United States Patent

Ambrico

[15] **3,657,716**

[45] **Apr. 18, 1972**

[54] CHARACTER GENERATOR FOR CATHODE RAY TUBE DISPLAY DEVICE

[72] Inventor: **Louis E. Ambrico,** Hyde Park, N.Y.

[73] Assignee: **International Business Machines Corporation,** Armonk, N.Y.

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[21] Appl. No.: **45,964**

[52] **U.S. Cl.** ....**340/324 A,** 315/18

[51] **Int. Cl.** **G06f 3/14**

[58] **Field of Search** ....340/324 A

[56] **References Cited**

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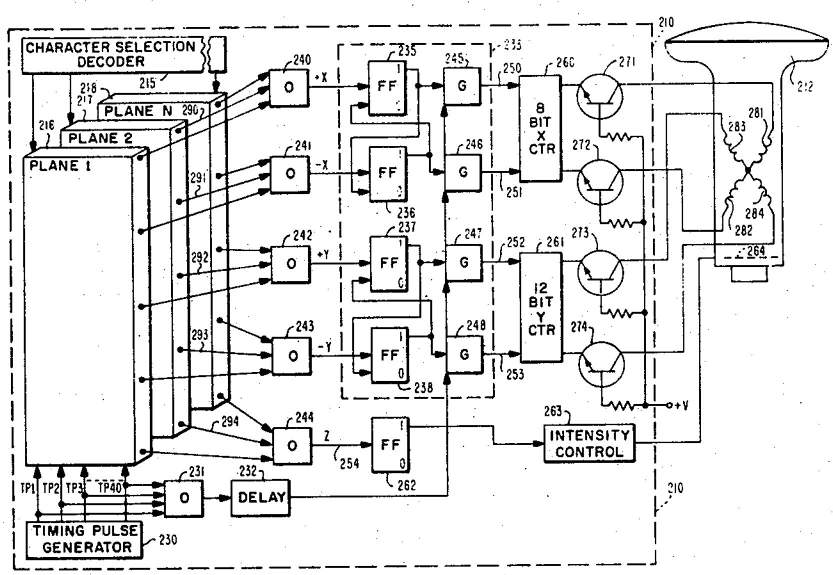
3,540,031	11/1970	Love	340/324 A
3,422,304	1/1969	Thorpe	315/18

Primary Examiner—David L. Trafton
Attorney—Ralph L. Thomas and Thomas & Thomas

[57] **ABSTRACT**

A character generator for a cathode ray tube display device generates X and Y deflection potentials and intensity control signals for the cathode ray tube by utilizing a separate storage matrix for each character with the storage elements in each such matrix being disposed where, and only where, a change is required in the direction of the X deflection, a change in the direction of the Y deflection, or a change in the intensity control signal, thereby to reduce the number of storage elements required in the storage matrices for the characters. Control signals from a selected storage matrix operate bistable storage devices which in turn operate gates to supply timing pulses to an up-down X counter and an up-down Y counter which count in either direction and convert digital quantities to analogue quantities thereby to control the vertical and horizontal deflection of the electron beam of the cathode ray tube to generate a character.

