current or light pulses of the coincident cell, assuming prior data storage thereat, occur at twice the frequency of any other cells which happen to be simultaneously providing output signals. This unique characteristic of the coincident cell output enables the interrogation to be performed with a single sensor, either electrically or optically. This characteristic also enables the interrogation to be performed by simultaneously addressing all the cells in place of coincident addressing as will be explained more fully in the following Description of the Preferred Embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a plasma panel interrogation apparatus constructed in accordance with the principles of the present invention.

FIGS. 2a and 2b depict waveforms illustrative of a double amplitude interrogation technique which may be employed in the apparatus of FIG. 1.

FIG. 2c is a simplified schematic indicating the manner in which the double amplitude interrogate signals are applied to the selected cell.
FIGS. 3a and 3b depict waveforms illustrative of a double frequency interrogation technique which may be employed in the apparatus of FIG. 1.

FIG. 3c is a simplified schematic indicating the manner in which the double frequency interrogate signals are applied to the selected cell.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings, a plasma panel 10 shown in exploded form comprises a multi-apertured shim 11 disposed between plates 12 and 13, all of which are typically constructed of glass or other suitable dielectric material. In assembly of the panel the plates and shim are held in contiguous relation and sealed about their periphery to form a gas tight structure for confining an ionizable gas in the individual cells 14 formed in shim 11. Vertically extending electrodes 16, through 16, affixed to the exterior surface of plate 12 in superimposed relation with cells 14 are coupled through respective transformers 17, through 17, to X-select matrix 18. Similarly, horizontally oriented electrodes 19, through 19, affixed to the exterior surface of plate 13 in superimposed relation to the cells are coupled through transformers 21, through 21, to Y-select matrix 22. A sustaining level signal (V_sin wt) is applied to all the cells from A.C. source 23 which has one output terminal connected to ground and its other output terminal connected by lead 26 to the secondary windings of the Y-select transformers, the A.C. signal path being completed through the individual gas cells to the secondary windings of the X-select transformers which, in turn, are connected by lead 27 back to the grounded side of the A.C. source. Current sensors 28, through 28, connected in series with the secondary windings of the respective X-select transformers, are included to detect the current pulses generated within the respective cells for the purpose of interrogating the panel. This will be explained more fully in the subsequent paragraphs pertaining to the operation of the inventive apparatus.

Before proceeding with the description of the operation, however, it should be understood that the inventive concept is not restricted to any particular constructional details insofar as the panel is concerned. Other cell arrangements and electrode configurations differing from those shown in the figure can also be used. For instance, a shim having a single large centrally located aperture could be used in place of the illustrative multi-apertured cell which is shown simply to facilitate the ensuing description.

Since the invention is concerned with means for interrogating the panel, it will be assumed that information has previously been written into the panel as hereinbefore explained such that all of the cells, or at least those selected by letters A through P, are in a lighted or on condition. The interrogation process commences in response to a computer or operator initiated interrogate command applied to interrogate signal generator 29 which then applies signals to the appropriate electrodes by way of the X and Y selection matrices. For example, during the time that a signal is applied to transformer 21, to energize the top horizontal electrode, signals can be applied in succession to transformers 17, through 17, to scan or read out the top row of cells (A, B, C and D). Then this procedure can be repeated with transformers 21, 21, and 21, successively receiving excitation from the Y-select matrix. At the instant that signals are applied to horizontal electrode 19, and vertical electrodes 16, cell A is the coincident (i.e., isolated) cell while cells B, C and D and E, F and M are the non-coincident (half-selected) cells. All other cells are designated as non-selected cells. Likewise at an instant when electrodes 16 and 19, are energized, cell F becomes the selected cell while cells E, G and H, and B, J and N are half-selected and the remaining cells are non-selected.

