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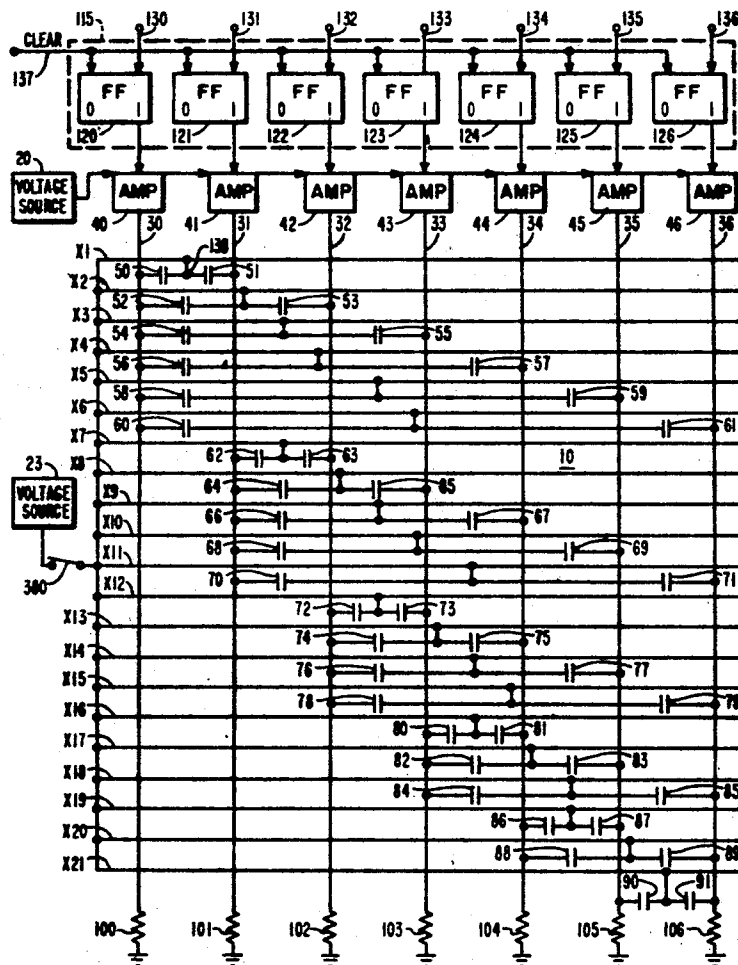
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[54] DISPLAY SYSTEM
11 Claims, 4 Drawing Figs.

[52] U.S. Cl. 340/324 R,
315/169, 340/166
[51] Int. Cl. G09f 9/30
[50] Field of Search 340/324,
166 EL; 315/169

ABSTRACT: A plasma display panel has X and Y drive lines disposed on opposite sides of the panel, and plural signal sources are connected to the X and Y drive lines for the purpose of generating light characters on a dark background. The gas panel which may be relatively large consists of an illuminable gas sealed in a flat envelope. The gas at a selected coordinate intersection is ignited by a firing potential for maintaining illumination of ignited regions is supplied directly to the X and Y drive lines.



