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Jones et al.

[11] **3,895,361**

[45] **July 15, 1975**

[54] **METHOD AND APPARATUS FOR RELIABLY PARALLEL SELF SHIFTING INFORMATION IN A PLASMA DISPLAY/MEMORY PANEL**

[75] Inventors: **Larry M. Jones**, Matawan, N.J.; **Roger L. Johnson**, Monticello, Ill.

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

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[52] **U.S. Cl.. 340/173 PL**; 340/166 EL; 340/324 M

[51] **Int. Cl.**.. **G11c 11/28**

[58] **Field of Search**.... 340/324 M, 166 EL, 173 PL

[56] **References Cited**

UNITED STATES PATENTS

2,984,765 5/1961 Englebart..................... 340/173 PL

Primary Examiner—Terrell W. Fears

Attorney, Agent, or Firm—Merriam, Marshall, Shapiro & Klose

[57] **ABSTRACT**

An improved method and apparatus for the reliable, parallel, self-shifting of information in a plasma display/memory panel. Two lines of transfer cells are sequentially, selectively activated to transfer information by cell-to-cell interaction from one line of display or information cells to the next such line of display cells on the panel. Reliability of the transfer operation is increased by applying a symmetrical erase signal waveform to the transfer cells during non-transfer periods. A two dimensional, four direction parallel, self-shifting method and apparatus for a plasma panel is described.

12 Claims, 4 Drawing Figures

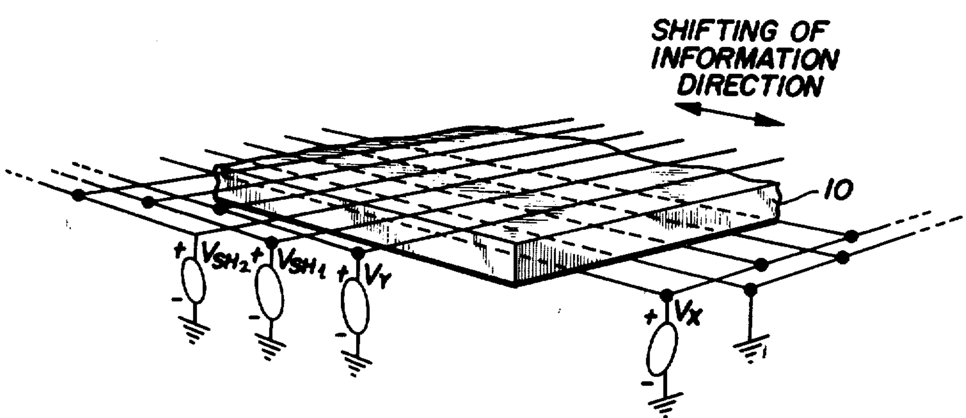


FIG. 1

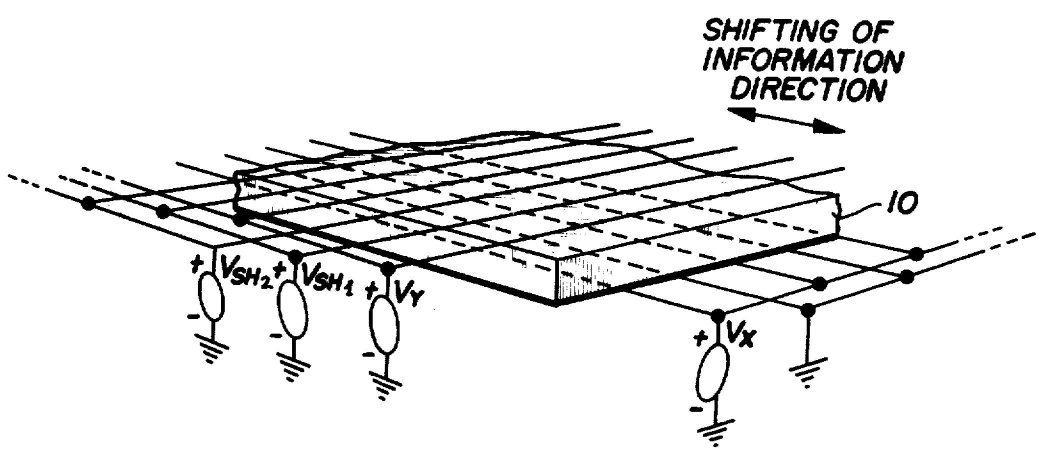
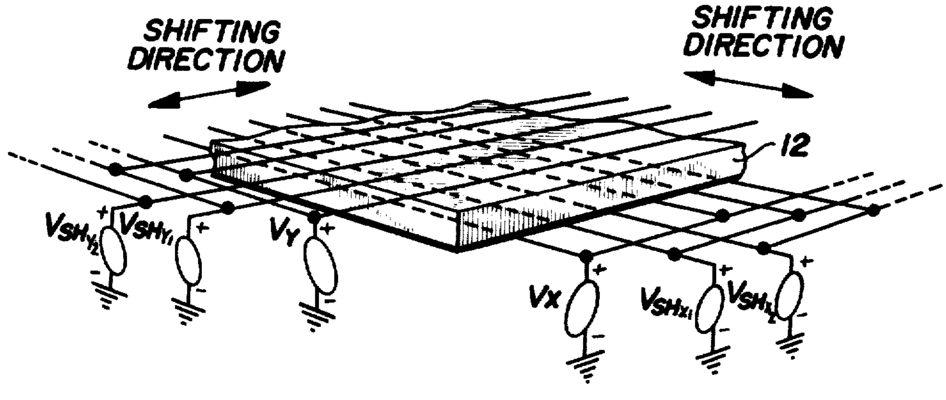