Consider this latter condition in further detail. The selected cell F is the one which it is desired to interrogate. As shown in FIG. 2a, when the interrogate signal is zero and only the sustaining signal V_s sin wt is applied to the panel, all the cells provide a current pulse output during each half cycle of the sustaining signal (for the previously assumed condition that all cells are in the on state). When an interrogate signal is applied equal in frequency to the sustaining signal, but twice the amplitude and 180° out of phase therewith as indicated in FIG. 2b, the resultant signal across the selected cell becomes −V_s sin wt which again provides a current pulse during each half cycle of the resultant signal. At the half-selected cells, however, the sustaining and interrogate signals cancel so that current pulses are no longer generated in these cells. The non-selected cells, on the other hand, still receive only the sustaining signal and therefore continue to generate current pulses as they did prior to application of the interrogate signal. The important consequence of the foregoing action is that in the rows and columns including the selected and half-selected cells only the selected cell provides output current pulses. Thus, the related current sensor, in this case sensor 28, detects information from only selected cell F. In this way individual sensors associated with each row or column of cells are able to read out the information from all the cells in that row or column, as the case may be. It will be understood, of course, that if the selected cell had not previously been driven above the ionizing lever it would have remained dark continuously, both prior to and during interrogation. Since a light pulse is produced coincident with each indicated current pulse, a photodetector cooperating with appropriate light directing elements could be used in place of each current sensor to perform the interrogation. As in the case of the current sensor, only one photodetector would be required for each row or column of cells. As a result of the aforementioned memory characteristic of the cells, at the conclusion of the interrogation period, when once again only the sustaining signal is applied to the panel, all the cells return to the state in which they were at prior interrogation.

A specific circuit implementation for applying an interrogate signal of the foregoing nature is shown in FIG. 2c where the plus and minus legends indicate instantaneous values of the A.C. signals. As indicated, the signals from the X and Y select matrices are both equal in amplitude and poles opposite to the sustaining signal.

In another embodiment of the invention, the interrogate signal is of the form V_s (sin 2 wt −sin wt), that is, it has one component equal in amplitude and frequency to the sustaining signal but 180° phase shifted therefrom and another component equal in amplitude but at twice the frequency of the sustaining signal. This composite interrogate signal is depicted in FIG. 3b. Prior to interrogation, the various waveforms appear as indicated in FIG. 3a which will be recognized as being identical to FIG. 2a. The interrogate signal can be applied to the selected electrodes in combination with the sustaining signal as shown in the simplified schematic of FIG. 3c. As in the previously described embodiment, application of the interrogate signal causes cancellation of the sustaining signal at the selected cell and the production thereat of a resultant signal equal to V_s sin 2 wt as shown in FIG. 3b. The selected cell now provides a current pulse during each half cycle of the resultant double frequency signal, that is, at twice the frequency of the sustaining signal. In this case the voltage at the half-selected cells does not reduce to zero but does decrease to a value less than that required to sustain ionization so that no current pulses are generated in these cells.

The maximum value of the resultant voltage at the half-selected cells can be readily determined by differentiating the half-selected cell voltage V_{2/1} = (V_s sin 2 wt + V_s sin wt) with respect to wt and setting the result equal to zero. This analysis indicates a maximum value of about 0.88 V_s occurring at 53° and 307° with smaller maxima occurring at 149° and 211° as shown in FIG. 3b. It is apparent therefore that the output of the selected cell can again be readily discriminated from the half-selected cells. In all other respects, namely output of the non-selected cells, absence of output from non-interactive cells, and restoration of the display subsequent to interrogation, the operation of the double frequency interrogation technique is essentially similar to the double amplitude technique.
Another interesting advantage inherent in the double frequency interrogator relates to the output pulses of the selected cell occurring at twice the frequency of the sustaining signal. This permits the selected cell to be discriminated from not only the half-selected cells but also the non-selected cells. If current sensing is employed, an individual sensor may be coupled to all rows or columns of cells; similarly, if photo sensing is employed, a single photodetector can be utilized.

Another unique feature of the double frequency technique is that it permits readout to be performed without coincident addressing. This can be accomplished, for example, by applying the interrogate signal in combination with the sustaining signal to a single row or column of cells, say the row in a superimposed relation with horizontal electrode 19a. The sustaining signal would be applied to all cells, as in the previously described cases. Then the row of cells receiving the interrogate signal would provide current and light output pulses at double the frequency of the sustaining signal. Accordingly, a current or photo sensor arranged to receive the signal from each column of cells, as in FIG. 1, would then be able to discriminate the interrogated cell output signal from the output signals of the remaining non-interrogated cells of each column.

