

[54] **SELF-SCANNING PLASMA DISPLAY
DEVICE WITH PHOSPHOR SCREEN**

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[58] Field of Search 315/169 R, 169 TV, 58;
313/220, 210, 108 A, 108

[56] **References Cited**

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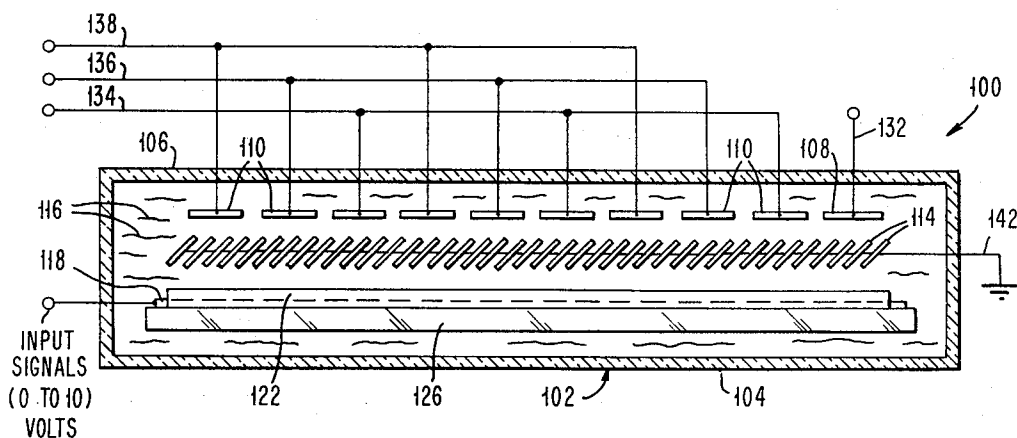
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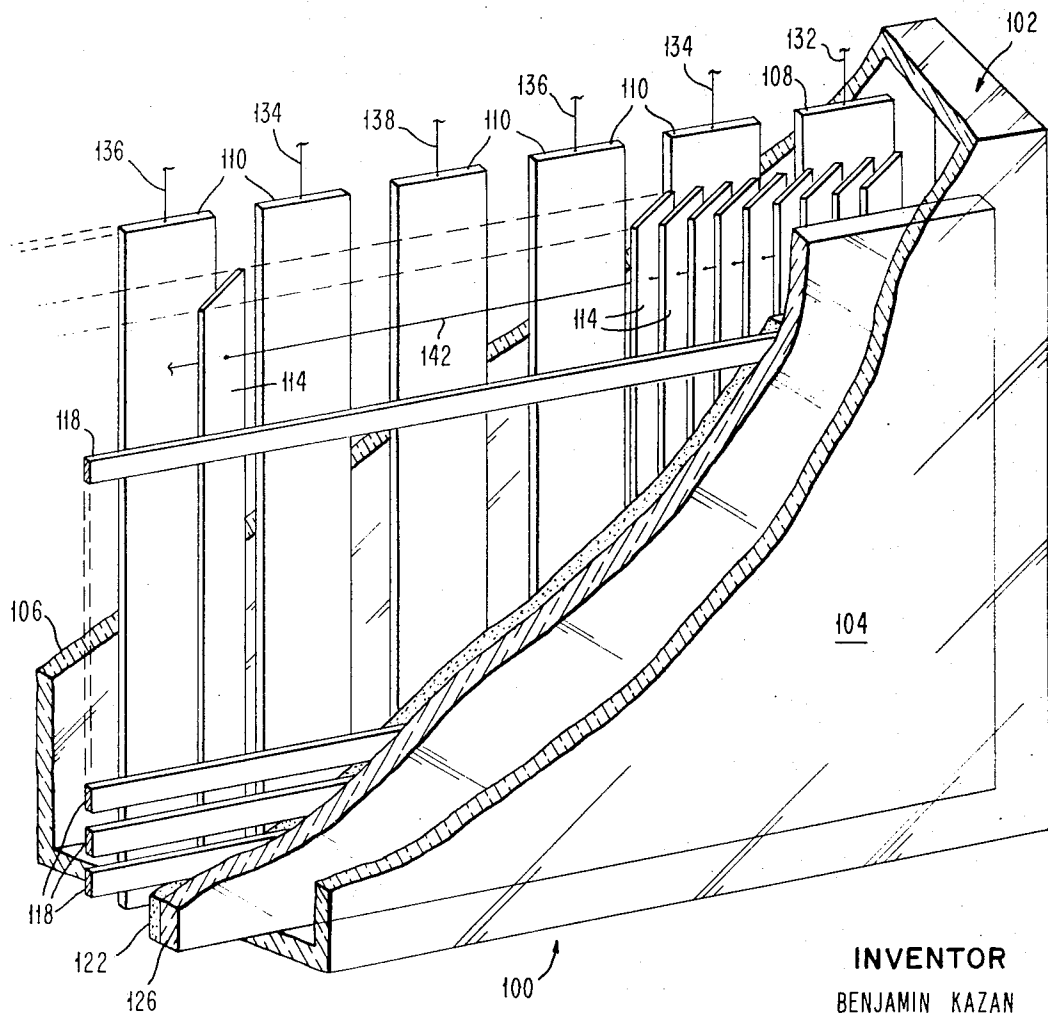
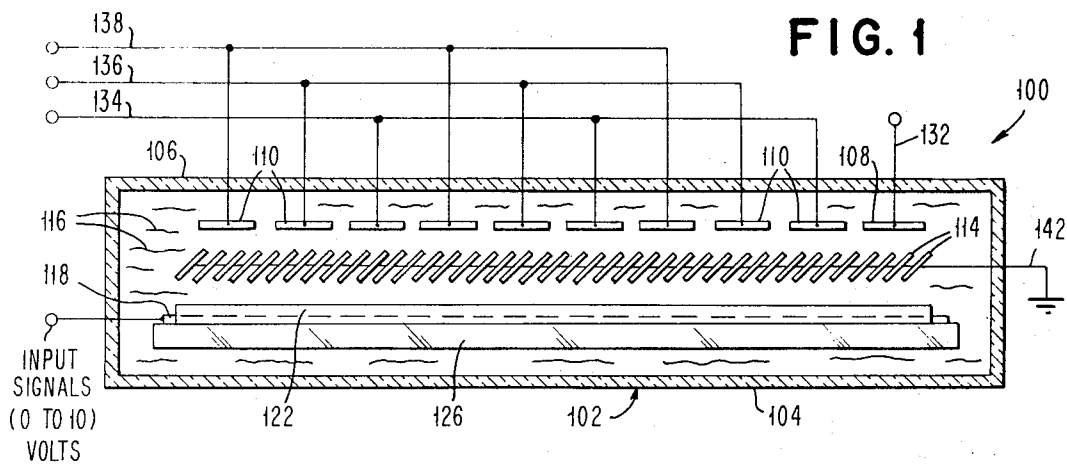
Primary Examiner—Nathan Kaufman
Attorney—G. E. Clark et al.

