

[72] Inventors **Wallace J. Hoff;**
Robert M. Willson, Ellicott City, both of,
Md.
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 [73] Assignee **Westinghouse Electric Corporation**
Pittsburgh, Pa.

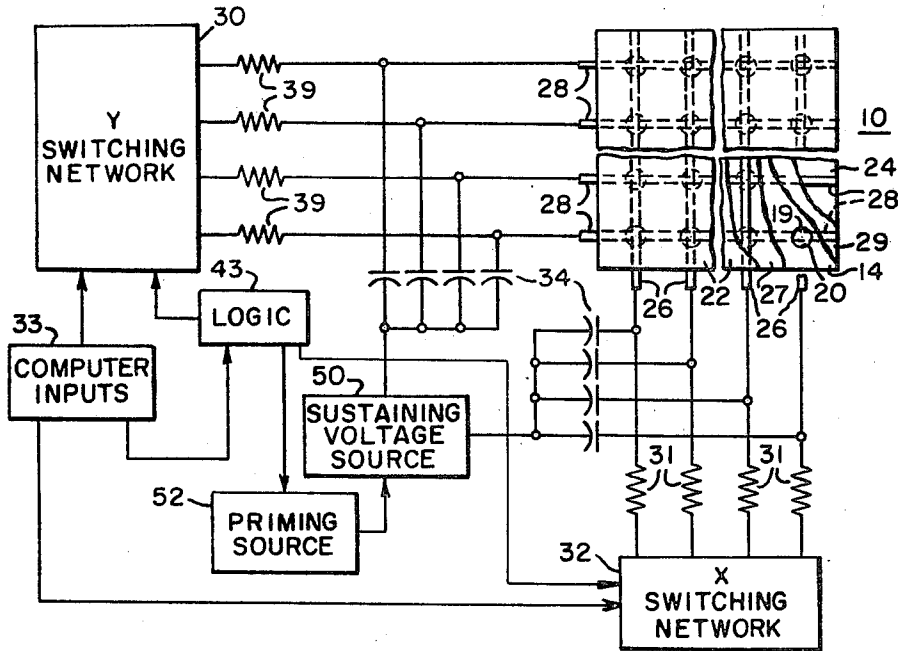
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Primary Examiner—Roy Lake
Assistant Examiner—E. R. La Roche
Attorneys—F. H. Henson and C. F. Renz

[54] **PLASMA PANEL DISPLAY SYSTEM HAVING A SOURCE OF PRIMING VOLTAGE**
6 Claims, 6 Drawing Figs.

[52] U.S. Cl..... 315/169,
 315/163, 315/166, 315/170, 315/174
 [51] Int. Cl..... H05b 41/20,
 H05b 41/44
 [50] Field of Search..... 315/161,
 165, 168, 169, 160, 166, 170, 174, 176, 163;
 313/108, 109.5, 201, 210, 234

ABSTRACT: This invention is directed to a large area panel display system comprised of a plurality of gas discharge elements or cells which may be individually controlled for the display of a visual image. More particularly, this invention is directed to systems and appropriate excitation waveforms to ensure that the gas cells are in condition and will fire on application of appropriate voltages to the cells.



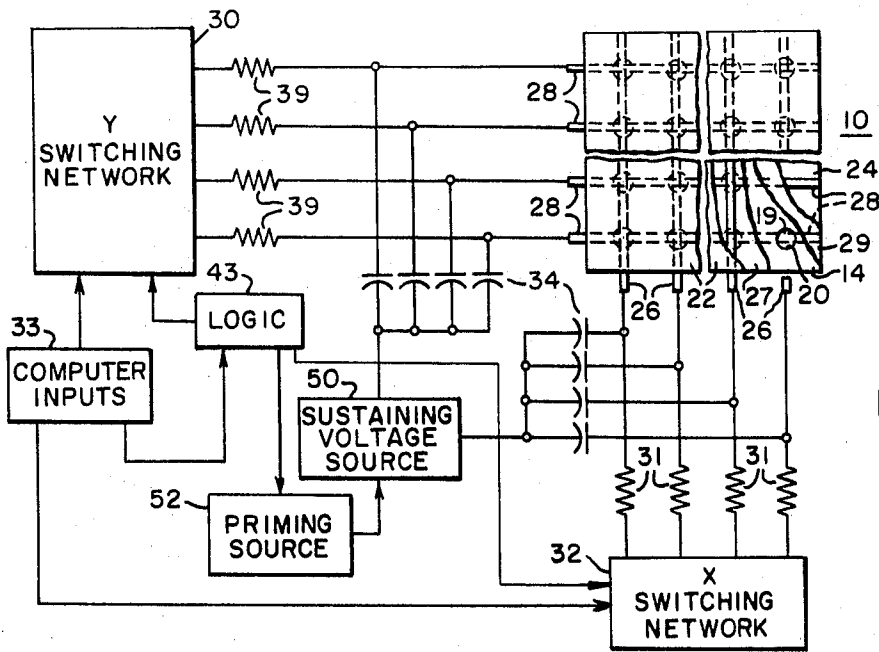


FIG. 1.