SHIFTING OF INFORMATION DIRECTION
10
VSH2
VSH1
VY
VX

FIG. 2


SHIFTING DIRECTION
SHIFTING DIRECTION
12
VSHY2
VSHY1
VY
VX
VSHX1
VSHX2

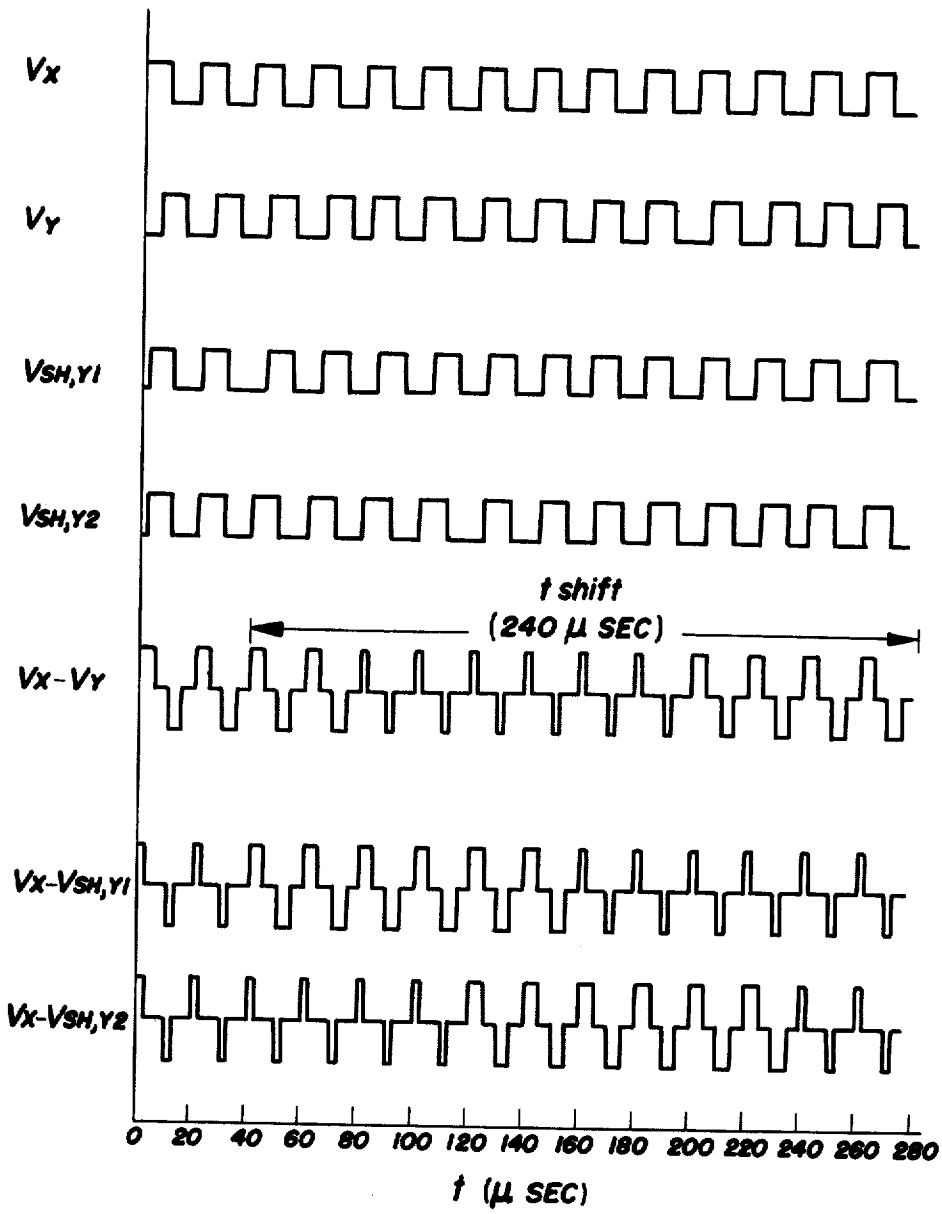

Vx
Vy
VSH,Y1
VSH,Y2
t shift
(240 μ SEC)
Vx-Vy
Vx-VSH,Y1
Vx-VSH,Y2
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280
t (μ SEC)