5 Claims, 7 Drawing Figures



Patented April 18, 1972 3,657,716

4 Sheets-Sheet 1

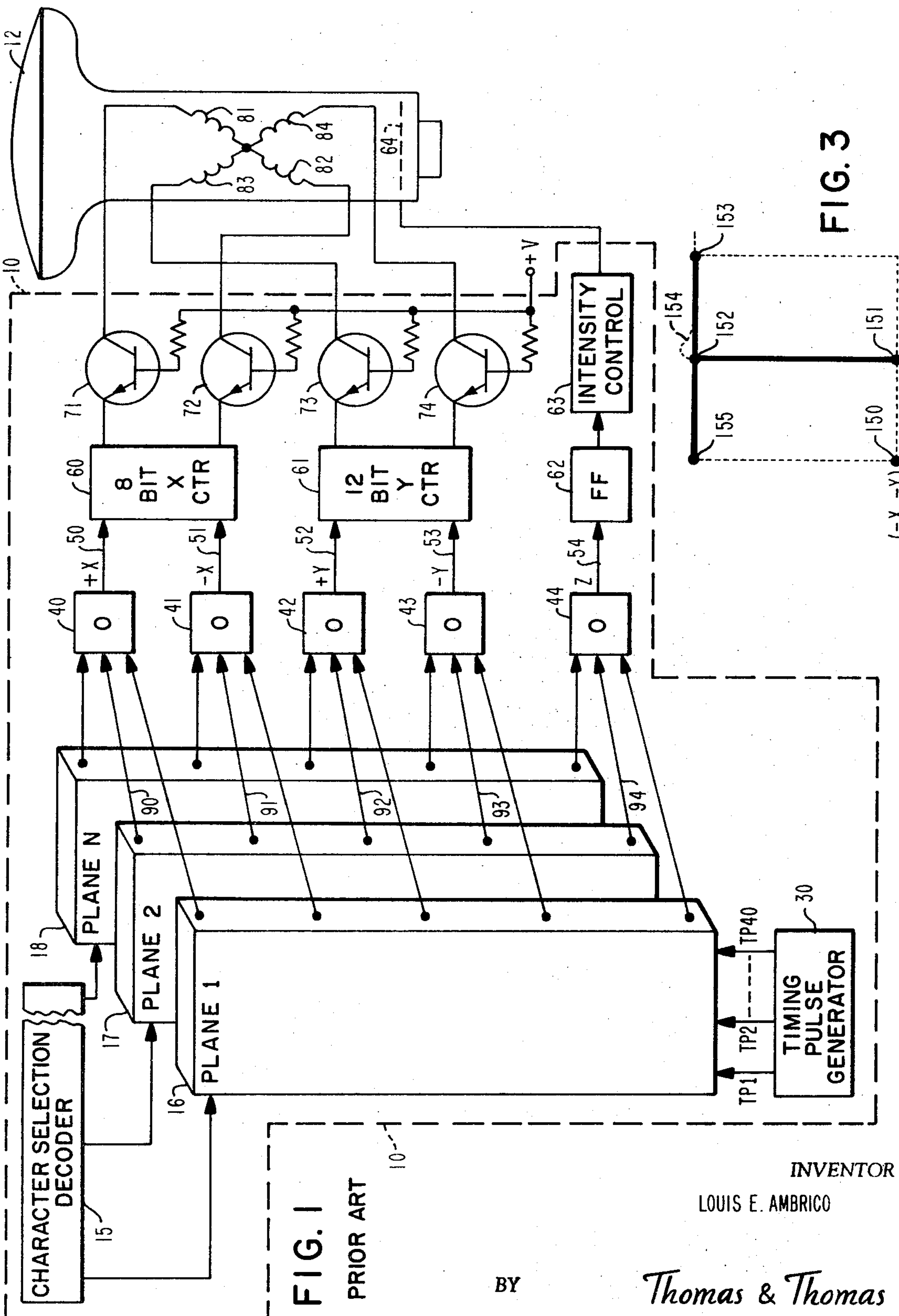


FIG. 1
PRIOR ART

FIG. 3

INVENTOR
LOUIS E. AMBRICO

BY Thomas & Thomas
ATTORNEYS

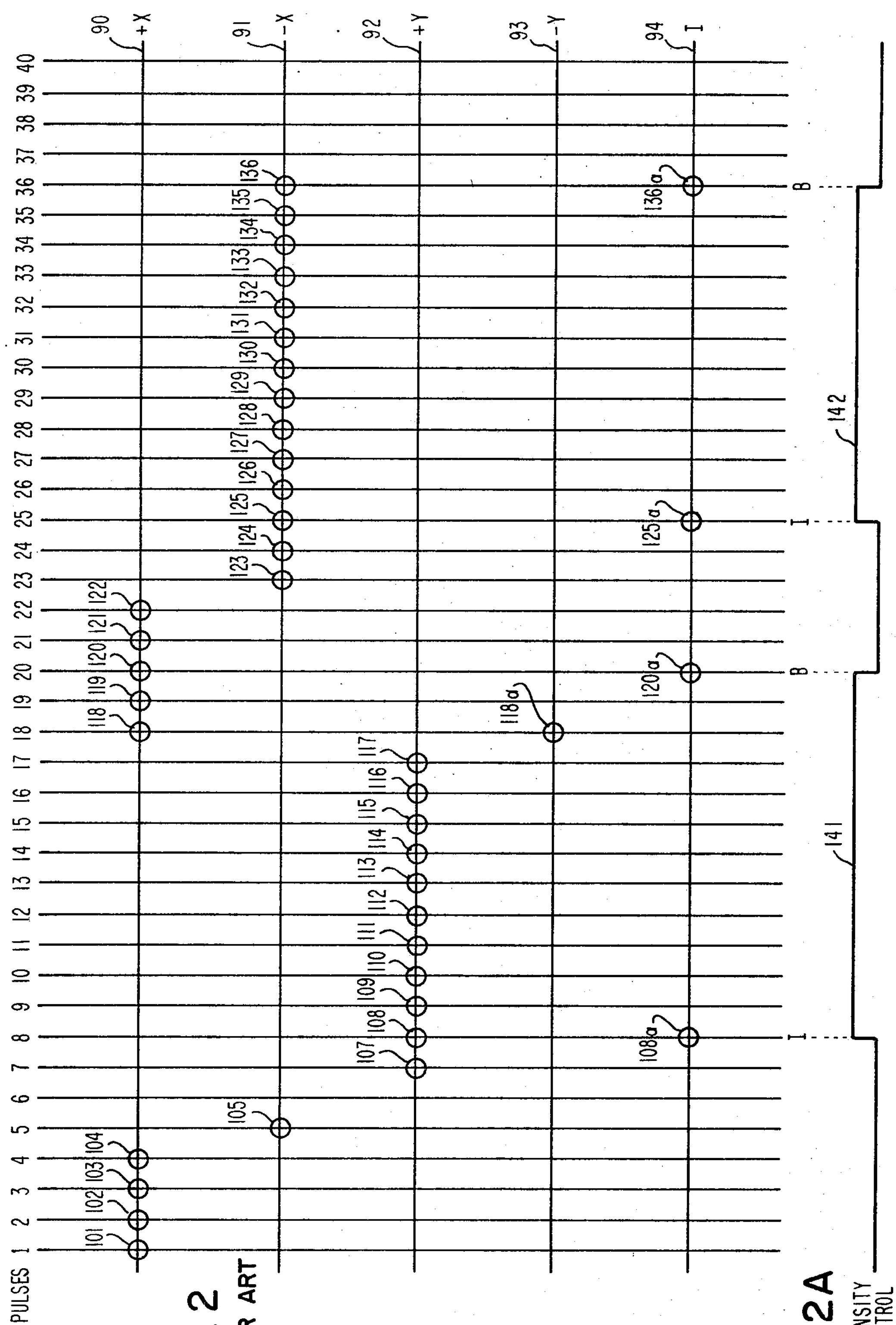


FIG. 2
PRIOR ART

FIG. 2A

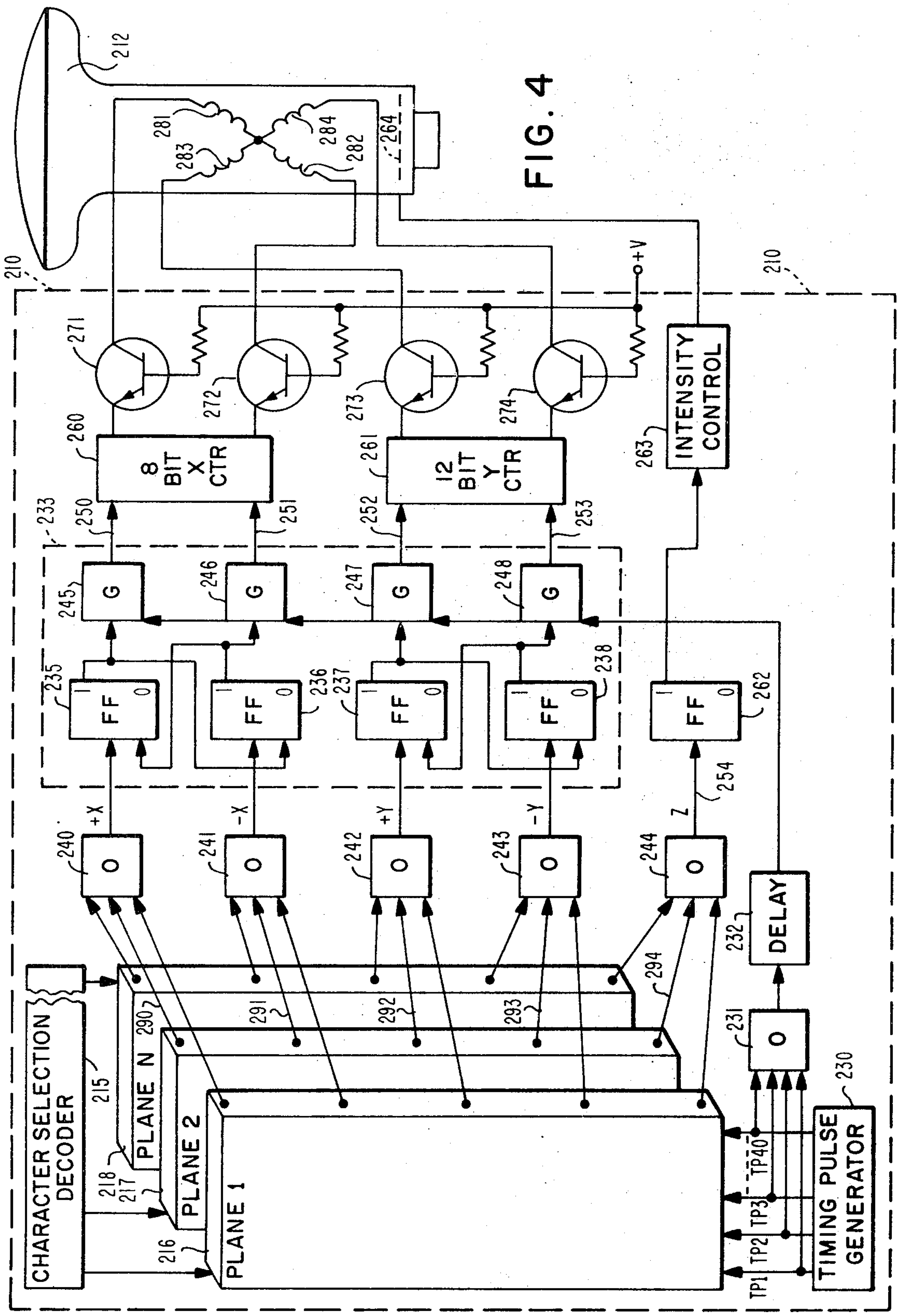

CHARACTER SELECTION DECODER
PLANE 1
PLANE 2
PLANE N
TIMING PULSE GENERATOR
TP1
TP2
TP3
TP40
DELAY
O
FF
G
+X
-X
+Y
-Y
Z
8 BIT X CTR
12 BIT Y CTR
INTENSITY CONTROL
+V
210
212
215
216
217
218
230
231
232
233
235
236
237
238
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FIG. 4