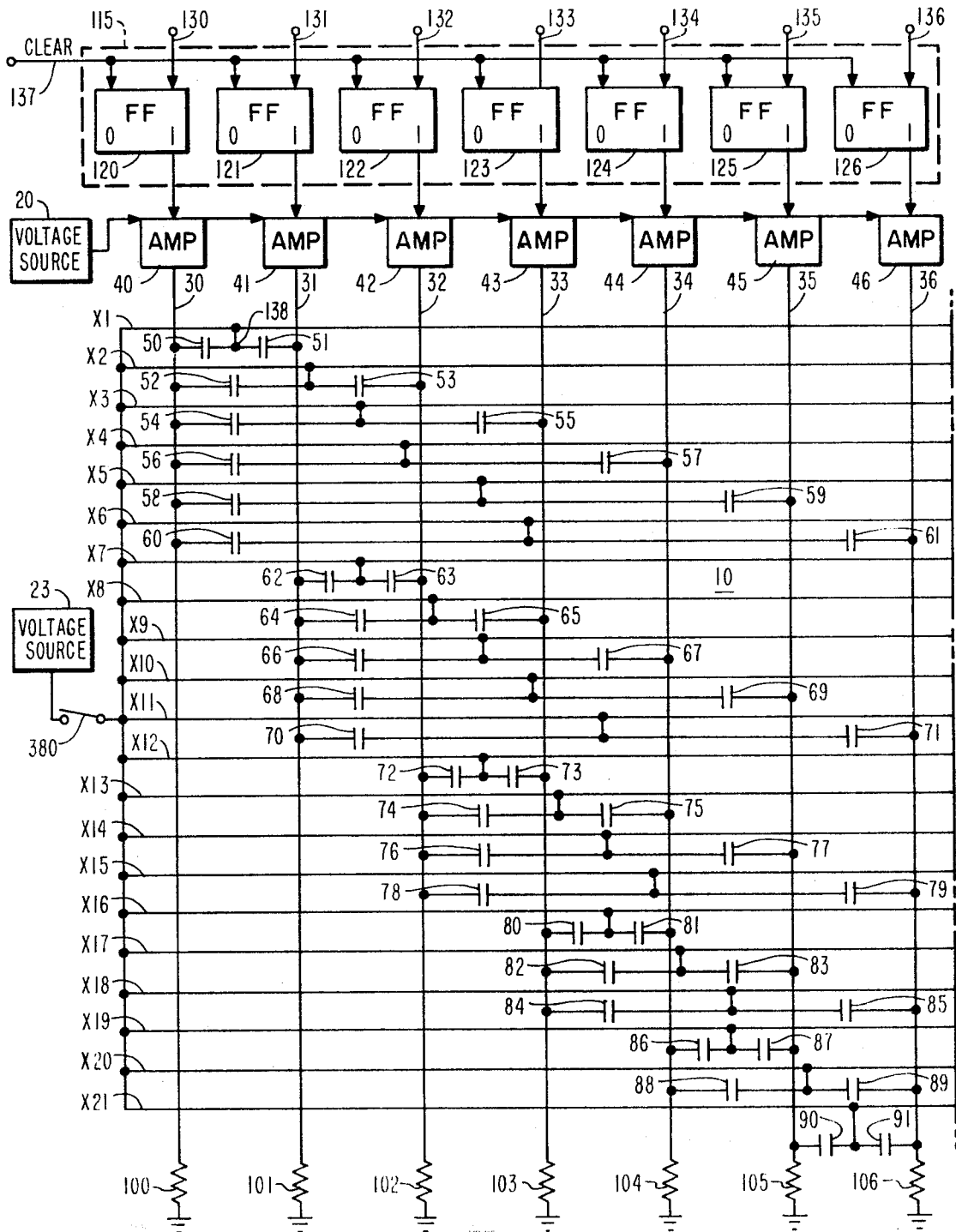


FIG. 1

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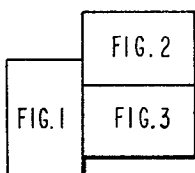
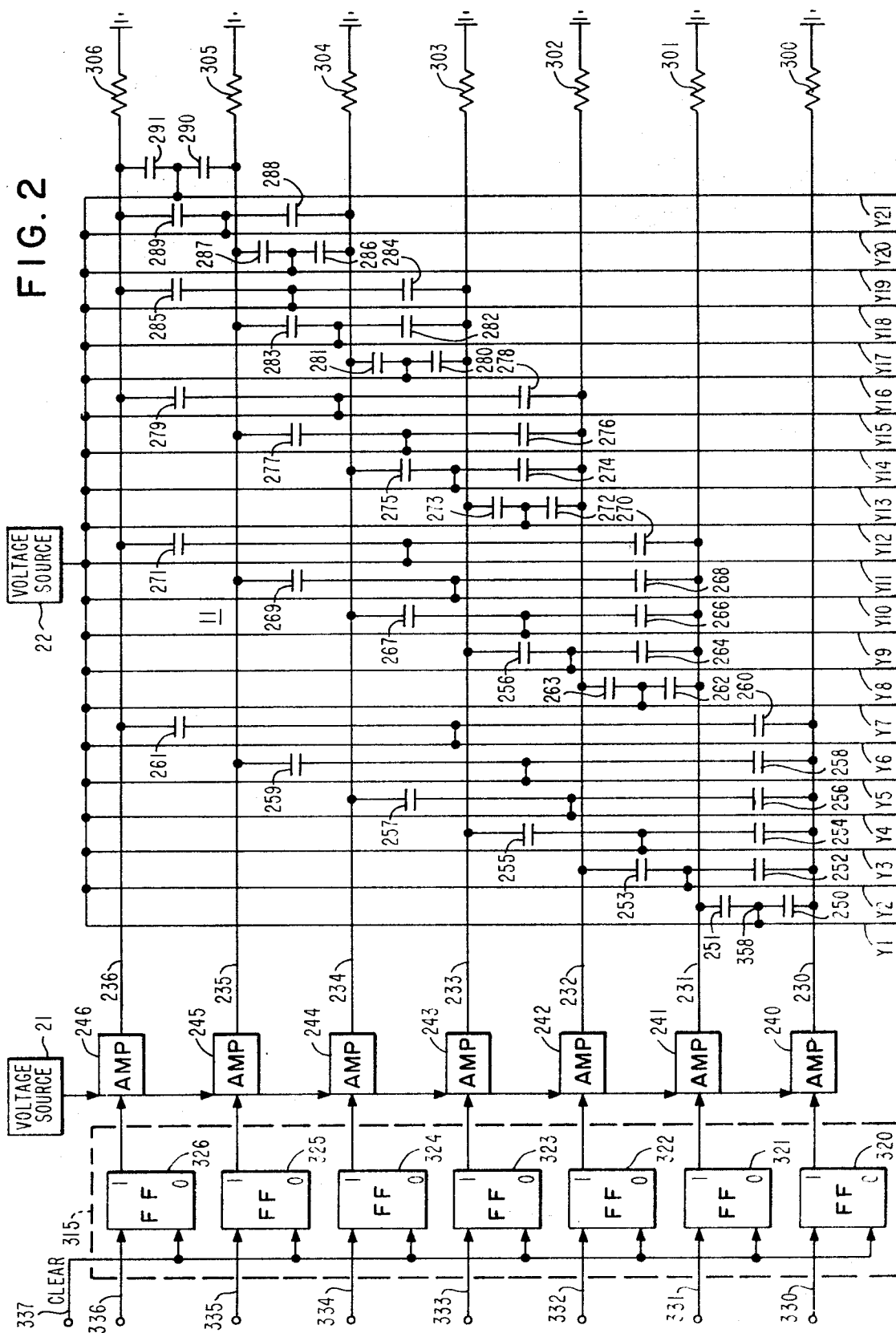