FIG. 3

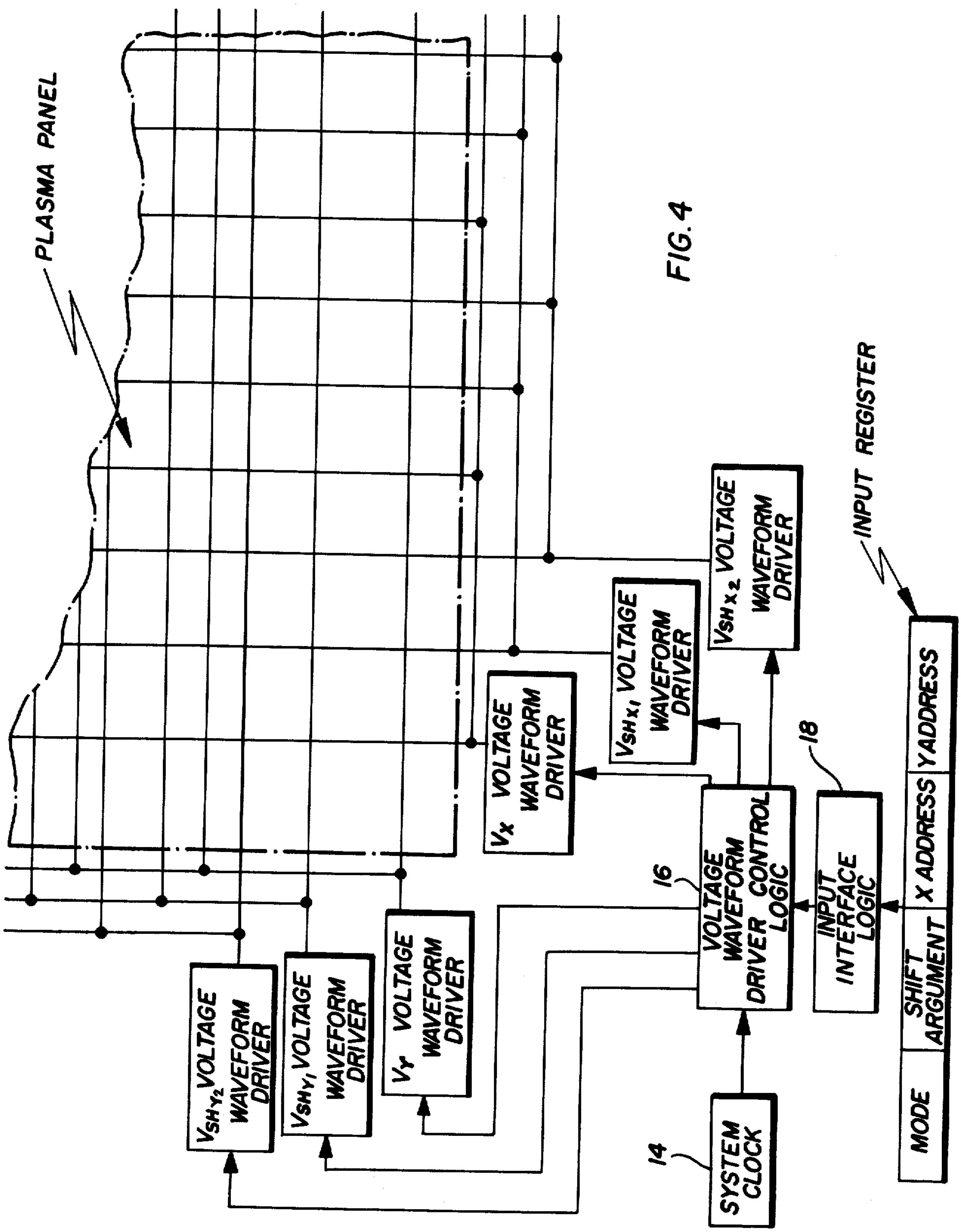

PLASMA PANEL
V_X VOLTAGE WAVEFORM DRIVER
V_{SHX_1} VOLTAGE WAVEFORM DRIVER
V_{SHX_2} VOLTAGE WAVEFORM DRIVER
INPUT REGISTER
18
INPUT INTERFACE LOGIC
16
VOLTAGE WAVEFORM DRIVER CONTROL LOGIC
MODE
SHIFT ARGUMENT
X ADDRESS
Y ADDRESS
14
SYSTEM CLOCK
V_{SHY_2} VOLTAGE WAVEFORM DRIVER
V_{SHY_1} VOLTAGE WAVEFORM DRIVER
V_Y VOLTAGE WAVEFORM DRIVER

FIG. 4

METHOD AND APPARATUS FOR RELIABLY PARALLEL SELF SHIFTING INFORMATION IN A PLASMA DISPLAY/MEMORY PANEL

This invention relates to information displays, and in particular to a method and apparatus for reliably shifting information in a gaseous discharge display/memory panel.

One type of display device having properties of an addressable matrix of light emitting elements exhibiting inherent memory now has become known as the "plasma display panel" or the "plasma display/memory panel." Such plasma display panels comprise an array of gas discharge cells separated from exciting electrodes by dielectric material, as described in U.S. Pat. No. 3,559,190, "Gaseous Display and Memory Apparatus," D. L. Bitzer, H. Gene Slottow and R. H. Willson, issued Jan. 26, 1971, and assigned to the same assignee here. The commercial development of such potentially low cost graphic display panels has accelerated the interest in systems which employ terminals using the panels as display devices. An example of such a system is the PLATO IV Computer-Based Information System at the University of Illinois and as shown for instance in U.S. Pat. No. 3,405,457, D. L. Bitzer, issued to the same assignee here.

Many of the design principles being utilized in the implementation of that system are common to many computer-based information systems which must support graphic display activity. For example, one of the key objectives of this type of system is to be able to support relatively high speed graphical image editing, such as animation and rotation over low bandwidth data lines. At present, plasma display/memory terminals can support activity