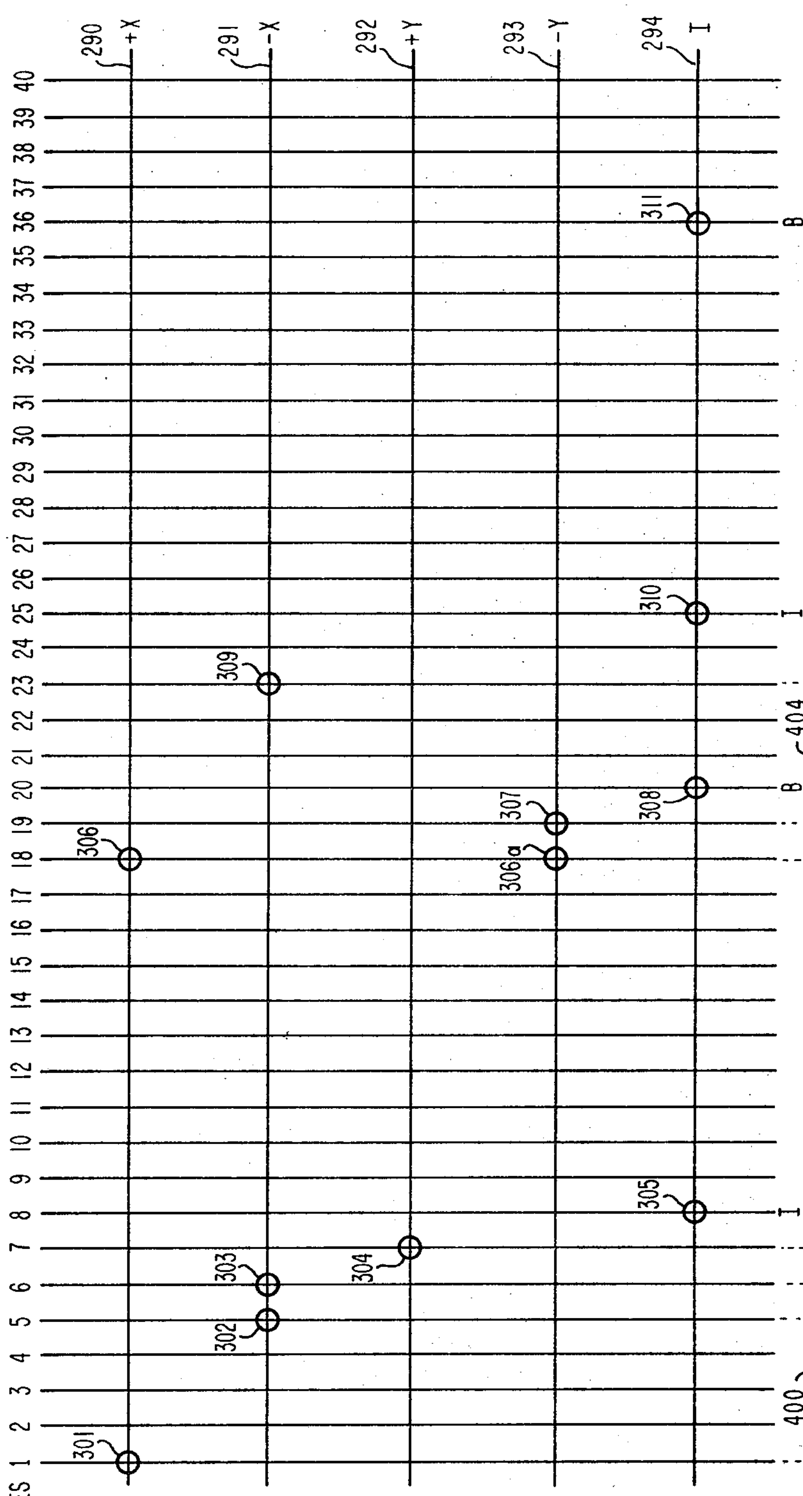

FIG. 5

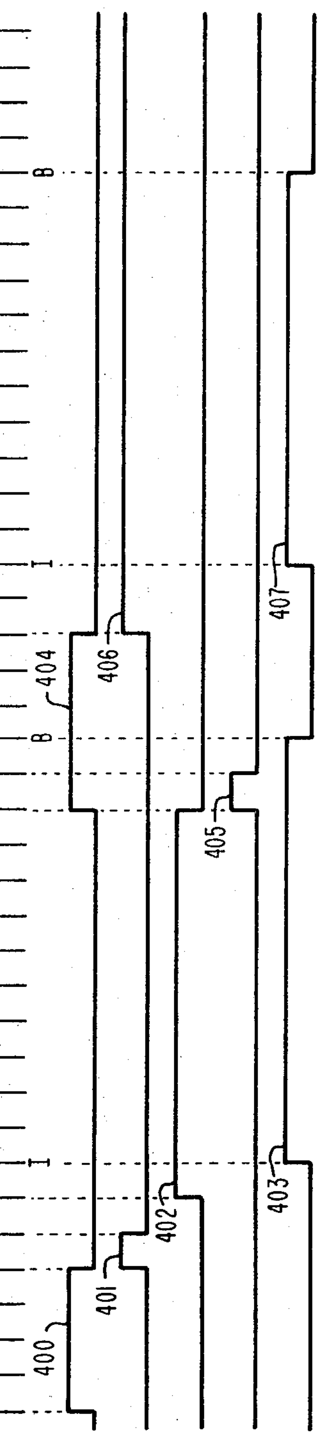

FIG. 6
(A) +X
(B) -X
(C) +Y
(D) -Y
(E) INTENSITY CONTROL

CHARACTER GENERATOR FOR CATHODE RAY TUBE DISPLAY DEVICE

CROSS-REFERENCES TO RELATED APPLICATIONS

Application Ser. No. 721,477 filed on Apr. 15, 1968 by William R. Lamoureaux for Symbol Generating Apparatus, now U.S. Pat. No. 3,609,745.

BACKGROUND OF THE INVENTION

1. This invention relates to display devices and more particularly to display devices which utilize cathode ray tubes to exhibit letters, numerals, characters and the like on the face thereof.

2. In earlier types of cathode ray tube display devices it is customary to use a main deflection system to position the electron beam at a selected site on the face of the cathode ray tube, and once the beam is positioned at the selected site, it is manipulated by a character generator to depict a selected character on the face of the cathode ray tube. One such arrangement is shown in U.S. Pat. No. 3,337,860. The electron beam of the cathode ray tube is unblanked when illuminating the face of the cathode ray tube to depict the selected character, and all other movements of the electron beam are blanked. In one known type of earlier cathode ray tube display device a character plane is provided for each character to be displayed. Each character plane provides appropriate control signals for (1) incrementing or decrementing an X counter which controls the horizontal positioning of the electron beam, (2) incrementing or decrementing a Y counter which controls the vertical positioning of the electron beam, and (3) manipulating an intensity control for blanking or unblanking the electron beam thereby to illuminate the face of the cathode ray tube only when a selected character is being outlined. The X and Y counters can be incremented or decremented to control the electron beam of the cathode ray tube as illustrated, for example in U.S. Pat. No. 3,422,304. Each character plane of such earlier display device constitutes a storage matrix having vertical lines which receive timed pulses in sequence and horizontal lines which in turn provide output control signals that increment or decrement X and Y counters and manipulate the intensity control to blank or unblank the electron beam. Control signals from the selected character plane are provided continuously throughout the generation of the selected character. Each character plane accordingly has numerous storage elements, and this results in a character generator which is relatively expensive to manufacture and maintain.

SUMMARY OF THE INVENTION

It is a feature of this invention to provide an improved character generator for a cathode ray tube.

It is a feature of this invention to provide an improved character generator for a cathode ray tube, which is less expensive to manufacture and to maintain.

It is a feature of this invention to provide a character generator which utilizes a separate storage matrix for each character, and the number of storage elements used in such storage matrices is reduced by a control arrangement which requires control signals from a selected character matrix if, and only if, there is a change to be made in the X deflection signal, the Y deflection signal, or the intensity control signal.

In one arrangement according to this invention an improved character generator for a cathode ray display device includes a plurality of matrix storage devices or character planes, one plane for each character, a control circuit, an up-down X counter, and an up-down Y counter. Each character plane includes a plurality of vertical lines which are sequentially energized with timing pulses and a plurality of horizontal lines which provide control pulses to the control circuit. Storage elements disposed at selected coordinate intersections between the vertical and horizontal lines are preferably read non-destructively. A first horizontal line provides control signals for incrementing the X counter, and a second horizontal line provides control signals for decrementing the X counter. A third horizontal line provides control signals for incrementing the Y counter, and a fourth horizontal line provides control signals for decrementing the Y counter. A fifth horizontal line provides control signals which blank or unblank the electron beam of the cathode ray tube at selected intervals during the generation of a character. First, second, third, fourth, and fifth Or circuits are provided. All of the first horizontal lines of each character plane are connected to the first Or circuit, and all of the second horizontal lines of each character plane are connected to the second Or circuit. The third horizontal lines of each character plane are connected to the third Or circuit, and the fourth horizontal lines of each character plane are connected to the fourth Or circuit. The fifth horizontal lines of each character plane are connected to the fifth Or circuit. The control circuit includes four bistable storage devices and four gates. The bistable storage devices preferably are flip flops, and they are connected to corresponding ones of the four gates. The first four Or circuits are connected to the complement input of the four control flip flops. The timing pulses applied to the vertical lines of the character planes are supplied through a delay circuit to the four gates. Those gates which are conditioned by their associated flip flops pass the delayed timing pulses. The first gate is connected to increment the X counter, and the second gate is connected to decrement the X counter. The third gate is connected to increment the Y counter, and the fourth gate is connected to decrement the Y counter. The X and Y counters are connected to deflection means which position the beam of the cathode ray tube. The fifth Or circuit is connected to a fifth flip flop which in turn is connected to an intensity control circuit which blanks or unblanks the beam of the cathode ray tube. The electron beam is unblanked to intensity or outline a character on the face of the cathode ray tube. The first through fourth flip flops control the corresponding ones of the four gates thereby to increment or decrement either or both of the X and Y counters. The electron beam moves when a character is generated. This movement may involve a change in the X direction, a change in the Y direction, or both a change in the X direction and the Y direction. Furthermore, these changes may involve movement in the X direction which is right or left and movement in the Y direction which is up or down. The character planes provide control signals through the associated Or circuits to the associated flip flop for the purpose of controlling the X and Y counters thereby to move the electron beam in a given manner to generate a particular character. The storage elements in each character plane are disposed in a fashion which provides control pulses on the first through the fifth horizontal lines of each character plane at the appropriate time as determined by the timing pulses on the vertical lines thereby (1) to provide control signals on the first through fifth horizontal lines of the selected character plane whenever there is a change to be made in the X or Y direction of the electron beam and (2) to unblank the electron beam at selected times to cause the character to be intensified on the face of the cathode ray tube. The use of storage elements in the character matrix to generate control signals (1) when, and only when, there is a change in the X or Y direction of the electron beam or (2) a change in the intensity of the electron beam thereby results in substantially decreasing the number of storage elements required in the character planes the number of storage element required in earlier character planes.