FIG. 4

FIG. 2



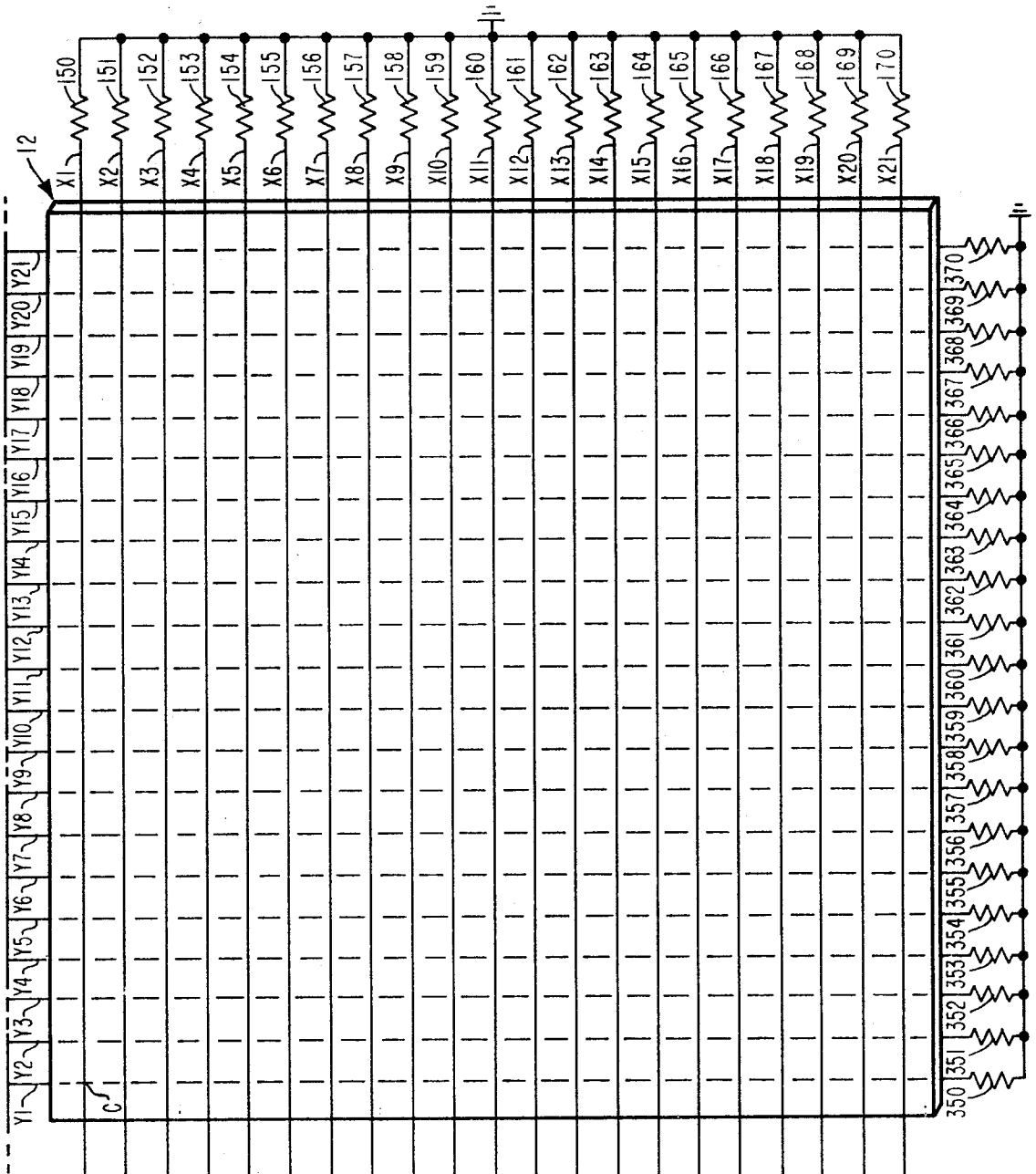


FIG. 3

DISPLAY SYSTEM

CROSS-REFERENCES TO RELATED APPLICATIONS

Application Ser. No. 785,210 filed Dec. 19, 1968 for "Gas Panel Apparatus And Method" by George M. Krembs.

BACKGROUND OF THE INVENTION

1. This invention relates to display devices and more particularly to gas panel display devices.

2. In constructing a plasma display panel it is desirable to provide as many vertical and horizontal drive lines per linear inch as practicable. The resolution increases as the number of drive lines per linear inch increases. It is desirable to have high resolution since this permits characters to be drawn more precisely, thereby improving their definition. As the number of drive lines per linear inch is increased to a large number to provide greater resolution, however, the problem of selecting a given one of the horizontal drive lines or a given one of the vertical drive lines becomes increasingly more difficult, particularly in large panels which may have a length of several feet or more. Thus equipment for selecting and firing the numerous gas cells tends to become bulky and complex, and an ultimate limit is reached concerning the size of the display panel. It is to the objective of increasing resolution, increasing the size of a plasma display panel, and at the same time providing selection equipment which is capable of performing the increased selection function without becoming unduly complex that this invention is directed.

SUMMARY OF THE INVENTION

It is a feature of this invention to provide an improved plasma display arrangement wherein the number of drive lines per unit length is increased, whereby generated characters may be more precisely drawn.

It is a further feature according to this invention to provide an improved selection arrangement for supplying firing potential to any selected point on a large gas panel.

In one arrangement according to this invention a gas panel is composed of a container filled with a gas which may be illuminated by an ignition or firing potential applied thereacross. X drive lines in the form of a grid pattern are disposed on one side of the panel with Y drive lines in the form of a grid located on the opposite side of the panel, and the Y drive lines are disposed orthogonally to the X drive lines. The crossover regions of the X and Y drive lines define coordinate intersections, and the gas between the drive lines in such regions of the gas panel constitute gas cells which may be ignited by electrical firing potentials on selected X and selected Y drive lines. The various regions or cells of the gas panel are selectively ignited to generate numbers, characters and the like on the display panel, such characters being light on a dark background. The drive lines are made of relatively thin metallic material which is transparent or opaque, and such drive lines may be round copper wire with a diameter of several mills. A first selection matrix is connected to the X drive lines, and a second selection matrix is connected to the Y drive lines. A first signal source having a frequency F1 is connected directly to all of the X drive lines, and a second signal source having a frequency F1 is connected directly to all of the Y drive lines, the first and second signal sources having sinusoidal wave forms which are equal in magnitude but opposite in phase. Signals from the first and second signal sources supply a holding potential which maintains the illumination of all ignited gas cells. A third signal source having a frequency F2 is connected through the first selection matrix to a selected X drive line, and a fourth signal source having a frequency F2 is connected through the second selection matrix to a selected Y drive line. The third and fourth signal sources preferably have sinusoidal wave forms which are equal in magnitude but opposite in phase. The third and fourth signal sources provide a potential difference across a selected

gas cell which causes ignition or illumination of the cell. The first and second selection matrices each have a plurality of selection lines and a plurality of passive elements connected between each associated drive line and different ones of the selection lines of the associated selection matrix. The passive elements are capacitors. Selection registers are connected to the first and second matrices and the selection registers operate the first and second matrices to connect the respective third and fourth signal sources to selected X and Y drive lines, respectively. The selection registers cause the third signal source to be applied to a fixed number of selection lines in the first selection matrix and the fourth signal source to be applied to a fixed number of selection lines in the second selection matrix. In a preferred arrangement according to this invention the fixed number is two, and a pair of selection lines in each of the selection matrices is energized by the respective third and fourth signal sources each time a gas cell on the panel is selected for ignition. By varying the particular pair of selection lines thus energized, any gas cell on the panel may be selectively ignited. Once ignited, a cell is maintained in the illumination state by a holding potential from the first and second sources.

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

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a selection matrix for the X drive lines of a gas panel.

FIG. 2 shows a selection matrix for the Y drive lines of a gas panel.

FIG. 3 shows a gas panel with X and Y drive lines disposed on opposite sides of the gas panel.

FIG. 4 illustrates the manner in which FIGS. 1 through 3 should be arranged with respect to each other to portray a display system according to this invention.

DESCRIPTION OF A PREFERRED EMBODIMENT

Reference is made to FIGS. 1 through 3 which illustrate a preferred arrangement according to this invention. FIGS. 1 through 3 should be arranged with respect to each other as indicated in FIG. 4. FIG. 1 shows a selection matrix 10, and FIG. 2 shows a selection matrix 11. A display panel 12 is illustrated in FIG. 3, and drive lines Y1 through Y21 and drive lines X1 through X21 are disposed as shown on opposite sides of the panel 12. The drive lines X1 through X21 arbitrarily are disposed above the gas panel 12, and the drive lines Y1 through Y21 accordingly are disposed below the gas panel. The gas panel is a container, preferably very thin, which contains a gas that may be illuminated in response to an electrical potential applied thereacross. The gas may be an inert gas such as Neon, Argon and the like, or it may include a mixture of such gases. The mixture may include inert gases along with other gases. One suitable mixture may include 90 percent Neon and 10 percent Nitrogen, for example. Different combinations of other gases in varying proportions may be suitably employed. For a more detailed discussion of the gas panel construction, reference may be made to copending application Ser. No. 785,210 for "Gas Panel Apparatus And Method" by George M. Krembs filed Dec. 19, 1968.

The crossover regions of the drive lines Y1 through Y21 and X1 through X21 define coordinate intersections, and the gas between the drive lines in such regions of the gas panel constitute gas cells which may be ignited by electrical firing potentials on selected X and selected Y drive lines. The various regions or cells of the gas panel are selectively ignited to generate numbers, characters and the like on the display panel. The result is a light character on a dark background. The drive lines are made of relatively thin metallic material which is transparent or opaque and permits light to pass through. In a practicable arrangement the drive lines are

round copper wire with a diameter on the order of several mils with a separation between drive lines of approximately several mils depending upon the technique of construction. Thus there may be a large number of drive lines per inch, and this provides a high degree of resolution, thereby permitting characters to be precisely defined.