rates of 180 characters per second and 60 random length lines per second. A great deal of image editing, however, consists of moving or shifting subportions of the image file which already exist on the display to other areas of the display. This is analogous to a memory move or relocation of data in a computer memory.

A proposed system for the shifting of data stored in a plasma display panel is presented for example in "Self Shift Plasma Display," Digest of Papers — SID International Symposium, Society of Information Display, San Francisco, June, 1972, S. Umeda and T. Hirose, pp. 38–39. The various proposed systems utilize the phenomenon that the applied voltage required to initiate a gas discharge in a cell in the "OFF" state but adjacent to a cell in the "ON" state is somewhat less than the normally required turn on voltage. There appears to be a cell-to-cell interaction or coupling mechanism which enables the normally OFF cell to be turned on at a lower voltage level. An explanation for this interaction might be that a high concentration of electrons, ions and metastable atoms are present in the immediate neighborhood of a cell adjacent to ON cells due to the nearness of the gas discharge in the ON cells. These particles apparently contribute to the lowering of the firing voltage of the adjacent OFF cell — somewhat in the form of a priming effect, and the lowered turn on voltage is therefore sufficient to start a discharge sequence in the adjacent OFF cell.

In the various proposed systems, it is desired to obtain improved performance characteristics particularly in terms of greater reliability of operation. For instance, in prior art proposed systems, certain cells in the plasma panel are provided with an average DC cell

wall voltage or accumulate a slight cell wall voltage. In either instance, the reliability of panel operation is adversely affected since although cell-to-cell interaction is desired during the shift operation, this phenomenon can cause erratic or undesired firing of such cells.