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 illustrates a display device including a cathode ray tube and a character generator connected thereto, and this arrangement typifies earlier such display devices.

FIG. 2 illustrates in detail the character planes shown in block form in FIG. 1.

FIG. 2A shows a waveform which is helpful in explaining the operation of the arrangement in FIG. 1.

FIG. 3 illustrates how the letter T is generated in a selected area on the face of a cathode ray tube.

FIG. 4 illustrates a display device which utilizes a cathode ray tube and an improved character generator according to this invention.

FIG. 5 illustrates in detail a character plane shown in block form in FIG. 4.

FIG. 6 illustrates curves A through E which are helpful in explaining the operation of the circuit arrangement in FIG. 4.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A display device according to this invention includes a cathode ray tube and an associated character generator for supplying signals to the cathode ray tube which control the electron beam to trace letters, numbers, symbols and the like on the face of the cathode ray tube. A main deflection device positions the beam in a selected location on the face of the cathode ray tube, and the character generator then supplies control signals to a character deflection yoke which manipulates the electron beam to generate the selected character at this location. A main deflection yoke and a character deflection yoke are illustrated, for example, in U.S. Pat. No. 3,337,860.

Reference is made to FIG. 1 which illustrates a character generator 10 and a cathode ray tube 12. The arrangement in FIG. 1 represents prior art, and this device is shown and described in copending application Ser. No. 721,477 filed Apr. 15, 1968 for Symbol Generating Apparatus by William R. Lamoureux. Briefly summarized, a character selection decoder 15 selects one of the planes 16 thorough 18. Each plane is a read only store in which is stored information for generating a selected character. In other words there is one plane for each character to be displayed on the cathode ray 12. A timing pulse generator 30 supplies timing pulses TP1 through TP40 the planes 16 through 18. Signals read from the selected plane pass through Or circuits 40 through 44 via respective lines 50 through 54 to operate an associated X counter 60 a Y counter 61 and a flip flop 62. More specifically, pulses from the selected plane pass through the Or circuits 40 through 44 on respective lines 50 through 54, and pulses on the line 50 increment the X counter 60. Pulses on the line 51 decrement the X counter 60. Pulses on the line 52 increment the Y counter 61, and pulses on the line 53 decrement the Y counter 61. Pulses on the line 54 complement the flip flop 62 which in turn operates an intensity control 63 which controls the signals on the grid 64 thereby to blank or unblank the beam of the cathode ray to 12. The X counter 60 is an up-down counter arrangement which provides control currents through associated character yoke drivers 71 and 72 to control the current through the character yoke windings 81 and 82, thereby to control the horizontal deflection of the beam of the cathode ray tube 12. Likewise, the Y counter 61 is an up-down counter which provides control currents through the character yoke drivers 73 and 74 to the yoke windings 83 and 84 thereby to control the vertical deflection of the electron beam in the cathode ray tube. The X counter 60 and the Y counter 61 may be any one of many well known types, but they preferably are of the type shown and described in patent 3,422,304.

There are as many planes in FIG. 1 as there are characters, and only one character is stored in a given plane. Let it be assumed for purposes of illustration that the plane 17 in FIG. 1 stores information for generating the letter T. The details of plane 17 are illustrated in FIG. 2. The plane 17 is a read only store matrix having horizontal lines 90 through 94 and vertical lines which receive timing pulses TP1 through TP40. The vertical lines are designated by their timing pulse number. The horizontal lines 90 through 94 supply pulse signals to the respective Or circuits 40 through 44 in FIG. 1. Storage elements are provided at selected coordinate intersections of the storage array in FIG. 2, and the storage elements are read non destructively by the timing pulses on the associated vertical lines.

The letter T is generated on the face of the cathode ray tube 12 at a location determined by the main deflection yoke which is not shown in the interest of simplicity. Any spot on the face of the cathode ray tube 12 may be selected by the main deflection yoke, and the character deflection yoke then generates the character T at the selected site. The selected site with the character T is illustrated in the blown-up view of FIG. 3. The main deflection yoke initially positions the electron beam of the cathode ray tube 12 at the point 150 in FIG. 3 and the character yoke controls the horizontal and vertical deflection from the point 150 thereby to generate the letter T. The generation of this character is described next.

Referring again to FIG. 2, the timing pulses TP1 through TP4 cause the respective storage elements 101 through 104 to provide a succession of pulses on the line 90 which pass through the Or circuit 40 in FIG. 1 and increment the X counter 60 four times. It thereby supplies current to the windings 81 and 82 of the character deflection yoke which causes the beam in FIG. 3 to move from the reference point 150 to the right past the point 151. The pulse TP5 reads the memory element 105 in FIG. 2 which in turn supplies a pulse on the line 91 through the Or circuit 41 in FIG. 1 which decrement the X counter 60. It changes the current in the windings 81 and 82 to move the beam to the left back to the point 151. The timing pulses TP7 through TP17 in FIG. 2 read the respective storage elements 107 through 117 which in turn supply a sequence of pulses on the line 92 through the Or circuit 42 in FIG. 1 which increment the Y counter 61. It thereby supplies current to the windings 83 and 84 of the character deflection yoke thereby to move the beam from the point 151 upwardly past the point 152. A storage element 108*a* in FIG. 2 is read simultaneously with the storage element 108 by the timing pulse TP8, and the storage element 108*a* supplies a signal on the line 94 which operates the flip flop 62 in FIG. 1 to turn on the intensity control 63 which thereby intensifies or unblanks the electron beam of the cathode ray tube 12 in FIG. 1. As the beam sweeps from the point 151 in FIG. 3 to the point 152, it illuminates the face of the cathode ray tube, and this is signified by the heavy line between the points 151 and 152 in FIG. 3.