The gas cells defined by the coordinate drive lines Y1 through Y21 and X1 through X21 are selectively ignited by an electrical potential from a voltage source 20 on a selected upper X drive line and an electrical potential from a voltage source 21 on a selected lower Y drive line. A voltage source 22 in FIG. 2 continuously supplies an electrical potential to all of the Y drive lines, and a voltage source 23 in FIG. 1 continuously supplies an electrical potential to all X drive lines. The combined electrical potential of the voltage sources 20 and 23 in FIG. 1 applied to a selected X drive line and the combined electrical potential of the voltage sources 21 and 22 in FIG. 2 applied to a selected Y drive line have a combined potential difference which exceeds the firing or ignition potential of the gas cell in the region of the selected coordinate intersection. Once the gas in the region of a selected coordinate intersection is ignited, the electrical potentials of the voltage sources 20 and 21 are removed, and the electrical potential supplied across the region of the selected coordinate intersection by the voltage sources 22 and 23 is sufficient to maintain ignition or illumination of the gas cell in the region of the selected coordinate intersection. The potential difference supplied to all coordinate intersections by the voltage sources 22 and 23 may be referred to as the holding potential since it maintains ignition or illumination. The magnitude of the potential difference between the voltage sources 22 and 23, however, is not sufficient to equal or exceed the firing or ignition potential.

The voltage source 22 and the voltage source 23 may provide sine waves having the same frequency and amplitude, but the sine waves are opposite in phase. For example, the sine wave signals of these sources may be 10 volts peak-to-peak with a frequency of 60 cycles per second. The voltage sources 20 and 21 are preferably sinusoidal signals having the same frequency and amplitude, but these sine waves likewise are opposite in phase. For example, these sources may be 600 volts peak-to-peak with a frequency of 50 kilocycles per second.

The voltage source 20 in FIG. 1 is selectively connected to the drive lines X1 through X21 by the matrix 10. The matrix 10 has selection lines 30 through 36 connected to the output of respective amplifiers 40 through 46. The selection lines 30 through 36 have condensers 50 through 91 connected therebetween, as shown. The selection lines 30 through 36 may be connected through associated resistors 100 through 106 to ground. A selection register 115 has flip-flops 120 through 126, and their one output sides are connected to respective amplifiers 40 through 46. The amplifiers 40 through 46 are biased off by a negative signal level on the binary one output side of the associated flip-flop, and when so biased, the amplifiers do not pass the sinusoidal signal from the voltage source 20. The amplifiers 40 through 46 are biased into the conductive region by positive signals from the binary one output side of the associated flip-flops 120 through 126, and when so biased, they pass the sinusoidal signals from the voltage source 20 to the associated output selection lines 30 through 36. The register 115 is supplied with control or selection signals on input lines 130 through 136 to set the flip-flops 120 through 126, and these flip-flops are cleared or reset to the zero state by a signal on a control line 137. More specifically, when any one of the lines 130 through 136 is energized with a positive signal, the associated one of the flip-flops 120 through 126 is set to the one state, thereby supplying a positive output signal to the associated one of the amplifiers 40 through 46. A positive signal applied to the line 137 resets the flip-flops 120 through 126 to the zero state, thereby supplying a negative output signal on the binary one output side of each flip-flop to the associated amplifiers 40 through 46.

It is a particular feature of this invention to set a given fixed number of flip-flops 120 through 126 to the one state for each selection of an X drive line. Whenever it is desired to energize a given one of the drive lines X1 through X21 with a firing signal, two and only two, of the selection lines 30 through 36 is energized with a signal from the voltage source 20. By energizing a selected pair of the lines 30 through 36 with signals from the voltage source 20, it is possible to energize selectively each of the drive lines X1 through X21 with a firing potential level, and chart 1 below shows which pair of selection lines 30 through 36 is energized with a signal from the voltage source 20 in order to select the various drive lines X1 through X21.

CHART 1

PAIR OF SELECTION LINES ENERGIZED		X DRIVE LINES SELECTED
30,31		X1
30,32		X2
30,33		X3
30,34		X4
30,35		X5
30,36		X6
31,32		X7
31,33		X8
31,34		X9
31,35		X10
31,36		X11
32,33		X12
32,34		X13
32,35		X14
32,36		X15
33,34		X16
33,35		X17
33,36		X18
34,35		X19
34,36		X20
35,36		X21

The condensers 50 through 91 in FIG. 1 are disposed in pairs between the selection lines 30 through 36, and each pair of condensers is connected in series. The common point between each pair of condensers is connected to an associated one of the drive lines X1 through X21. For example, note that a pair of condensers 50 and 51 has a common point 138 connected to the X1 drive line. A common point between the condensers 52 and 53 is connected to the X2 drive line. The remaining pairs of condensers have their common points connected to the associated X drive lines, as shown. It is pointed out that an individual pair of condensers is connected between each selection line and each of the remaining selection lines. For example, the pairs of condensers 50 through 61 are all connected between the selection line 30 and the remaining selection lines 31 through 36, as shown in the upper portion of FIG. 1. Accordingly, the X drive lines X1 through X6 individually are selected by energizing the selection line 30 and one of the selection lines 31 through 36 with signals from the voltage source 20.

In like fashion the pairs of condensers 50, 51 and 62 through 71 are connected between the selection line 31 and remaining ones of the selection lines 30 and 32 through 36, as shown in FIG. 1. Accordingly, the selection line 31 must be one of the pair of selection lines energized by a signal from the voltage source 20 whenever one of the drive lines X2 or X7 through X11 is selected to be energized by the voltage source 20.

The pairs of condensers 52, 53, 62, 63, and 72 through 79 are connected between the selection line 32 and the remaining ones of the selection lines 30, 31, and 33 through 36, as shown in FIG. 1. The selection line 32 must be one of the pair of selection lines energized by the voltage source 20 whenever one of the drive lines X3, X7, or X12 through X15 is selected to be energized by the voltage source 20.

The pairs of condensers 54, 55, 64, 65, 72, 73, and 80 through 85 are connected between the selection line 33 and the remaining ones of the selection lines 30 through 32 and 34 through 36, as shown in FIG. 1. The selection line 33 must be one of the pair of lines energized whenever one of the drive lines X3, X8, or X12 through X15 is selected for energization by the voltage source 20.

The pairs of condensers 56, 57, 66, 67, 74, 75, 80, 81, and 86 through 89 are connected between the selection line 34 and the remaining selection lines 30 through 33, 35 and 36, as shown in FIG. 1. The selection line 34 must be one of the pair of selection lines energized whenever one of the drive lines X4, X9, X13, X16, X19 or X20 is selected for energization by the voltage source 20.

The pairs of condensers 58, 59, 68, 69, 76, 77, 82, 83, 86, 87, 90, and 91 are connected between the selection line 35 and the remaining selection lines 30 through 34, and 36, as shown in FIG. 1. The selection line 35 must be one of the pair of selection lines energized whenever one of the drive lines X5, X10, X14, X17, X19, or X21 is selected for energization by the voltage source 20.