SUMMARY OF THE INVENTION

In accordance with the principles of the present invention, there is provided a method and apparatus for the reliable, parallel, self-shifting of information in a plasma display/memory panel. In particular, the present invention provides an information display in which information stored in a plasma display panel can be reliably shifted in all four coordinate directions. A 256-line by 256-line section of a 60-line-per-inch plasma panel has been utilized in a constructed embodiment in order to demonstrate the operational characteristics of a four directional shift technique in accordance with the invention. Using the technique of the present invention, shifting of information in the panel can occur at a rate as high as 5,000 lines per second. Using a one directional shift technique applied to a selected area of a 60-line-per-inch panel, shift rates as high as 10,000 lines per second were achieved.

The plasma display panel is arranged such that a serial string of cells and the associated electrodes form the information or display portion of the panel — the panel also being provided with a serial string of cells and associated electrodes forming the shifting or transfer portion. Two lines of shifting or transfer cells are provided intermediate each line of information or display cells.

In operation, all transfer cells adjacent to the display cells in the desired shift direction are activated in such a way as to effect a transfer of the display cell information to the transfer cells. Next, all of the display cells are placed in a clear or erase mode which inhibits any undesired transfer of information to the display cells. Then, the remaining transfer cells are activated in such a manner that the information is transferred from the first line of transfer cells to the second line of transfer cells, and the first line of transfer cells is placed in an erase mode to prevent any undesired accumulation of wall voltage during their inactive, non-transfer periods. The erase mode maintains the transfer cells in a more reliable OFF state. Finally, the display cells are removed from the erase mode and activated so as to transfer the information from the second transfer cells to the display cells, and the second transfer cells are placed in a clearing or erase mode during their inactive, non-transfer period. In this manner the information stored in all of the display cells has been reliably shifted in parallel to the next adjacent display cells in the direction of the desired shift.

In the present invention, reliability of the shift operation has been increased over the prior art in that the transfer cells are maintained in a clearing or erase mode during inactive, non-transferring periods.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram illustrating a one dimensional parallel, self-shift technique in accordance with the present invention;

FIG. 2 is a schematic diagram illustrating a two dimensional parallel, self-shift technique in accordance with the present invention;

FIG. 3 illustrates the timing sequence and the wave forms to provide a one-line shift of information in the plasma panel in accordance with the present invention; and

FIG. 4 is a block diagram illustrating apparatus for providing the sequential wave forms illustrated in FIG. 3.

DETAILED DESCRIPTION

Referring now to FIG. 1, there is illustrated a portion of a plasma panel 10 including the usual set of respective X and Y crossing electrodes. As is well known, information can be entered into the plasma panel 10 by coupling appropriate firing or turn on voltages to a respective X and Y electrode such that the desired information can be entered into the associated gas cell. The information is then normally retained in the panel by coupling a suitable sustaining voltage to the panel electrodes.

As can be seen from FIG. 1, a line voltage generator V_Y is connected to every third Y electrode and a line voltage generator V_X is connected to every other X electrode. The alternate X electrodes are connected to ground to prevent information transfer in an undesired direction on the panel.

Two shifting voltage generators are provided as indicated and labeled V_{SH_1} and V_{SH_2} — each of the shifting or transfer voltage generators being connected to every third Y electrode or line of the panel. The crossings of the V_Y and V_X electrodes are associated with the information or display cells normally utilized during a non-shift operation of the panel. These cells can be addressed to effect a write or erase condition as during standard, well-known plasma panel operation. The crossings of the V_X electrodes and the respective V_{SH_1} and V_{SH_2} electrodes are associated with the shifting or transfer cells which are used during a shift operation to temporarily store and transfer the information contained in the display cells. Thus, on a standard 60-lines-per-inch plasma panel having the present information shifting capability, the viewing resolution would be reduced to 20 lines per inch. The arrowhead directions on FIG. 1 illustrate the directions in which shifting of information can be provided on the plasma panel 10.