While the invention has been described in its preferred embodiments, it is to be understood that the words which have been used are words of description rather than limitation and that changes may be made within the purview of the appended claims without departing from the true scope and spirit of the invention in its broader aspects.

I claim:

1. Apparatus for interrogating an A.C. plasma panel wherein information storage is represented by the ionization condition of each of a plurality of gas discharge cells, said apparatus comprising

   means for applying to each cell a sustaining signal having an amplitude in the range between the extinction and ionizing levels whereby any cell activated to a lighted state as a consequence of the cell voltage momentarily exceeding the extinction level thereafter remains lighted under the influence of the sustaining signal, and

   means for applying an interrogate signal to prescribed cells of said plurality of cells, the interrogate signal having one component which effectively cancels the sustaining signal in at least one of said prescribed cells and an additional component which thereafter maintains the state of said one prescribed cell as it existed prior to application of the interrogate signal.

2. The apparatus of claim 1 wherein the additional component has an amplitude substantially the same as the sustaining signal and is further related thereto in one or two respects, one being a 180° phase shift from the sustaining signal and the other being a frequency which is a harmonic of the sustaining signal.

3. The apparatus of claim 1 wherein the panel includes respective sets of electrodes arranged transversely to one another on opposite sides of the cells and in superimposed relation therewith and further including

   an interrogate signal source, and

   means in said interrogate signal applying means for selectively connecting said interrogate signal source to individual electrodes of one set.

4. Apparatus for interrogating an A.C. plasma panel incorporating a plurality of gas discharge cells, comprising

   means for applying to each cell a sustaining signal having an amplitude intermediate the extinction and ionization levels of the cells, and

   means for simultaneously applying first and second components of an interrogate signal to first and second groups respectively of the plurality of cells, one cell being common to both groups and the interrogate signal being operative to maintain the voltage at the common cell above the extinction level while simultaneously reducing the voltage across the other cells of said groups below the extinction level.

5. The apparatus of claim 4 wherein the means for applying the interrogate signals includes means for selectively applying the interrogate signal components to different groups such that the common cell can be selected as any one of the plurality of cells.

6. The apparatus of claim 4 further including means for sensing the output signal provided by said common cell in response to the interrogate signal.

7. The apparatus of claim 4 wherein the interrogate signal is of the same frequency and inverted in phase relative to the sustaining signal.

8. The apparatus of claim 4 wherein the one component of the interrogate signal includes a frequency which is a first harmonic of the sustaining signal frequency.

9. Apparatus for interrogating an A.C. plasma panel incorporating a matrix of gas discharge cells disposed between first and second sets of transversely oriented electrodes having cross-over points defining the location of the respective cells, said apparatus comprising

   an A.C. signal source coupled to the first and second sets of electrodes to establish a sustaining signal across each cell whereby any cell activated to a lighted state as a consequence of the cell voltage momentarily exceeding the ionization level thereafter remains lighted under the influence of the sustaining signal, and

   means for applying one component of an interrogate signal to a selected electrode of said first set of electrodes and applying an additional component of the interrogate signal to a selected electrode of said second set of electrodes simultaneously with the sustaining signal such that the cell located at the cross-over of the selected electrodes has a resultant signal applied thereto exceeding the extinction level of the cell whereas at the remaining cells associated with the selected electrodes the resultant signal applied to the cells is less than the extinction level.

10. The apparatus of claim 9 wherein the interrogate signal is of the same frequency but inverted in phase relative to the sustaining signal and approximately twice the amplitude thereof.

11. The apparatus of claim 9 wherein the interrogate signal includes one frequency component equivalent to the sustaining signal frequency and other frequency component which is a first harmonic of the sustaining signal frequency.

12. The apparatus of claim 9 further including means for sensing the output signal provided by the selected cross-over cell in response to the interrogate signal.

13. The apparatus of claim 12 wherein each component of the interrogate signal is of substantially the same amplitude and frequency as the sustaining signal but phase shifted 180° therefrom.

14. The apparatus of claim 12 wherein each component of the interrogate signal includes respective subcomponents of half the amplitude of the sustaining signal, one subcomponent having a frequency equal to but inverted in phase relative to the sustaining frequency and another subcomponent, having a frequency which is a first harmonic of the sustaining frequency.

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