The pairs of condensers 60, 61, 70, 71, 78, 79, 84, 85, and 88 through 91 are connected between the selection line 36 and the remaining ones of the selection lines 30 through 35, as shown in FIG. 1. The selection line 36 must be one of the pair of selection lines energized when the drive lines X6, X11, X15, X18, X20 or X21 is selected for energization by the voltage source 20.

Signals on the drive lines X1 through X21 pass through associated resistors 150 through 170 in FIG. 3 to ground.

The voltage source 21 in FIG. 2 is selectively connected to the drive lines Y1 through Y21 by the matrix 11. The matrix 11 has selection lines 230 through 236 connected to the output of respective amplifiers 240 through 246. The selection lines 230 through 236 have condensers 250 through 291 connected therebetween as shown. The selection lines 230 through 236 are connected through associated resistors 300 through 306 to ground. A selection register 315 has flip-flops 320 through 326, and their binary one output sides are connected to respective amplifiers 240 through 246. Each of the amplifiers 240 through 246 is biased off by a negative signal level on the binary one output side of the associated flip-flops 320 through 326, and when so biased, each amplifier does not pass the sinusoidal signal from the voltage source 21. Each of the amplifiers 240 through 246 is biased into the conductive region by a positive signal from the binary one output side of the associated flip-flops 320 through 326, and when so biased, each amplifier passes the sinusoidal signal from the voltage source 21 to the associated selection lines 230 through 236. The register 315 is supplied with positive control or selection signals on input lines 330 through 336 to set the flip-flops 320 through 326, and these flip-flops are cleared or reset to the zero state by a positive signal on a control line 337. When the lines 330 through 336 are energized with a positive signal, the associated flip-flops 320 through 326 are set to the one state, thereby supplying a positive output signal to the associated amplifiers 240 through 246 to pass signals from the voltage source 21 to the selection lines 230 through 236. A positive signal applied to the control line 337 resets the flip-flops 320 through 326 to the zero state, thereby supplying a negative output signal on the binary one output side of all flip-flops to the associated amplifiers 240 through 246 to block the passage of signals from the voltage source 21 to the selection lines 230 through 236.

As pointed out earlier it is a particular feature of this invention to energize a fixed number of the selection lines 230 through 236 when selecting a given gas cell for illumination. For the matrix 11 in FIG. 2 the fixed number is two. Hence, two, and only two, of the selection lines 230 through 236 is energized with signals from the voltage source 21 when it is desired to selectively energize a given one of the drive lines Y1 through Y21 with a firing signal from the voltage source 21. By energizing different given pairs of the selection lines 230

through 236 with a signal from the voltage source 20, it is possible to energize selectively each of the drive lines Y1 through Y21, and Chart 2 below shows which pair of selection lines 230 through 236 is energized with signals from the voltage source 21 in order to select the various drive lines Y1 through Y21.

CHART 2

PAIR OF SELECTION LINES ENERGIZED	Y DRIVE LINE SELECTED
230,231	Y1
230,232	Y2
230,233	Y3
230,234	Y4
230,235	Y5
230,236	Y6
231,232	Y7
231,233	Y8
231,234	Y9
231,235	Y10
231,236	Y11
232,233	Y12
232,234	Y13
232,235	Y14
232,236	Y15
233,234	Y16
233,235	Y17
233,236	Y18
234,235	Y19
234,236	Y20
235,236	Y21

The condensers 250 through 291 in FIG. 2 are disposed in pairs between the selection lines 230 through 236, and each pair of condensers is connected in series. The common point between each pair of condensers is connected to an associated one of the drive lines Y1 through Y21. For example, note that the pair of condensers 250 and 251 has a common point 358 connected to the Y1 drive line. The common point between condensers 252 and 253 is connected to the Y2 drive line. The remaining pairs of condensers have their common points connected to the associated drive lines, as shown. It is pointed out that an individual pair of condensers is connected between each selection line and each of the remaining selection lines. For example, the pairs of condensers 250 through 261 are all connected between the selection line 230 and the remaining selection lines 231 through 236, as shown in the left-hand portion of FIG. 2. Accordingly, it is seen that the drive lines Y1 through Y6 are individually selected by selecting the selection line 230 and one of the selection lines 231 through 236.

In like fashion, the pairs of condensers 250, 251, and 262 through 271 are connected between the selection line 231 and the remaining ones of the selection lines 230 and 232 through 236, as shown in FIG. 2. Therefore, the selection line 231 must be one of the pair of selection lines energized by a signal from the voltage source 21 whenever one of the drive lines Y1 or Y7 through Y11 is selected.

The pairs of condensers 252, 253, 262, 263, and 272 through 279 are connected between the selection line 232 and the remaining ones of the selection lines 230, 231, and 233 through 236, as shown in FIG. 2. The selection line 232 must be one of the pair of selection lines energized by the voltage source 21 whenever one of the drive lines Y2, Y7, or Y12 through Y16 is selected to be energized by the voltage source 21.

The pairs of condensers 254, 255, 264, 265, 272, 273, and 280 through 285 are connected between the selection line 233 and the remaining ones of the selection lines 230 through 232 and 234 through 236, as shown in FIG. 2. The selection line 233 must be one of the pair of lines energized whenever one of the drive lines Y3, Y8, Y12, or Y16 through Y18 is selected for energization by the voltage source 21.

The pairs of condensers 256, 257, 266, 267, 274, 275, 280, 281, and 286 through 289 are connected between the selection line 234 and the remaining selection lines 230 through 233, 235 and 236, as shown in FIG. 2. The selection line 234 must be one of the pair of lines energized whenever one of the drive lines Y4, Y9, Y13, Y16, Y19, or Y20 is selected for energization by the voltage source 21.

The pairs of condensers 258, 259, 268, 269, 276, 277, 282, 283, 286, 287, 290, and 291 are connected between the selection line 235 and the remaining selection lines 230 through 234 and 236. The selection line 235 must be one of the pair of selection lines energized whenever one of the drive lines Y5, Y10, Y14, Y17, Y19, or Y21 is selected for energization by the voltage source 21.

The pairs of condensers 260, 261, 270, 271, 278, 279, 284, 285, and 288 through 291 are connected between the selection line 236 and the remaining ones of the selection lines 230 through 235, as shown in FIG. 2. The selection line 236 must be one of the pair of selection lines energized when one of the drive lines Y6, Y11, Y15, Y18, Y20 or Y21 is selected for energization by the voltage source 21.

Signals on the lines Y1 through Y21 pass through associated resistors 300 through 306 in FIG. 3 to ground.