The overall technique for shifting of information is as follows. Initially, it is assumed that in a standard, well-known manner information can be entered on the V_Y lines — that is, the information is entered into the cells associated with the V_Y lines. Next, the voltage difference across the cells associated with the first shifting or transfer lines, V_{SH_1} is provided such that all of the information stored on the V_Y lines is shifted by cell-to-cell interaction to the V_{SH_1} lines. A voltage difference is then provided across the information or display cells such that all of the cells associated with the V_Y lines go to the OFF state, and the information in the panel has thus undergone one line of temporary shift. In other words, the information formerly present in the information or display cells has been transferred one line up to the next line of shifting or transfer cells.

A suitable voltage difference is then provided on the electrodes associated with the second line of transfer or shifting cells, i.e. those cells on lines connected to the V_{SH_2} generators, causing by cell-to-cell interaction the shifting of information stored on the V_{SH_1} voltage lines to also be stored on the V_{SH_2} lines. The transfer cells formed by the crossing of the V_{SH_1} and the V_X lines were originally the receiving cells receiving information from the V_Y lines, and are now the initiating cells so that the role that the various cell undertake must be interchangeable. Next, the V_{SH_1} lines are erased, and a suitable voltage difference is provided to the display cells such that the information now on the V_{SH_2} lines is also coupled by cell-to-cell interaction to the next adjacent V_Y line. Finally, the V_{SH_2} lines are erased and the shifting of information from one display line to the next has been completed. To effect a shift of information in the reverse direction from that previously described, the roles of the V_{SH_1} and V_{SH_2} lines are interchanged.

Referring to FIG. 2, there is illustrated a plasma panel 12 in which there has been provided shifting generators not only on the Y electrodes but also on the respective X electrodes. Note that the V_X line generators associated with the panel display cells are connected to every third C electrode. Also respective $V_{SH_{X1}}$ and $V_{SH_{Y1}}$ transfer generators are connected to every third X electrode. Thus, information on panel 12 can be shifted in each of the two dimensions and in each of the four directions illustrated by the arrowheads in FIG. 2.

Referring now to FIG. 3, there is illustrated the various sequential waveforms for producing a one-line shift sequence on the Y electrodes. The waveforms labeled V_X, V_Y, $V_{SH_{Y1}}$ and $V_{SH_{Y2}}$ correspond to the line generators shown in FIGS. 1 and 2. The waveform identified as V_X–V_Y in FIG. 3 represents the voltage difference provided between the X and Y electrodes associated with the information or display cells on the plasma panel. The waveform in FIG. 3 identified as V_X–$V_{SH_{Y1}}$ represents the voltage difference applied between the electrodes associated with the first Y line of shifting or transfer cells. Similarly, the last waveform in FIG. 3 identified as V_X–$V_{SH_{Y2}}$ represents the voltage difference applied to the second line of shifting or transfer cells of the respective Y electrodes.

In utilizing the timing sequence shown in FIG. 3, the voltage pulses of the various line generators have been overlapped to produce the desired cell voltage. It is to be understood, of course, that any suitable voltage generators can be used to provide the resulting desired waveforms. However, the approach illustrated in FIG. 3 for producing the required cell voltages has several advantages over the methods employed in the prior art. One advantage is that the erase pulse width can now be made arbitrarily narrow without imposing severe switching requirements on the high voltage switching transistors commonly used in the presently available drive circuitry. Another advantage is that it is now a straight forward process to generate symmetrical waveforms, and thereby maintain a more controlled situation with initial wall voltage. A third advantage is that the various line generators produce voltage waveforms with a 50 percent duty cycle which provides a more dependable and efficient operation of the drive circuitry.

For convenience, FIG. 3 also shows reference time intervals of 20 microseconds. As shown, a one-line shift of information (i.e., from one line of display cells to the next line of display cells) is provided according to the invention in 240 microseconds. With reference to FIG. 3, and assuming that there is at least one line of display cells containing information on the panel, the combination of the V_X and V_Y generated waveforms provide the standard square wave sustaining signal waveform from time period, $t=0$ to $t=80$ microseconds to the plasma panel display cells. Between reference 0 and 40 microseconds the combined V_Y and $V_{SH_{Y1}}$ line generators provide the standard symmetrical erase waveform so as to maintain all of the transfer cells associated therewith in the OFF state. Starting at about 40 microseconds a normal sustaining signal waveform is applied to the first transfer line and due to the cell-to-cell interaction previously referred to, the information present on the adjacent line of display cells is transferred to the first transfer line of transfer cells associated with the V_Y and $V_{SH_{Y1}}$ electrodes during the time interval of t=40 to t=80 microseconds. Starting at about 80 microseconds, it can be seen that a series of erase signals are applied to the display cells continuing to about 200 microseconds in order to place all display cells in the OFF state (see waveform V_Y–V_X in FIG. 3).