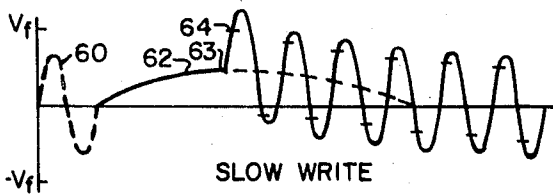


FIG. 2.

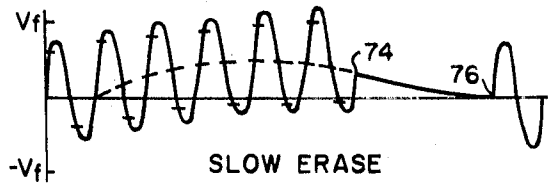


FIG. 3.

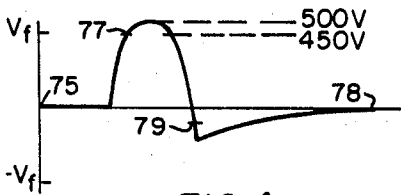


FIG. 4.

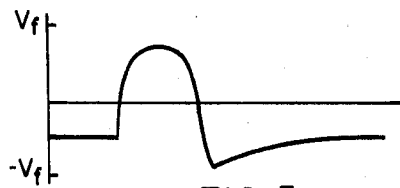


FIG. 5.

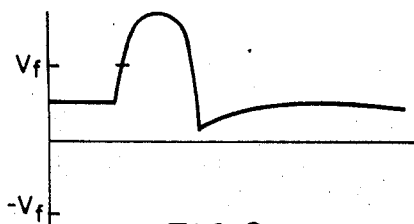


FIG. 6.

PLASMA PANEL DISPLAY SYSTEM HAVING A SOURCE OF PRIMING VOLTAGE

BACKGROUND OF THE INVENTION

This invention is directed to a flat-type display utilizing gas discharges as a source of light. This type of device has been referred to as the plasma display and a more thorough description of such a device is found in copending U.S. application Ser. No. 773,468 entitled "Large Area Plasma Display Panel 38 by H. Goldie et al. filed Nov. 5, 1968 and assigned to the same assignee as this invention. In addition, a description of the operating characteristics of such a device is found in an article entitled "The Plasma Display—A Digitally Controllable, High Brightness Display With Inherent Memory" by R. Willson and found on page 113 of NASA Report NAASASP-159 entitled "Recent Advances In Display Media" and published May 1, 1968. The plasma display basically is three pieces of thin flat glass panels which are sandwiched together. The center panel is a honeycomb structure with holes. Transparent electrically conductive electrodes are deposited on the outside surface of the two outer glass panels and aligned with the holes in the center panel. The two sets of electrodes are orthogonally positioned. Each hole forms a small volume which is completely surrounded by glass to form a cell. Voltage is applied to the appropriate row and column electrodes which are capacitively coupled to the cells. The capacitive reactance isolates the cells from the row and column electrodes and any combination of cells can be on at one time. The cells are filled with a suitable gas mixture such as neon and nitrogen to a pressure of about 200 torr. It is found in such a device that these cells exhibit a bistable characteristic, that is, once the discharge is initially ignited subsequent discharges occur even though the applied voltage is reduced.

One problem associated with this device is supplying a source of initial electrons within the cells so that the cells may be fired at any specified time. In the prior art, ultraviolet light was utilized to illuminate the display and photoelectrons are ejected into the cells from the glass surfaces by a photoelectric effect. The prior art type systems also included means for application of writing voltages to the electrode network to fire the cells at appropriate times and places. A sustaining voltage source was utilized of lower potential than firing potential to continue firing of the cells to provide a continuous display to the eye in that the cell would be fired for each half cycle of the sustaining voltage. The frequency of the sustaining source could be several hundred kilohertz. This invention is directed to the provision of additional circuitry to provide a suitable waveform of suitable repetition rate to ensure the priming of all the cells in the display so that there will be an adequate supply of electrons within each of the cells to fire in response to the write excitation pulse.