[57] **ABSTRACT**

A display device having an inert gas-filled, transparent envelope, containing a set of parallel cathode elements an anode grid structure forming a venetian blind type structure and a glass support plate carrying a set of parallel conducting strips perpendicular to the plane of the parallel cathode strips and coated with a layer of ZnO phosphor. Light is emitted by the phosphor when one of the cathode elements is connected to a negative potential, the anode grid structure connected to a ground potential and one of the phosphor bearing conducting strips is connected to a low positive signal voltage. Color displays may be generated by applying a series of phosphors which generate different colors in an alternating fashion on the glass support plate.

8 Claims, 5 Drawing Figures





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FIG. 3

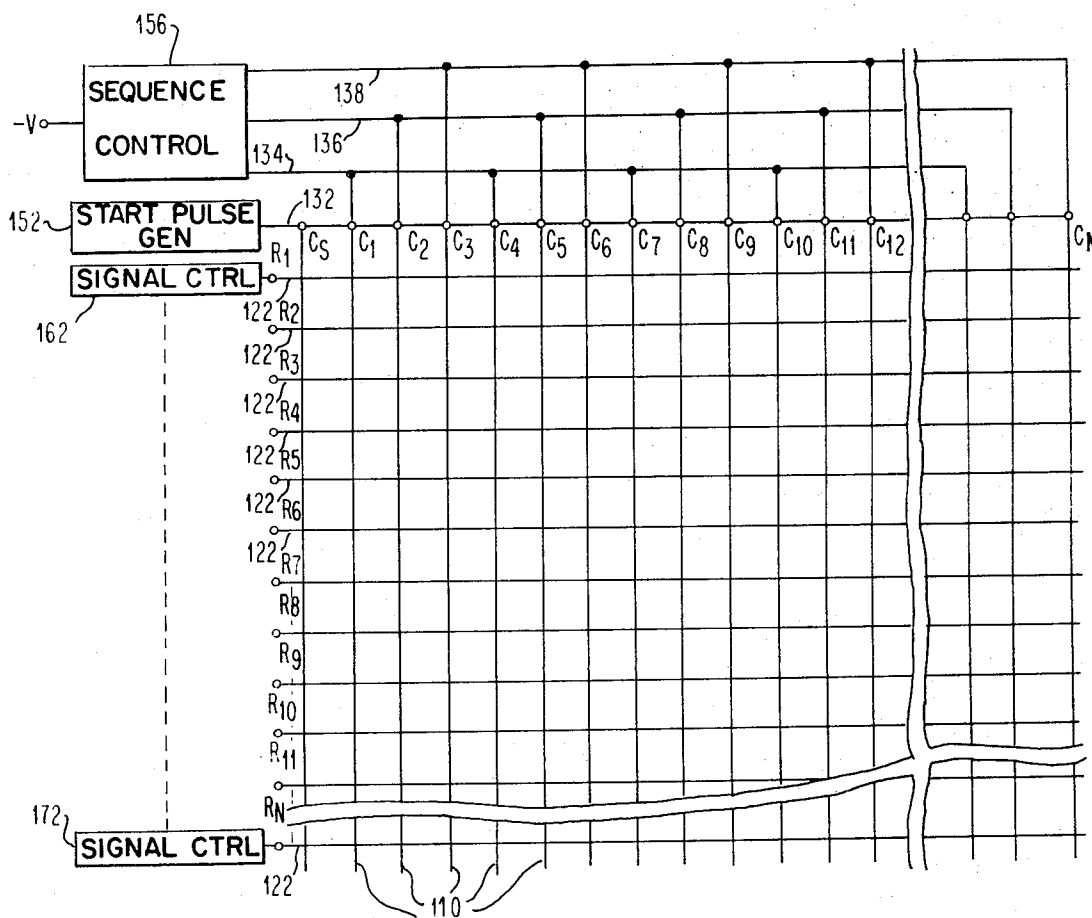


FIG. 4

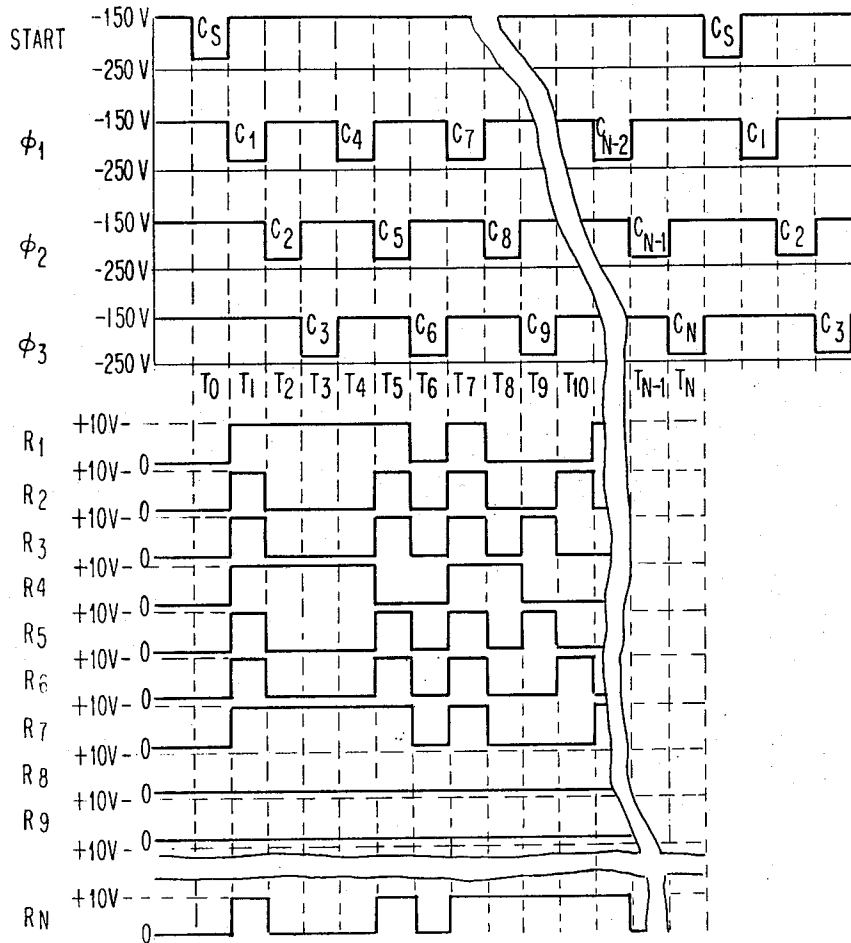
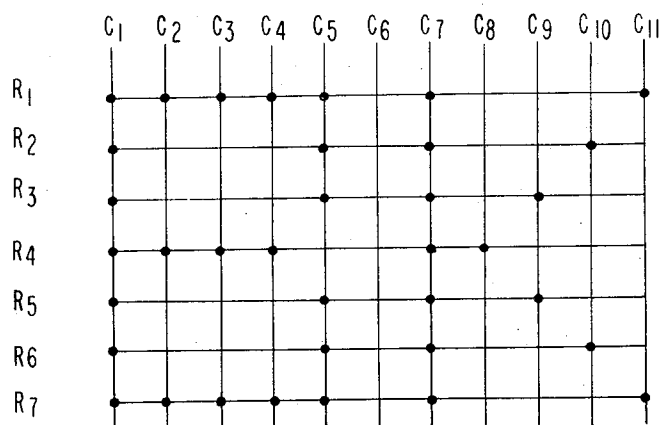


FIG. 5



SELF-SCANNING PLASMA DISPLAY DEVICE WITH PHOSPHOR SCREEN

BACKGROUND OF THE INVENTION

The present invention relates to gas plasma display devices and more particularly to gas panel display devices in which a phosphor coating is used to produce light when bombarded by electrons.

In the prior art, gas plasma display devices are known in which light emission results directly from the ionization of the gas plasma. In gas plasma display devices of the type known in the prior art, the gas plasma is switched on and off to create the display which requires a high potential driver in the order of several hundred volts for each display element.

Further, gas plasma display devices in which the gas plasma generates light are difficult to control for purposes of obtaining a grey scale rendition. In general, the light emission is binary in that the plasma is either ionized and emitting light or unionized and blanked.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to display information on a display device including a light emitting phosphor layer energized by electrons emitted from an ionized gas plasma.

It is another object of the present invention to reduce the cost of a large scale gas plasma phosphor display device by the use of low-cost, low-voltage driving circuits.

A still further object of the present invention is to display grey scale information from a gas plasma phosphor display device.

A still further object of the present invention is to display color information from a gas plasma phosphor display device.

Briefly, the present invention relates to a display device in which a gas plasma provides a source of electrons for energizing a phosphor layer to produce a visual display.