During the interval from 80 to 120 microseconds, the information is present only on the first transfer line. After 120 microseconds and to about 160 microseconds the shifting sequence is repeated but this time from the first transfer line to the second transfer line. As shown in FIG. 3, in accordance with the invention the transfer cells associated with the V_Y and $V_{SH_{Y2}}$ electrodes are provided with a symmetrical erase signal until 120 microseconds from reference O. This keeps these cells in the OFF state and prevents erratic and undesired shifting of information. At that time, the respective second transfer lines are provided with sustaining signals such that by cell-to-cell interaction the information on the first transfer line is transferred to the second transfer line during the interval 120 to 160 microseconds.

After 160 microseconds, an erase signal is applied to the first transfer lines so as to maintain the associated transfer cells in the OFF state. Thus, during the interval 160 to 200 microseconds, the information which had been present on the respective lines of display cells is now located only on the next associated second line of transfer cells. Between 200 and 240 microseconds the display lines have the sustaining signal applied thereto so that by cell-to-cell coupling, the information is now also present on the next display line. At 240 microseconds, the erase signal is again applied to the second line of transfer cells associated with line electrodes V_Y and $V_{SH_{Y2}}$ so that these cells are again placed in the OFF state to prevent erratic or undesired shifting in accordance with the invention. Thus, the information which was present on respective lines of display cells on the plasma panel has been shifted one line up to the next respective line of display cells.

In accordance with the invention, it is to be particularly noted that during the inactive portions of the transfer cells, each of the transfer cells is maintained in the OFF state by the symmetrical erase signal applied thereto. This significantly increases the operational reliability of the present invention as compared to the prior art in that the transfer cells are definitely maintained in the OFF state so that they do not and can not accumulate any wall voltage during their inactive portions. This prevents undesired premature or erratic firing and reduces the possibility of errors in shifting the desired information during the shifting sequence.

In a constructed embodiment of the invention, the shift sequence shown in FIG. 3 accomplished a one-line shift of information in 240 microseconds which corresponds to about 5.3 meters per second or about 4,000 lines per second. The high voltage level was 155 volts plus or minus 2 volts for the 12-cycle shift sequence. The sustaining signal pulse width was about 4.5 microseconds and the erase signal pulse width was about 2 microseconds. This shift sequence was reduced to 200 microseconds or 5,000 lines per second, but the shift operation became very sensitive to changes in the high voltage level. It has been observed that one important characteristic of the cell-to-cell coupling mechanism is that the larger the voltage applied to the initiating cell, the greater the shift margin attainable. Another important observed characteristic of the coupling mechanism is that the cell voltage of all of the neighboring cells of the receiving cell can contribute to increasing the shift margins attainable, and that making these cell voltages as nearly similar as possible to that of the receiving cell voltage without permitting a discharge to occur enhances the shift margin the greatest. Also, an effective way to control the coupling mechanism is to pulse width modulate the sustaining signal waveforms.

Referring now to FIG. 4, there is illustrated the controlled driver apparatus for producing the timing sequence of wave forms shown in FIG. 3. The illustrated V_Y, $V_{SH_{X1}}$, and $V_{SH_{X2}}$ voltage waveform drivers and the respective Y electrode voltage waveform drivers correspond to the line generators shown in FIG. 2. Such driver units are well-known in the plasma panel art. A system clock 14 operates through a well-known driver control logic apparatus 16 to provide the basic system time sequence of FIG. 3. An input interface logic apparatus 18 interconnects the driver control logic apparatus 16 with an input register containing mode, shift and cell address information being presented from a computer, terminal, or other source. The modes required are as follows: Shift Up; Shift Down; Shift Right; Shift Left; Write; Erase; Bulk Erase; and Sustain.

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 a method for parallel shifting of information in a plasma panel during a transfer period, sequentially from one panel line of information cells to at least one panel line of transfer cells and to the next line of information cells, the improvement comprising placing the panel line of transfer cells in an erase mode during their inactive, non-transfer period to provide more reliable information transfer during the transfer period.