SUMMARY OF THE INVENTION

This invention is directed to plasma display-type device systems in which gas discharge display elements are utilized and in which suitable circuitry provides suitable waveforms at proper repetition rates to ensure an adequate supply of electrons within each of the gas discharge elements of the display to allow excitation in response to normal write pulse excitation to a display cell.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a diagrammatic view of a display device with associated control circuitry in cooperating with the teachings of this invention;

FIG. 2 is a plot of the voltages applied on a time basic illustrating the slow write operation;

FIG. 3 is a plot of the voltages applied to a cell in a time relation with regard to the slow erase function;

FIG. 4 is a plot of the voltage on a gas cell which is in the off condition with a prime voltage waveform applied thereto;

FIG. 5 illustrates the voltage on an on cell in response to application of a prime voltage; and

FIG. 6 illustrates the application of the prime voltage pulse to an on cell.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring in detail to FIG. 1, there is shown a display screen 10 which is described in more detail in the previously mentioned Goldie et al. application. The display screen 10 consists of a first outer electrode plate 22 having a plurality of X conductors 26 provided on the inner surface thereof and a second outer electrode panel 24 having a plurality of Y conductors 28 thereon. Insulating sheets 27 and 29 are positioned over the electrode covered surfaces of the electrode panels 22 and 24 respectively and a honeycomb insulating plate 14 is positioned between the insulating surfaces of the electrode panels 22 and 24. A plurality of apertures 20 are provided within the honeycomb plate 14 and a gas fill of a suitable gas mixture such as neon and nitrogen at a pressure of about 200 torr is provided within the apertures 20. A display element 19 is thus formed which consists of the gas fill in the aperture 20 and the associated electrodes 26 and 28 to which a voltage may be applied which will cause a breakdown and firing of the gas within the aperture 20 and the generation of light emission. The Y conductors 28 are connected through resistors 39 to a suitable Y switching network 30 to permit selection of the conductor 28 to which a voltage may be applied. The X conductors 26 are also connected through resistors 31 to a suitable X switching network 32 capable of selecting the desired X conductor 26 to which a voltage will be applied.

A sustaining voltage source 50 is connected to each of the conductive electrodes 26 and 28 through suitable isolating capacitors 34. The source 50 may provide a sine wave output of a frequency of about 50 kHz. and amplitude of 400 volts. In addition, a computer input 33 is provided through the switching networks 30 and 32. The computer input 33 is connected to a logic system 43 which is in turn connected to the switching networks 30 and 32. The logic circuitry 43 is also connected to the sustaining voltage source 50 and to a priming source 52. The priming source 52 is also connected to each of the conductive leads 26 and 28 through the isolating capacitors 34.

Referring now to FIGS. 2 and 3 the sustaining voltage source 50 provides a waveform as illustrated in FIG. 2 as the dotted portion 60 which has an amplitude of about 400 volts and a frequency of about 50 kHz. This amplitude is selected so as to be of a less value than that necessary for causing initial firing of a discharge within a display element 19. In the absence of any write information the display screen 10 will be dark in that none of the display elements 19 will be excited. In response to an input from the computer input 33, the switching networks 30 and 32 apply voltages to selected lines 28 and 26 through the resistors 39 and 31. The RC network made up of the resistors 39 and 31 and capacitors 34 isolates the switching networks 26 and 28 from the sustaining voltage source 50. The logic circuitry 43 controls the application of the write voltage pulses and erase voltages pulses the sustaining voltage and the priming voltage. To fire a display element 19, the sustaining voltage source 50 is removed at a zero crossing of the sustaining voltage and a voltage pulse is added to the selected X conductor 26 and selected Y conductor 28 of reversed polarity. This is indicated in FIG. 2 by the section 62 of the waveform. The sustaining voltage is then reapplied at the point 63 and, with the proper choice of pulse amplitude the total voltage across the cell 19 exceeds the firing voltage and the cell fires at a point on a curve indicated at 64. The cell 19 is now in the on state and will refire with each half cycle of the sustaining voltage and thereby provide illumination from this display element 19. The write pulse is then removed and the cell 19 continues to fire on each half cycle.

To erase a cell 19 from on condition to off condition, an erase pulse is added before the sustaining voltage is removed

as illustrated in FIG. 3 and the cell 19 tracks the resulting voltage. Just before the erase voltage is removed, the total voltage across the cell is nearly zero. The sustaining voltage is now removed at the point 74 just after the wall of the cell 19 is positively charged and if the amplitude of the voltage pulse is correct, no net voltage will appear across the cell 19. With the resumption of the sustaining voltage at point 76, the net wall voltage is zero and the cell 19 will not fire and the cell 19 is erased to a dark condition. It is found that about four half cycles of the sustaining voltage must be allowed for the tracking of the pulse voltages. Thus, at least two periods must be allowed for writing or erasing the cell 19.