The timing pulses TP18 through TP22 in FIG. 2 are used to read the storage elements 118 through 122, and a series of output pulses are established on the line 90 in FIG. 2 which are supplied through the Or circuit 40 in FIG. 1 to increment the X counter 60. This changes the current in the character yoke windings 81 and 82 and causes the beam to move from the point 152 in FIG. 3 to the point 153. The storage element 118*a* in FIG. 2 is read by the timing pulse TP18, and a resulting pulse on the line 93 is supplied through the Or circuit 43 in FIG. 1 to decrement the Y counter 61. In this connection it is pointed out that as the beam approaches the point 152 in FIG. 3 it overshot this point, and by decrementing the Y counter 61, the beam is brought back to the line which lies between the points 152 and 153. This overshoot and return is illustrated by the dotted line 154 which is exaggerated for illustrative purposes. The storage element 120*a* in FIG. 2 is read by the timing pulse TP20, and the resulting signal on the line 94 passes through the Or circuit 44 in FIG. 1 to complement the flip flop 62 and deactivate the intensity control 63 which in turn blanks the electron beam. Consequently, the beam is blanked as it travels from the point 152 to the point 153 in FIG. 3. In fact, the beam travels to the right past the point 153 in FIG. 3 in response to the timing pulse TP22, and timing pulses TP23 through TP25 read the respective storage elements 123 through 125 thereby to generate pulses on the line 91 which decrement the X counter 60 in FIG. 1 and moves the beam to the left back to the point 153 in FIG. 3. The timing pulse TP25 reads the storage element 125*a* in FIG. 2, and the resultant pulse on the line 94 passes through the Or circuit 44 in FIG. 1 to complement the flip flop 62 which in turn operates the intensity control 63 to unblank or intensify the electron beam. The timing pulses TP25 through TP36 read respective storage elements 125 through 136 in FIG. 2, and the resultant series of pulses on the line 91 is supplied through the Or circuit 41 to decrement the X counter 60 in FIG. 1 and thereby change the current in the character yoke windings 81 and 82 to move the electron beam from the point 153 in FIG. 3 to the left to the point 155. When the electron beam reaches the point 155 in FIG. 3, the timing pulse TP36 reads the storage element 136a in FIG. 2, and the resulting pulse on the line 94 passes through the Or circuit 44 in FIG. 1 to complement the flip flop 62 and deactivate the intensity control 63 thereby to blank the electron beam. The waveform in FIG. 2A illustrates when the electron beam is blanked and unblanked. The electron beam is unblanked during the period of the positive pulses 141 and 142. As soon as the electron beam is blanked, the X counter 60 and the Y counter 61 are reset to return the beam to the point 150 in FIG. 3. The main deflection yoke, not shown, may be operated to move the electron beam to another site where another selected character may be generated.

FIG. 4 illustrates an improved character generator arrangement according to this invention. The reference numbers used to designate the elements in FIG. 4 are identical to those used to designate corresponding parts in FIG. 1 except the value 200 is added to the reference number in FIG. 4. For example, the character selection decoder 15 in FIG. 1 is numbered 215 in FIG. 4. The system of FIG. 4 is similar to that of FIG. 1 with the exception that an Or circuit 231, a delay circuit 232 and a control circuit 233 are added. The control circuit 233 includes flip flops 235 through 238 which are connected to respective gates 245 through 248. Signals from the Or circuits 240 through 243 control the operation of the flip flops 235 which in turn control the operation of respective gates 245 through 248 to pass or inhibit pulses TP1 through TP40 which pass through the Or circuit 231 and the delay circuit 232. It is pointed out that all of the timing pulses are delayed by the delay circuit 232 before being applied to the gates 245 through 248, and the amount of the delay is sufficient to permit signals read from the selected one of the planes 216 through 218 to pass through the Or circuits 240 through 243 and operate the associated flip flops 235 through 238 thereby to control the associated gates 245 through 248 before the delayed signals are applied to these gates. For example, if the plane 216 in FIG. 4 is selected and the timing pulse TP1 reads a storage element which supplies a signal to the Or circuit 240, then the amount of the time delay in the delay circuit 232 is sufficient to permit the flip flop 235 to be operated and condition or decondition, as the case may be, the gate 245 before the delayed TP1 pulse emerges from the delay circuit 232. The gates 245 through 248 are controlled to pass the delayed timing pulses to the associated X counter 260 and the counter 261 which operate in the manner explained with reference to the system in FIG. 1.

It should be explained by way of introduction that characters are generated on the face of the cathode ray tube by visible segments or vectors disposed end to end. Each segment or vector has length and direction. The segments or vectors vary in lengths. Each segment or vector is straight, and its direction does not change. A curved section of a character is generated by numerous minute, straight segments or vectors disposed end to end with each having a different direction.

It is a feature of this invention to reduce the number of storage elements in the character planes 216 through 218 in FIG. 4. This is done by utilizing the storage elements in the planes to define change over points between the segments or vectors which compose a character. In essence, therefore, the changeover points indicate a change in direction of the beam sweep. The storage elements serve to make changes in the X and Y counters and hence alter the X and Y directions of the sweep of the electron beam in the cathode ray tube 212. The technique for generating characters on the face of the cathode ray tube 212 by the control circuit 210 in FIG. 4 involves the disposition of storage elements in the planes 216 through 218 at selected coordinate intersections to provide control signals which manipulate the control flip flops 235 through 238 thereby to operate the associated X counter 260 and the Y counter 261 to deflect the electron beam in the respective X and Y directions. The flip flop 235 is complemented to the one state whenever deflection of the electron beam horizontally to the right is desired. In this case the gate 245 is conditioned to pass the timing pulses from the delay circuit 232, and these pulses increment the X counter 260 to deflect the electron beam horizontally to the right. The flip flop 236 is complemented to the one state whenever it is desired to deflect the electron beam to the left horizontally. In this case the one output side of the flip flop 236 resets the flip flop 235, and the one output from the flip flop 236 conditions the gate 246 to pass timing pulses which decrement the X counter 260 and thereby sweep the electron beam horizontally to the left. When both of the flip flops 235 and 236 are reset to the zero state, the X counter 260 is neither incremented nor decremented, and the electron beam does not move horizontally to the right or to the left. In a similar fashion the control flip flops 237 and 238 control respective gates 247 and 248 to operate the Y counter 261. The Y counter is incremented under control of the flip flop 237 to move the electron beam upwardly, and the Y counter 261 is decremented under control of the flip flop 238 to move the electron beam downwardly. When the flip flops 237 and 238 are reset, the Y counter 261 is neither incremented nor decremented. In this case the electron beam does not move up or down. The flip flop 262 in FIG. 4 operates the intensity control 263 to blank or unblank the electron beam. The intensity control 263 is used to intensify or unblank the electron beam whenever the selected character is being generated on the face of the cathode ray tube 212. Otherwise, the electron beam is blanked.