The operation of the system is described next. As pointed out above the regions of the gas panel 12 defined by the coordinate intersections of the drive lines X1 through X21 and the drive lines Y1 through Y21 are arbitrarily designated gas cells. If a sufficient potential difference is supplied across each gas cell by the X and Y lines, the selection cell, and only the selected cell ignites or fires and is illuminated. The firing potential is designated V_f . Once a gas cell is ignited or fired, illumination may be maintained by a substantially lower potential difference applied across the cell. This potential difference is designated the holding potential V_h . Let it be assumed for purposes of illustration that the registers 115 in FIG. 1 and 315 in FIG. 2 are cleared by positive signals applied to respective lines 137 and 337, and positive signals are applied to input lines 130 and 131 in FIG. 1 and to input lines 330 and 331 in FIG. 2. As a result the flip-flops 120 and 121 in FIG. 1 are set to the one state, and they condition the associated amplifiers 40 and 41 to pass signals from the voltage source 20 to the associated selection lines 30 and 31. Likewise, the flip-flops 320 and 321 in FIG. 2 are set to the one state, and they condition associated amplifiers 240 and 241 to pass signals from the voltage source 21 to associated selection lines 230 and 231 in FIG. 2. When the selection lines 30 and 31 in FIG. 1 are energized by the voltage source 20, the drive line X1 is thereby selected for energization with a firing potential as indicated in Chart 1 above. When the selection lines 230 and 231 in FIG. 2 are selectively energized by the voltage source 21, they select the Y1 drive line for energization with a firing potential as indicated in Chart 2 above. The cell C at the coordinate intersection X1, Y1 in FIG. 3 is thereby ignited or illuminated. Once a selected cell is ignited, the registers 115 and 315 are cleared by positive signals on respective lines 137 and 337, thereby removing the firing potential applied across the selected cell C and preparing these registers for the subsequent selection of a different cell for ignition. The selected cell C at the coordinate intersection X1, Y1 is maintained in the ignition state by a holding potential V_h which potential difference is supplied by the voltage sources 22 and 23. More specifically the voltage source 23 supplies a potential to the drive line X1 and the voltage source 22 supplies a potential to the drive line Y1. The potential difference applied by the voltage sources 22 and 23 across the cell C is sufficient to maintain or hold ignition of this cell. Consequently, the selected cell remains ignited so long as the voltage sources 22 and 23 are applied. If either of the voltage sources 22 or 23 is removed temporarily, ignition is terminated. If a switch 380 in FIG. 1 is opened, the voltage source 23 is removed, and the ignition is thereby terminated. It is readily seen, therefore, that cells at selected coordinate intersections may be illuminated in succession by the foregoing process to generate numbers, 75

letters, and characters of various shapes on the display panel 12 in FIG. 3 merely by presenting different combinations of pairs of positive signals to the various stages of the registers 115 and 315, and the illuminated characters thus generated are light on a dark background. Once a display has been generated, the registers 115 and 315 remain cleared. The display may be continued for any desired period by maintaining the holding potential. The displayed characters are removed by opening the switch 380 in FIG. 1, thereby removing the holding potential source 23 and darkening the entire panel 12 in FIG. 3.

Next the operation described above is discussed in detail with respect to the signal levels involved. Referring first to FIG. 1, the flip-flops 120 and 121, having been set to the one state by positive signals on respective input lines 130 and 131, condition the associated amplifiers 40 and 41 to pass signals from the voltage source 20 to the selection lines 30 and 31. It is assumed that the signals on the lines 30 and 31 are substantially identical and that the condensers 50 through 91 have substantially the same capacitance. It is assumed further that the resistors 150 through 170 in FIG. 3 have substantially the same resistance. The current on the line 30 from the amplifier 40 is supplied through the condensers 50, 52, 54, 56, 58, and 60, then along respective drive lines X1 through X6, and thence through respective resistors 150 through 155 in FIG. 3 to ground. Six parallel paths are thus defined, and the current through each is substantially equal in magnitude. For purposes of illustration let the current along the line 30 be designated I. The current through the resistor 100 in FIG. 1 may be made negligible, and it is disregarded for purposes of this discussion. The current on the line 30 divides equally among the six parallel circuits, and the current through each parallel circuit is therefor I/6. More specifically, a current I/6 flows along each of the lines X1 through X6 from the line 30. The potential on each of the drive lines X1 through X6 is a voltage V1 which is equal to IR/6 where R represents the resistance of each of the resistors 150 through 155. The voltage V1 on the drive line X1 includes an additional component derived from the selection line 31, and this is described next. The current on the selection line 31 is substantially identical to the current on the selection line 30, and the current on the selection line 31 is likewise I. Neglecting the component of current through the resistor 101 in FIG. 1, the current I on the line 31 is divided substantially equally between the six parallel circuits which include the condensers 51, 62, 64, 66, 68, and 70 which are connected to respective drive lines X1, and X7 through X11 which in turn are connected to respective resistors 150 and 156 through 160. Thus, a current is supplied through each of these drive lines which is equal to I/6. It is pointed out that the drive line X1 is the only X drive line which receives two units of current with each unit being I/6. The remaining drive lines X2 through X11 each receive one unit of current I/6. Thus the voltage on each of the drive lines X2 through X11 is V1. However, the drive line X1 receives two units of current with each being I/6, and the voltage on the drive line X1 is therefore 2V1.

Referring next to FIG. 2, the flip-flops 320 and 321 are set to the one state by positive signals on the input lines 330 and 331. Accordingly, associated amplifiers 240 and 241 pass signals from the voltage source 21 along the selection lines 230 and 231. Let it be assumed for purposes of illustration that the current along each of the lines 230 and 231 is I, neglecting for this discussion a negligible current through the resistors 300 and 301. The current I on the line 230 is divided substantially equally among six parallel circuits defined by the condensers 250, 252, 254, 256, 258, and 260 which are connected to respective drive lines Y1 through Y6 which in turn are connected through respective resistors 350 through 355 in FIG. 3 to ground. Let it be assumed that the resistors 350 through 370 in FIG. 3 are equal, and each likewise has a value of R. It is seen, therefore, that a current I/6 is established on each of the drive lines Y1 through Y6 by the current I on the selection line 230 in FIG. 2, thereby establishing a voltage V1 on each of these drive lines.

The Y1 I on the line 231 in FIG. 2 likewise divides among six parallel circuits defined by the condensers 251, 262, 264, 266, 268, and 270 which are connected by respective drive lines Y1 and Y7 through Y11 through respective resistors 350 and 356 through 360 in FIG. 3 to ground. A current 1/6 supplied from the selection line 231 in FIG. 2 to each of the drive lines Y1 and Y7 through Y11, and hence a voltage V_1 is established on each of these drive lines. However, the drive line Y1 receives a current 1/6 from the drive line 230 and a current 1/6 from the drive line 231. Hence the voltage on the drive line Y1 is $2V_1$.

The voltage difference between the drive line X1 and the drive line Y1 across the selected cell C is $2V_1 - 2V_1$. However, the voltage sources 20 and 21 are sine waves of opposite phase, and the voltage difference across the selected cell is therefore $2V_1 - (-2V_1) = 2V_1 + 2V_1 = 4V_1$. The firing or ignition potential V_F is equal to or less than $4V_1$.