As previously pointed out, the problem of supplying a source of initial electrons within the cells 19 that are in the off condition so that the cells 19 can be fired by the write pulse at any specified time must be provided for. It is believed that metastable atoms are the most likely source for initial electrons between discharges. It is therefore the teaching of this invention that with the application of appropriate excitation waveforms the cells 19 may be fired often enough to ensure a supply of excited atoms (metastables), but at a low enough rate so that the resulting discharge is not visible to the observer. This firing must be accomplished so that it leaves the walls of the off cells 19 in the zero state and does not change the state of the cells in the on state. This priming operation is illustrated in FIGS. 4, 5 and 6. The appropriate waveform is illustrated in FIG. 4 between the points 75 and 78. In operation the sustaining voltage is removed and the voltage pulse shown in FIG. 4 between point 75 and 78 is applied to the entire array. In FIG. 4, there is illustrated the response of a cell 19 that is in an off condition. The prime waveform includes a rapidly rising front edge of sufficient amplitude to initiate firing of the cell 19 at the point 77 and again firing at the point 79. The net voltage across the cell 19 after the second firing point 79 is erased by the trailing edge portion of the prime waveform, that is that portion between point 79 and point 78, such that the net voltage across the cell 19 after the second firing is reduced to zero. The portion of the waveform between the point 79 and 78 is of a similar waveform as that used in the cell erase as indicated in FIG. 3. The sustaining voltage is then reapplied at point 78 to the cell 19 and is of insufficient magnitude to initiate any firing of the cell. However, the cell 19 does have adequate electrons present to initiate firing in response to a write pulse. The repetition frequency of the priming pulse from the source 52 must be larger than $1/t$ where t is the diffusion time constant of metastable nitrogen in neon in order that the cells 19 in on state will continue to refire when the sustaining voltage is reapplied. However the repetition frequency of the priming pulse need not be larger than 3 or 4 times $1/t$. In FIGS. 5 and 6 the response of cells that are on prior to application of prime voltages is indicated and it is seen that the prime pulse returns the cells 18 to their original condition and therefore the cells 19 will fire on reaplication of the sustaining voltage.

If it is assumed that the major deexcitation mechanism for metastable atoms is the atoms bombarding the walls of the cells 19 then the average lifetime of the metastables is of the order of the largest diffusion time constant t , which is

$$\frac{1}{t} = \frac{D}{P} \left\{ \frac{\pi^2}{d^2} + \frac{2.405^2}{r^2} \right\}$$

where d is the cell thickness and r is the cell radius. For a cell

0.025 inches in depth and 0.050 inches in diameter filled to a gas pressure of 180 torr for metastable nitrogen in neon, D is approximately equal to 157 and therefore t is equal to 4×10^{14} . Thus if the repetition rate is 2×10^{14} seconds which is approximately 5×10^3 Hz. the cell 19 will refire with resumption of the sustaining voltage and a supply of electrons will be available in the cells originally in the off condition. At a time repetition rate of 5×10^3 Hz. and a sustaining voltage of several hundred kilohertz, the average cell brightness is 0.01 times that of a normally on cell so that the contrast ratio of the display and the cell brightness are negligibly affected by this priming operation.

Although the invention has been described with a certain degree of particularity, it should be understood that the present disclosure has been made only by way of example and that numerous changes may be resorted to without departing from the spirit and scope of the present invention.

What we claim is:

1. A plasma display system comprising an array of bistable display elements, said display elements comprising a gaseous medium and electrical conductive means for impressing a voltage on selected elements to impress a voltage across said gaseous medium, writing circuit means operatively associated with said electrically conductive means to impress a voltage across a first portion of elements to induce a discharge and activate said first portion of elements, a sustaining circuit means operatively associated with said electrical conductive means to impress an alternating voltage across all of said display elements of sufficient value to sustain said discharge across said first portion of elements and insufficient to initiate a discharge in a second portion of elements, said sustaining circuit providing an output of a first frequency, and a priming circuit means operatively associated with said electrical conductive means to impress a voltage pulse across said display elements to induce a discharge in said second portion of elements to insure the responsiveness of said display elements to said writing circuit means, the frequency rate of said priming pulses of a lower value than the frequency of said sustaining voltage, said priming circuit means returning said first and second portions of display elements to their initial value so that said sustaining voltage will cause said first portion of elements to continue to discharge and will cause said second portion of display elements to remain off.

2. The system set forth in claim 1 in which said sustaining circuit means voltage has a frequency greater than 100 times the frequency of said priming circuit means voltage.

3. The system set forth in claim 1 in which said priming circuit means voltage induces a charge at a rate to insure the existence of metastable atoms in said gaseous medium.

4. The system set forth in claim 1 in which said sustaining circuit means voltage is removed from said display elements while said priming circuit means voltage is applied.

5. The system set forth in claim 1 in which said priming circuit means voltage is applied in a manner to induce a discharge and return said display elements to their original condition.

6. The system set forth in claim 1 in which said sustaining circuit means voltage is removed from said display elements for about three periods and said priming circuit means voltage is applied during the removal of said sustaining circuit means voltage.

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