Each of the planes 216 through 218 in FIG. 4 store different characters, and only one character is stored in a given one of these planes. Let it be assumed for purposes of illustration that the plane 217 in FIG. 4 is used to store signals for generating the letter T. The details of the plane 217 in FIG. 4 are illustrated in FIG. 5. Timing pulses TP1 through TP40 are supplied to the vertical lines of the storage matrix in FIG. 5, and each one of the horizontal lines 290 through 294 of the storage matrix is energized with an output pulse signal each time one of the timing pulses interrogates a storage element disposed on such horizontal line. The signals supplied on the lines 290 through 294 are control signals which manipulate the associated flip flops 235 through 238 and 262 in FIG. 4 for the purposes outlines above. The storage elements 301 through 311 in FIG. 5 are disposed at selected coordinate intersections as shown, and they serve the function of providing control signals to generate the letter T. It is appropriate at this point to describe the operation of the circuit arrangement in FIG. 4 whenever it generates the letter T on the face of the cathode ray tube 212, and for this purpose let it be assumed that the character selection decoder 215 in FIG. 4 selects the plane 217.

The timing pulse generator 230 in FIG. 4 supplies timing pulses TP1 through TP40 in succession to the memory planes 216 through 218 in FIG. 4. Since the memory plane 217 is selected by the character selection decoder 215, these timing pulses interrogate the storage elements in the plane 217. More specifically, the timing pulses TP1 through TP40 are applied to the vertical lines of the storage array in FIG. 5. The pulse TP1 interrogates the non-destructive storage element 301, and a pulse signal is supplied on the line 290 through the Or circuit 240 in FIG. 4 to the complement input of the flip flop 235. Let it be assumed that initially the flip flops 235 through 238 and the flip flop 262 are reset. Positive pulse signals received by the flip flops 235 through 238 and 262 from the associated Or circuits 240 through 244 are effective to complement these flip flops. Accordingly, the positive pulse signal from the Or circuit 240 complements the flip flop 235 to condition the gate 245. The pulse TP1 in FIG. 4 is supplied also through the Or circuit 231 and the delay circuit 232 to all of the gates 245 through 248. All of these gates are deconditioned except the gate 245, and the gate 245 therefore passes the TP1 pulse to increment to X counter 260. The output signals from the control flip flops 235 through 238 and 262 are shown in FIG. 6. FIG. 6A represents the output signals from the control flip flop 235, and FIG. 6B represents the output signals from the control flip flop 236. FIG. 6C depicts the output signals from the control flip flop 237 in FIG. 4, and FIG. 6D shows the output signals from the control flip flop 238. FIG. 6E shows the intensity control signals provided by the output from the control flip flop 262 in FIG. 4. As timing pulses TP2 through TP4 occur, they are uneventful in the storage matrix in FIG. 2. However, these pulses pass through the Or circuit 231 and the delay circuit 232, and each is passed by the gate 245 to increment the X counter 260. The X counter changes the current in the character yoke windings 281 and 282 which thereby moves the electron beam from the point 150 in FIG. 3 to the right past the point 151. When the pulse TP5 occurs, it interrogates the storage element 302 in FIG. 5, and a positive pulse is supplied on the line 291 through the Or circuit 241 to complement the flip flop 236 to the one state which thereby conditions the gate 246 to pass the delayed TP5 pulse from the delay circuit 232. The signal from the one output side of the flip flop 236 resets the flip flop 235 which thereby deconditions the gate 245. The positive pulse from the gate 246 decrements the X counter 260 and changes the current in the yoke windings 281 and 282 to move the electron beam to the left back toward the point 151 in FIG. 3 thereby to correct for the overshoot to the right.

The timing pulse TP6 reads the storage element 303 in FIG. 5, and the resulting positive output pulse on the line 291 passes through the Or circuit 241 in FIG. 4 and complements the flip flop 236 to the zero state. This deconditions the gate 246 before the delayed timing pulse TP6 emerges from the delay circuit 232, the application of further pulses to the X counter 260 in FIG. 4 is terminated. Hence the electron beam stops moving to the left, and it stops at the point 151 in FIG. 3. It is pointed out that the one output side of the flip flop 235 in FIG. 4 generates a positive pulse 400 as shown in FIG. 6A. The positive pulse 400 is initiated by the timing pulse TP1, and it is terminated by the timing pulse TP5, as shown. The one output side of the flip flop 236 in FIG. 4 generates a positive pulse 401 as illustrated in FIG. 6B. The positive pulse 401 is initiated by the timing pulse TP5, and it is terminated by the timing pulse TP6. All of the control flip flops 235 through 238 and 262 in FIG. 4 are in the reset condition upon termination of the timing pulse TP6.

The timing pulse TP7 reads the storage element 304 in FIG. 5, and the resulting positive pulse on the line 292 passes through the Or circuit 242 in FIG. 4 to complement the flip flop 237 to the one state and thereby condition the gate 247. The delayed timing pulse TP7 passes through the gate 247 and increments the Y counter 261, and this changes the current in the character yoke windings 283 and 284 to move the electron beam upwardly from the point 151 in FIG. 3. The one output of the flip flop 237 in FIG. 4 generates the positive pulse 402 in FIG. 6C, and the timing pulse TP7 initiates the positive pulse 402. The positive pulse 402 is terminated by the timing pulse TP18 as described more fully hereinafter. The positive signal 402 in FIG. 6C conditions the gate 247 in FIG. 4 to pass the delayed timing pulses TP7 through TP17, and these timing pulses increment the Y counter 261 to change the current in the character yoke deflection windings 283 and 284 to move the electron beam upwardly from the point 151 in FIG. 3 toward the point 152.

The timing pulse TP8 reads the storage element 305 in FIG. 5, and the resulting positive pulse on the line 294 passes through the Or circuit 244 in FIG. 4 to complement the flip flop 262 to the one state. The positive signal from the one output side of the flip flop 262 operates the intensity control 263 and changes the signal level on the grid 264 thereby to unblank the electron beam and intensify the face of the cathode ray tube 212. The electron beam illuminates the face of the cathode ray tube commencing at the point 151 in FIG. 3 and continuing to the point 152 at which time the electron beam is blanked by the timing pulse TP20 as described subsequently. The one output side of the flip flop 262 in FIG. 4 provides the positive pulse 403 in FIG. 6E to the intensity control 263. The positive pulse 403 is initiated by the timing pulse TP8, and it is terminated by the timing pulse TP20 as illustrated in 6E.