The voltage difference across the non selected cells in the display panel 12 in FIG. 3 must be less than the firing potential. The potential difference across the cells defined by the drive lines X2 through X11 and the drive lines Y2 through Y11 is $V_1 - (-V_1) = 2V_1$. The voltage $2V_1$ is less than the firing potential V_F , and this insures that the nonselected cells are not ignited.

It is pointed out that the voltage source 23 is continuously applied to the drive lines X1 through X21, and the voltage source 22 is continuously applied to the drive lines Y1 through Y21. The voltage from each of these sources is designated V_2 . These voltage sources supply sine wave signals of substantially the same amplitude, but they are opposite in phase. Therefore the potential difference across these drive lines at the coordinate intersections is $V_2 - (-V_2) = 2V_2$. The potential difference $2V_2$ supplied across each of the coordinate intersections of the display panel 12 is sufficient to exceed the holding potential V_H when the voltage sources 22 and 23 are at their peak levels, and hence they maintain illumination of an ignited cell.

The total potential V_X applied to the selected drive line X_1 therefore, is as follows:

$$(1) \quad V_X = 2V_1 + V_2 \text{ (selected X line)}$$

The voltage V_X on the selected drive line X1 includes one voltage component from the voltage source 23 and two voltage components from the currents on the selection lines 30 and 31, as explained above. The total voltage V_X on the partially selected drive lines X_2 through X_{11} is as follows:

$$(2) \quad V_X = V_1 + V_2 \text{ (partially selected X lines)}$$

The total voltage on the partially selected drive lines X_2 through X_{11} includes one component from the voltage source 23 and one component from the current on the selection line 30 or the selection line 31. The voltage on the unselected drive lines X_{12} through X_{21} is the voltage V_2 from the voltage source 23.

The total potential V_Y applied to the selected drive line Y_1 is as follows:

$$(3) \quad V_Y = 2V_1 + V_2 \text{ (selected Y line)}$$

The voltage V_Y on the selected drive line Y_1 includes one voltage component from the voltage source 22 and two voltage components from the current on the selection lines 230 and 231, as explained above. The total voltage V_Y on the partially selected drive lines Y_2 through Y_{11} is as follows:

$$(4) \quad V_Y = V_1 + V_2 \text{ (partially selected Y lines)}$$

The total voltage on the partially selected drive lines Y_2 through Y_{11} includes one component from the voltage source 22 and one component from the current on the selection line 230 or the selection line 231. The voltage on the unselected drive lines Y_{12} through Y_{21} is the voltage V_2 from the voltage source 22.

The total potential difference V_{XY} across the selected cell C at the coordinate intersection of the drive line X_1 and the drive line Y_1 is as follows:

$$(5) \quad V_{XY} = 4V_1 + 2V_2 \text{ (selected X, Y lines)}$$

equation (5) is obtained by combining equations (1) and (3). The total potential difference across the partially selected

coordinate intersections defined by the drive lines X_2 through X_{11} and the drive line Y_2 through Y_{11} is as follows:

$$(6) \quad V_{XY} = 2V_1 + 2V_2 \text{ (partially selected X, Y lines)}$$

equation (6) is obtained by combining equations (2) and (4).

The potential difference across the unselected coordinate intersections defined by the drive lines X_{12} through X_{21} and Y_{12} through Y_{21} is $2V_2$.

From the foregoing equations the mathematical relationships between the firing potential V_F and the holding potential V_H may be defined as follows:

$$(7) \quad 2V_2 \quad V_H \quad V_F \quad 4V_1 + 2V_2 \text{ (selected X, Y lines)}$$

The potential difference $2V_2$ maintained across each coordinate intersection of the display panel 12 in FIG. 3 must exceed the holding potential V_H . The holding potential V_H is less than the firing potential V_F . The firing potential V_F across the cell at the selected X drive line and the selected Y drive line is equal to or exceeded by the voltage $(4V_1 + 2V_2)$. The voltage relationships at the coordinate intersections of the partially selected X and Y drive lines is as follows:

$$(8) \quad 2V_2 \quad V_H \quad V_F \quad 2V_1 + 2V_2 \text{ (partially selected X, Y lines)}$$

The voltage $2V_2$ exceeds the holding potential V_H , and the holding potential V_H is less than the firing voltage V_F . The potential difference across the cells at the partially selected X, Y drive lines $(2V_1 + 2V_2)$ is less than the firing potential V_F . The potential difference across the coordinate intersections defined by the nonselected X and Y drive lines is $2V_2$ which exceeds the holding potential V_H but is less than the firing potential V_F .

It is seen, therefore, from the foregoing illustration that the selected cell C in FIG. 3 at the coordinate intersection of the X_1 drive line and the Y_1 drive line is ignited because the potential difference $(4V_1 + 2V_2)$ exceeds the firing potential. The partially selected cells and the nonselected cells have a potential difference which exceeds the holding potential but is less than the firing potential. Hence the selected cell C in FIG. 3 is the only cell which is ignited when the selection lines 30 and 31 in FIG. 1 and the selection lines 230 and 231 in FIG. 2 are energized with signals from associated signal sources 20 through 23. Once the selected cell C is ignited, the registers 115 in FIG. 1 and 315 in FIG. 2 are cleared. These registers may be operated to selectively energize any pair of associated selection lines in FIGS. 1 and 2, as indicated in Charts 1 and 2 above, thereby to energize selectively the associated X and Y drive lines to ignite the associated cell at any coordinate intersection. Thus numbers, letters and characters may be displayed on the panel 12 in FIG. 3, and the generated display continues until terminated by clearing the registers 115 in FIG. 1 and 315 in FIG. 2 and opening the switch 380 in FIG. 1.

The foregoing illustration assumes that the voltage sources 20 and 21 have equal signal amplitudes. It is possible to vary their signal amplitudes by decreasing one and increasing the other. The effect is to change the distribution of potential differences across the coordinate intersections of the drive lines X_1 through X_{21} and Y_1 through Y_{21} , but one, and only one, selected cell is fired nevertheless. Also, the voltage sources 22 and 23 likewise may be varied by increasing one and diminishing the other. However the voltage sources 20 through 23 may be varied, it is essential that the net potential difference provided by the voltage sources 22 and 23 exceed the holding potential V_H and be less than the firing potential V_F , and it is essential that the combined effect of all voltage sources 20 through 23 provide a potential difference at the selected coordinate intersection which exceeds the firing potential V_F while at the same time providing a net potential difference at the partially selected coordinate intersections of the X and Y drive lines which is less than the firing potential V_F .