A set of cathode elements are contained in a gas-filled glass envelope, the cathode elements being connected in subsets to a plurality of pulse voltage sources, which control the application of potential to the cathode elements to cause a flow discharge to step in sequence from a first cathode element through all the cathode elements to a last cathode element in the display device. A grid structure of anode elements is connected to a fixed potential to provide a field between the cathode elements and the anode to accelerate electrons to the light emitting phosphor layer and prevent ions from striking and damaging the phosphor layer. The light emitting phosphor is placed on a transparent carrier, such as glass, which surface is provided with a series of parallel transparent conductors each of which is connected to one of a set of signal sources. The coincidence of a signal potential on one of the transparent conductors with a pulse voltage at a cathode at which a glow discharge may be supported, causes the phosphor to emit light at the intersection of these elements. Since the signal potentials applied to the transparent conductors, may be less than 10 volts positive, relatively low cost driving circuits may be used to activate a particular row of display elements.

One of the advantages of a display device constructed according to the present invention is that such

a display device could be made on a large scale having a very large number of display elements in both the horizontal and vertical directions in contrast to display devices constructed according to the prior art which are limited by the cost of the high voltage driving circuitry to a relatively small number of elements.

The foregoing and other objects, features and advantages of the invention will be apparent from the following, more particular description of the preferred embodiments of the invention, as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view showing a preferred embodiment of the present gas plasma display invention.

FIG. 2 is an isometric view showing the preferred embodiment of the gas plasma display device from the front where the relative position of each element is more apparent.

FIG. 3 is a schematic diagram showing in block form the circuitry required to operate a display device constructed according to the present invention.

FIG. 4 is a timing diagram showing the relative times of the application of signals to the various elements of a display device constructed according to the present invention to produce a specific character display.

FIG. 5 is a representation of the characters generated by the signal shown in FIG. 4.

DETAILED DESCRIPTION

A preferred embodiment of a gas plasma phosphor display device will be described with reference to FIGS. 1 and 2.

A top cross section view of a display device 100 for displaying alphanumeric information is shown schematically in FIG. 1, where a transparent envelope 102 (see also FIG. 2) contains each of the structural elements which will be identified below.

A group of sequentially excited cathode elements 110 are mounted vertically adjacent to a back wall 106 of envelope 102. A first of the cathode elements is designated as the starting cathode 108 and is located at the end of the row of sequentially excited cathode elements 110.

A grid or set of anode elements 114 is mounted vertically in front of cathode elements 110. Each of the vertical anode elements 114 is mounted at an oblique angle to the path of electron flow from the plane of the cathode element 110 toward the front of envelope 102 (see FIG. 2).

A gas 116 fills the envelope 102 and when ionized provides a source of electrons.

A transparent support plate 126 is mounted between the row of anode elements 114 and the front plate 104 of envelope 102. A set of closely spaced parallel transparent conducting strips 118, deposited on support plate 126 carries signal voltages to the addressed display column. These strips may be made of tin oxide.

Over this substructure is then deposited a layer of phosphor 122 such as ZnO.

This structure forms the signal electrodes and the light-emitting phosphor layer within the glass envelope 102 of the display device 100.

Referring now to FIG. 3, it is seen that display device 100 which may be schematically represented as a

matrix of cathode elements 110 and signal elements 118 is connected to driving circuitry to supply necessary activation potentials to establish and transfer the glow discharge plasma which provides a source of electrons and the driving circuitry to provide the low voltage signal to attract the electrons from the plasma to a particular point on the phosphor 122.

Starting cathode element 108 is connected to start pulse generator 152 by lines 132. Sequentially activated cathode elements 110 are connected in three groups to one of three lines from sequence control device 156 in the following manner:

Cathodes C1, C4, C7, C10, etc. are all connected in parallel to lines 134 which represent phase 1 of a three-phase control sequence;

Cathodes C2, C5, C8, C11, etc. are all connected in parallel to lines 136 which are activated at phase 2 of a three-phase sequence control device 156;

Cathodes C3, C6, C9, C12, etc. are connected in parallel to lines 138, which are connected to the phase three output of sequence control device 156.

Each of the conducting elements 118 are connected to one of a group of signal control devices such as signal control device 162 or signal control device 172 shown in FIG. 3.