2. The improved method of claim 1 further including placing the panel line of transfer cells in said erase mode during periods just prior to receiving information from a line of information cells until just after transferring said information to the next panel line.

3. The improved method of claim 1 wherein placing the panel line of transfer cells in an erase mode includes the step of applying to said transfer cells a symmetrical erase signal to reliably maintain said cells in the OFF state and prevent the undesired accumulation of cell wall voltage.

4. A method for reliably parallel self shifting of information in a plasma panel comprising the steps of:

providing at least two lines of information cells;

providing first and second lines of transfer cells intermediate said two lines of information cells;

maintaining said lines of transfer cells in the OFF state by coupling an erase signal thereto;

removing said erase signal from said first line of transfer cells and activating same to transfer information from one of said lines of information cells to said first line of transfer cells;

removing said erase signal from said second line of transfer cells and activating same to transfer information from said first line of transfer cells to said second line of transfer cells;

recoupling said erase signal to said first line of transfer cells to erase said information and maintain said transfer cells in the OFF state;

transferring information from said second line of transfer cells to the other of said lines of information cells; and

recoupling said erase signal to said second line of transfer cells to erase said information and maintain said transfer cells in the OFF state.

5. The method of claim **4** including the steps of applying said erase signal to said lines of information cells immediately following transfer of said information to said first line of transfer cells to erase said information from said information cells, and removing said erase signal from said lines of information cells immediately prior to transfer of said information from said second line of information cells to said other line of information cells.

6. The method of claim **4** wherein the coupling of an erase signal to said transfer cells includes the step of applying to said transfer cells a symmetrical erase signal.

7. In plasma panel apparatus including a plasma panel having alternating lines of information cells and transfer cells, means for sequentially shifting information during a transfer period from one line of information cells to at least one line of transfer cells and then to the next line of information cells, the improvement comprising means for preventing said transfer cells from accumulating a cell wall voltage during their inactive, non-transfer period to provide more reliable transfer of information during said transfer period.

8. The improvement of claim **7** including erase signal means providing an erase signal capable of maintaining a plasma panel cell in the OFF state, and means for sequentially coupling said erase signal to said transfer cells during said inactive, non-transfer period.

9. The improvement of claim **8**, wherein said erase signal means includes means providing a symmetrical erase signal for selective sequential coupling to said line of transfer cells.

10. Apparatus for shifting information selectively in X and Y transverse coordinate directions corresponding to an X and Y array of line electrodes and cells on a plasma panel, said apparatus comprising:

voltage generating means coupled to at least a first, second, third and fourth respectively adjacent X and Y line electrodes in said array for generating a timed sequence of signal waveforms during an information transfer period;

said voltage generating means including;

means for generating a sustaining signal waveform including means for selectively sequentially coupling said sustaining signal waveform between said first X and Y line electrodes, between said first X and said second Y electrodes, between said first X and said third Y electrodes and between said first X and said fourth Y electrodes for sequentially transferring information from said first to said fourth Y electrode along a selected direction corresponding to said Y coordinate on said plasma panel; and

means for generating an erase signal waveform including means for selectively sequentially coupling said erase signal waveform between said last mentioned series of respectively adjacent X and Y line electrodes following the respective coupling of said sustaining signal waveform for sequentially erasing information on said first, second and third Y line electrodes;

said means for generating a sustaining signal waveform further including means for selectively sequentially coupling said sustaining signal waveform between said first X and Y line electrodes, between said first Y and said second X electrodes, between said first Y and said third X electrodes and between said first Y and said fourth X electrodes for sequentially transferring information from said first to said fourth X electrode along a selected direction corresponding to said X coordinate on said plasma panel; and

said means for generating an erase signal waveform further including means for selectively sequentially coupling said erase signal waveform between said last mentioned series of respectively adjacent X and Y line electrodes following the respective coupling of said sustaining signal waveform for sequentially erasing information on said first, second and third X line electrodes.

11. Apparatus as claimed in claim **10**, wherein said means for generating an erase signal waveform further includes means for selectively coupling said erase signal waveform between said first X and said second and third Y line electrodes and between said first Y and said second and third X line electrodes during non-information transfer periods for reliably maintaining the associated cells in the "OFF" state.

12. Apparatus as claimed in claim **11**, wherein said means for generating an erase signal waveform further includes means for generating a symmetrical erase signal waveform.

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