The number of selection lines 30 through 36 of the matrix 10 in FIG. 1 may be expanded, and in like fashion the number of selection lines 230 through 236 in FIG. 2 may be expanded to provide the necessary capability for selecting each cell regardless of the expanded number of coordinate intersections

included in the display panel 12 in FIG. 3 as the size of the panel is increased. The X and Y drive lines on the display panel 12 in FIG. 3 may be made of a transparent material, and such drive lines may be laid quite close by well-known techniques. The display panel 12 may be 1 foot wide and 2 or more feet long, and the total number of coordinate intersections may be in the thousands where precise definition or spot resolution is required. The cell area diminishes in size as the size of the X and Y drive lines is decreased, and a lower limit on the cell size is determined by the inability to make the X and Y drive lines smaller from a practicable standpoint and by the ultimate loss of visibility as the light from the cell is diminished too much for a given use of the display panel. It is seen therefor that a display arrangement according to this invention may generate characters composed of minute cells having a razor edge thickness so to speak where so required. It is pointed out that in some uses of display devices precise character definition is not required, and for such applications relatively larger transparent X and Y drive lines may be employed. The size of the display panel 12 may be varied as desired, and the size of the characters generated on the face of the display panel likewise may be varied as desired.

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

What we claim is:

1. A plasma display device including:

a gas panel consisting of an illuminable gas sealed in a flat envelope,

a plurality of X lines disposed on one side of the flat envelope, and a plurality of Y lines disposed on the other side of the flat envelope with the Y lines oriented orthogonally with respect to the X lines, the crossover regions of the X and Y lines defining coordinate intersections, the gas in the region of each coordinate intersection forming an individual gas cell, each such gas cell being illuminated in response to a firing potential difference from the X and Y lines and each illuminated cell being maintained in such state by a holding potential difference from the X and Y lines,

an X selection matrix coupled to the X lines, and a Y selection matrix coupled to the Y lines,

the X selection matrix having a plurality of selection lines and a plurality of capacitors coupled between each X line and various selection lines,

the Y selection matrix having a plurality of selection lines and a plurality of capacitors coupled between each Y line and various selection lines.

2. The device of claim 1 further including:

first selection means coupled to the X selection matrix for applying a first AC signal to a fixed number of the selection lines of said X selection matrix, and second selection means coupled to the Y selection matrix for applying a second AC signal to a fixed number of the selection lines of said Y selection matrix, whereby said X selection matrix energizes a selected X line and said Y selection matrix energize a selected Y line with a potential difference which exceeds the firing potential of the gas cell at the selected coordinate intersection.

3. The apparatus of claim 2 further including means to apply a holding potential difference to each illuminated gas cell.

4. A display device comprising:

a gas panel including a container filled with a gas which may be illuminated by an electrical potential applied thereacross,

X drive lines and Y drive lines disposed in close proximity to said gas panel,

a first selection matrix connected to said X drive lines, and a second selection matrix connected to said Y drive lines,

a first signal source having a frequency F1 connected directly to the X drive lines, and a second signal source having a frequency F1 connected directly to the Y drive lines, said first and second signal source being equal in magnitude but opposite in phase,

a third signal source having a frequency F2 connected to the first selection matrix, and a fourth signal source having a frequency F2 connected to the second selection matrix, the frequency F2 being higher than the frequency F1, said third and fourth signal sources being equal in magnitude but opposite in phase,

selection means connected to the first selection matrix and the second selection matrix which operates the first and second matrices to connect the respective third and fourth signal sources to selected X and Y drive lines respectively,

said gas panel responding to signals on the X and Y drive lines from said first, second, third and fourth signal sources in combination to illuminate the gas in the region of the coordinate intersection of the selected X and Y drive lines, and said gas panel responding to signals on the X and Y drive lines from the first and second signal sources in combination to maintain illumination of all ignited regions.

5. The apparatus of claim 4 wherein:

the said first selection matrix has a plurality of selection lines, a plurality of capacitors connected between each X line and various ones of said selection lines, and said selection means supplies said third signal source to a fixed number of said selection lines,

said second selection matrix has a plurality of selection lines, a plurality of capacitors connected between each Y line and various ones of said selection lines in said second selection matrix, and said selection means supplies said fourth signal source to a fixed number of said selection lines in said second selection matrix.

6. A display device including:

a gas panel, and gas panel including an illuminable gas disposed in a sealed container,

a plurality of X drive lines disposed on one side of said panel, and a plurality of Y drive lines disposed on the opposite side of said panel, the crossover regions of said X and Y drive lines defining coordinate intersections and the gas in each such region defining a gas cell,

a first signal source of frequency F1 connected to all of said X drive lines and a second signal source of frequency F1 connected to all of said Y drive lines,

An X drive matrix having a plurality of first selection lines, a first plurality of pairs of condensers connected in series and having a common point therebetween, an individual pair of said first plurality of pairs of condensers being connected between each of said first selection lines and each of the remaining ones of said first selection lines, means connecting said common point of different pairs of said first plurality of pairs of condensers to different ones of said X drive lines,

a third signal source having a frequency F2, first means selectively connecting said third signal source to any pair of said first selection lines, whereby the associated pair of condensers supply a signal of a given magnitude to the associated X drive line,

a Y drive matrix having a plurality of second selection lines, a second plurality of pairs of condensers connected in series and having a common point therebetween, an individual pair of said second plurality of pairs of condensers being connected between each of said second selection lines and each of the remaining ones of said second selection lines, means connecting said common point of different pairs of said second plurality of pairs of condensers to different ones of said Y drive lines,

a fourth signal source having a frequency F2, second means selectively connecting said fourth signal source to any pair of said second selection lines, whereby the associated

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pair of condensers supply a signal of a given magnitude to the associated Y drive line, whereby the gas cell at the coordinate intersection of a selected X line and a selected Y line is energized with sufficient signal magnitude by all of said signal sources combined to exceed the ignition potential of said gas cell, and the magnitude of the first and second signal sources combined exceeds the holding potential but is less than the ignition potential of said gas cell.

7. The apparatus of claim 6 wherein the third signal source supplies less than half of the ignition potential, the fourth signal source supplies more than half of the ignition potential, and the combined effect of the third signal source and the fourth signal source exceeds the ignition potential.

8. A display device comprising:
a gas-filled panel, X drive lines located on one side of said panel, and Y drive lines located on the other side of said panel and disposed orthogonally to the X drive lines, first and second selection matrices connected to the respective X drive lines and Y drive lines, potential means connected to said matrices, said matrices responding to said potential means and energizing said X drive lines and the Y drive lines with ignition potential

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and holding potential, the ignition potential firing or igniting selected regions of said gas to cause illumination and the holding potential maintaining illumination of such regions,

5 selection means connected to said first and second matrices which operates said matrices to control the energization of said X drive lines and said Y drive lines, said first and second selection matrices each have a plurality of selection lines, and a plurality of capacitors connected between each associated drive line and different ones of the selection lines of the associated selection matrix.

9. The apparatus of claim 8 wherein the selection means energizes a fixed number of the selection lines of each of said matrices.

10. The apparatus of claim 9 wherein the potential means and said matrices energize the X drive lines with one magnitude of potential and the Y drive lines with another magnitude of potential.

11. The apparatus of claim 10 wherein the potential means supplies a sinusoidal wave to the X drive lines and Y drive lines, and the phase of the wave on the X drive lines is 180° out of phase with the wave on the Y drive lines.

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