While specific details of starting pulse generator 152, sequential control device 156 and signal controls 162, 172 have not been shown, these elements are all well known to those skilled in the art and could be implemented in any number of specific circuits or combination of circuits to operate with the display device embodying the present invention.

Similar structural details of various elements of a display device constructed according to the present invention are also shown in application, Ser. No. 103,049, entitled, "A Low Voltage Luminescent Display Device" to the same inventor as in the present application.

OPERATION

Referring now to FIGS. 3, 4 and 5, the operation of a preferred embodiment to display representative alphanumeric symbols, B K, as shown in FIG. 5, will be described.

A negative pulse voltage of approximately -250 volts is generated by start pulse generator 152 and applied to start cathode element 108 by line 132. This start pulse causes the gas plasma in the region of start cathode element 108 to ionize due to the field created between the start cathode element 108 at -250 volts and the anode grid structure 114 at approximately 0 volts.

Once the ionized plasma has been formed by the electric field, start pulse generator 152 switches the voltage applied to start cathode 108 to a more positive value, such as -150 volts and sequence control 156 activates lines 134 applying -250 volts to cathode elements C1, C4, C7, etc. Since cathode element C1 is immediately adjacent to start cathode element 108, the localized gas plasma moves stepwise from the region of start cathode 108 to the region of cathode element C1.

The mechanism of the transfer of the plasma from a first cathode element region to a second cathode element region is described in chapter eight of *Cold Cathode Discharge Tubes*, by G. F. Weston. Weston describes the application of stepping a glow-discharge

plasma region from a first element to a second element in a device known as a stepping tube.

Referring now specifically to FIGS. 4 and 5, if appropriate signal voltages of approximately 5-10 volts are applied to conducting elements R1, R2, R3, R4, R5, R6, and R7 at an instant of time, a column of spots will be illuminated due to the action of the display device as follows:

With the cathode element C1 at a high negative potential, such as -250 volts, and anode elements at approximately ground potential, electrons extracted from the gas plasma will be drawn toward the anode elements 114. With a positive potential applied to transparent conducting strips 122, R1 through R7, the electrons will be further attracted to the phosphor surface to produce a light output at each point where there is an intersection of an active row element R_n with an active cathode element C_n supporting an ionized gas plasma immediately adjacent thereto.

It may be noted that even though there is a coincidence of a signal voltage applied in the area of cathode elements C4, C7, etc., since the localized discharge moves only from one cathode element to the next, there will be no output of light at the first instant of time at any position other than those in line with cathode element C1 during phase 1 of the first cycle of a display scan.

During a second time period, phase 2 is activated by sequence control 156 causing a -250 volt signal to appear on lines 136 and a more positive voltage to appear on lines 134, thereby deactivating cathode elements C1, C4, C7, etc. and causing the localized discharge to move from cathode element C1 to cathode element C2.

Referring again to FIGS. 4 and 5, it is seen that at phase 2 time, when C2 is active, rows R1, R4, and R7 are still on, while rows R2, R3, R5 and R6 are off, resulting in having three points illuminated in the second column of the alphanumeric character B, as shown in FIG. 5.

At a third time, phase 2 is turned off, that is, returned to a more positive potential and phase three is activated; that is, sequence control 156 applies a -250 volt signal to lines 138 while maintaining lines 134 and 136 at a more positive potential. The localized discharge then is transferred from cathode element C2 to cathode element C3 and the combination of signal voltages on R1 through R_n then cause the third column of points to be illuminated in the alphanumeric character B.

This sequence of operation continues with the localized discharge moving from cathode C1 through cathode C_n as sequence control 156 steps from phase 1 to phase 2 to phase 3 during a single scan of the entire display area. Scanning of the entire display is repeated at a rate such as 30 or 60 times a second to avoid any noticeable flicker to the human observer.

The points to be illuminated on the face of the display device are controlled by the coincidence of signal voltages appearing on lines 118 at the appropriate row R_n and cathode elements C_n , activated by the appropriate phase voltage. A signal voltage of approximately 6-10 volts is applied to these rows R_n which are to be activated, and a zero potential is applied to those rows R_m which are to be inactive. (Signal voltages applied to columns R_n may be varied in an analog or

digital fashion corresponding to variations in intensity to achieve gray scale rendition.)

In the specific example as shown in FIGS. 4 and 5, the alphanumeric characters B, K, indicate a character block of five cathode elements in the horizontal direction by seven rows in the vertical direction with a space of one cathode element appearing between each character. At the time in which phase 3 is activated for the second time, which would normally activate cathode element C6, none of the row elements 118 are activated, thereby resulting in no illumination at that column on the phosphor.

COLOR

To generate a multicolor display, a plurality of phosphor strips, each for emitting a different color light is deposited over conducting strips 118 on support plate 126 rather than a single monochrome phosphor as described above.

In this embodiment, to generate a multicolor display, sequence control 156 controls application of phase 1, 2 and 3 signals representative of three primary colors, such as, red, green and blue. When, for example, phase 1 is activated C₁ will support ionization of a gas plasma which results in electrons striking a red emitting phosphor strip causing a red light output at that instant of time. In like manner as the sequence progresses, electrons striking other phosphor strips will produce light output of different color.

It is to be specifically noted in regard to the present invention that a structure embodying the present invention could be extended in the horizontal and vertical direction to produce a complete large screen display device having as many separate rows of characters with many characters in each row with limitations only in the technology in constructing the cathode element and the transparent conducting strips 118.

Further, gray scale rendition may be achieved by varying the potential applied to lines 118 in an analog or digital manner between 0 and some positive potential.

While the invention has been particularly shown and described with reference to the preferred embodiment herein, it will be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. A device for displaying information, comprising:
 - a transparent envelope containing a gas;
 - a plurality of cathode elements, each contained within said transparent envelope, each of said cathode elements being connected to one of a plurality of stepping voltage sources;
 - an anode structure, placed within said transparent envelope and adjacent said plurality of cathode elements, said anode structure being connected to a fixed potential;
 - a transparent carrier, mounted between said anode structure and the front plate of said transparent

envelope; a plurality of closely spaced parallel transparent signal conductor strips at right angles to said cathode elements, deposited on one face of said transparent carrier, and a layer of phosphor deposited over the carrier which is capable of emitting light when impacted by electrons, the transparent carrier contained within said transparent envelope so that when a cathode element is activated by one of said plurality of stepping voltage sources in coincidence with a signal voltage applied to one or more of said signal conductors, electrons available from the region of said cathode element which are attracted by said anode structure, strikes said phosphor layer emitting light.

2. A display device for displaying alphanumeric information comprising:

a gas filled transparent envelope;

transparent carrier having a plurality of linear conductors mounted on one face of said carrier, said conductors carrying a signal voltage to a row of elements to be displayed, and a layer of phosphor deposited over the carrier and conductors

a plurality of anode elements contained in said transparent envelope and adjacent to and space from the layer of phosphor each of said anode elements being connected to a fixed potential, said anode elements accelerating electrons to said phosphor layer;

a plurality of cathode elements adjacent to and space from the anode, contained in said transparent envelope, each of said cathode elements perpendicular to said linear conductors and connected to one of a plurality of control devices, said control devices controlling the potentials applied to groups of said cathode elements, wherein on a coincidence of an activating potential applied to a cathode element, and a signal voltage applied to one of said conductors, electrons emitted by said cathode element and accelerated by said anode elements, strike said phosphor layer causing light to be emitted.

3. A display device as in claim 2 wherein said anode elements are placed at an oblique angle to the direction of electron flow to reduce ion bombardment of said phosphor layer.

4. A display device according to claim 3 wherein said phosphor layer is ZnO.

5. A display device according to claim 3 wherein said phosphor layer is a conducting material.

6. A display device according to claim 1 wherein said gas is an inert gas.

7. A display device according to claim 1 wherein said phosphor layer comprises a plurality of sets of strips of phosphor wherein each of said sets of strips of phosphor emits light of a different color to produce a colored information display.

8. A display device according to claim 1 wherein said signal voltage is varied to display information in a gray scale rendition.

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