The timing pulse TP18 reads the storage element 306 in FIG. 5, and the resulting positive pulse on the line 290 passes through the Or circuit 240 in FIG. 4 to complement the flip flop 235 to the one state which thereby conditions the gate 245 to pass the delayed timing pulse TP18 to increment the X counter 260. Incrementing the X counter 260 causes the electron beam to move to the right in FIG. 3 from the vicinity of the point 152 toward the point 153. The one output side of the flip flop 235 continues as a positive level until the timing pulse TP23 occurs subsequently, and this output level is depicted as the positive pulse 404 in FIG. 6A. This positive output signal conditions the gate 245 to pass each of the timing pulses TP18 through TP22, and each increments the X counter 260 thereby to move the electron beam toward the right until it reaches the point 153 in FIG. 3.

The timing pulse TP18 also reads the storage element 306*a* in FIG. 5, and the resultant positive pulse on the line 293 passes through the Or circuit 243 in FIG. 4 to complement the flip flop 238 to the one state which thereby conditions the gate 248 to pass the delayed timing pulse TP18 to decrement the Y counter 261. Decrementing the Y counter 261 causes the electron beam to move downwardly in FIG. 3 to correct for the overshoot depicted by the dotted line 154. The positive output signal from the one side of the flip flop 238 generates a positive pulse, and this is shown as the pulse 405 in FIG. 6D. This positive pulse terminates with the timing pulse TP19 as explained subsequently. The positive signal from the one output side of the flip flop 238 is applied to the zero input side of the flip flop 237, and it is effective to reset the flip flop 237 and thereby terminate the positive output signal from the one output side of the flip flop 237 which thereby deconditions the gate 247. This action terminates the positive pulse 402 in FIG. 6C.

The timing pulse TP19 reads the storage element 307 in FIG. 5, and the resultant positive pulse on the line 293 passes through the Or circuit 243 in FIG. 4 to complement the flip flop 238 to the zero state, and this terminates the positive pulse 405 in FIG. 6D. Consequently, the gate 248 in FIG. 4 is deconditioned to prevent further decrementing of the Y counter 261, and compensation has been completed for the vertical overshoot depicted by the dotted line 154.

The timing pulse TP20 reads the storage element 308 in FIG. 5, and the resultant positive pulse on the line 294 passes through the Or circuit 244 in FIG. 4 and complements the flip flop 262 from the one state to the zero state. This deactivates the intensity control 263 and thereby blanks the electron beam. This action causes the termination of the positive pulse 403 in FIG. 6E. The delayed pulses TP18 through TP22 pass through the gate 245 in FIG. 4 to increment the X counter 260 and thereby move the electron beam to the right from the vicinity of the point 152 in FIG. 3 to the point 153.

When the timing pulse TP23 occurs, it reads the storage element 309 in FIG. 5, and the resultant positive pulse on the line 291 passes through the Or circuit 241 in FIG. 4 and complements the flip flop 236 to the one state which thereby conditions the gate 246. The positive signal from the one output side of the flip flop 236 is shown as the positive pulse 406 in FIG. 6B. The positive output signal from the one output side of the flip flop 236 is supplied to the zero input side of the flip flop 235, and it is effective to reset this flip flop to the zero state. This terminates the positive pulse from the one output side of the flip flop 235 which is shown as the pulse 404 in FIG. 6A. The timing pulses TP23 through TP40 are passed by the gate 246 to decrement the X counter 260 which in turn changes the current through the character yoke windings 281 and 282 to move the electron beam from the vicinity of the point 153 in FIG. 3 to the left toward the point 155 thereby to generate the upper portion of the letter T.

The timing pulse TP25 reads the storage element 310 in FIG. 5, and the resulting positive pulse on the line 294 passes through the Or circuit 244 in FIG. 4 and complements the flip flop 262 to the one state to initiate the positive pulse 407 in FIG. 6E. The positive output pulse 407 from the one side of the flip flop 262 operates the intensity control 263 to supply a signal level to the grid 264 which unblanks the electron beam. The line between the point 153 in FIG. 3 and the point 155 is intensified as the electron beam sweeps to the left between these two points in response to timing pulses TP23 through TP36.

The timing pulse TP36 reads the storage element 311 in FIG. 5, and the resulting positive pulse on the line 294 passes through the Or circuit 244 and complements the flip flop 262 from the one state to the zero state. This terminates the positive pulse 407 from the one side of the flip flop 262 in FIG. 4 and thereby deactivates the intensity control 263 which supplies a signal level to the grid 264 that blanks the electron beam as it reaches the point 155 in FIG. 3. Thus the letter T is generated on the face of this cathode ray tube 212. Once the electron beam is blanked by the timing pulse TP36, the flip flops 235 through 238 in FIG. 4 may be reset to return the electron beam to the point 150 in FIG. 3. The character yoke may then position the electron beam, to a new location where another selected character may be generated.

The storage elements in FIG. 5 are disposed in the read only storage matrix in a fashion which provides control pulses on the horizontal lines 290 through 294 at the appropriate times as determined by the timing pulses on the vertical lines. It is pointed out in this connection that the positive pulse 400 in FIG. 6A is initiated by the storage element 301, and the positive pulse 400 is terminated by the action of the storage element 302. During the interim the X counter is incremented by the delayed timing pulses TP1 through TP4, and the electron beam moves from the point 150 in FIG. 3 to the point 151. Actually, the beam moves past the point 151, and this overshoot is corrected by decrementing the X counter 260. This decrementing is done under control of the pulse 401 in FIG. 6B which is initiated and terminated under control of respective storage elements 302 and 303. Then the positive pulse 402 in FIG. 6C is initiated by the storage element 304, and it is terminated by the action of the storage element 306A. For the duration of the positive pulse 402 the delayed timing pulses TP7 through TP17 increment the Y counter 261 in FIG. 4 to move the electron beam from the point 151 in FIG. 3 to the point 152. The positive pulse 403 is generated next. It is initiated by the action of the storage element 305 and terminated by the action of the storage element 308. The electron beam is unblanked and for the duration of the pulse 403. The positive pulse 404 in FIG. 6A is generated. It is initiated by the action of the storage element 306, and it is terminated by the action of the storage element 309. For the duration of the positive pulse 404 the timing pulses TP18 through TP22 increment the X counter 260 in FIG. 4, and this moves the electron beam from the point 152 in FIG. 3 to the point 153. The positive pulse 405 in FIG. 6D is generated to decrement the Y counter 261 in FIG. 4 and correct for vertical overshoot. The positive pulse 405 is initiated and terminated by action of the respective storage elements 306*a* and 307 in FIG. 5. Next the positive pulse 406 in FIG. 6B is generated. The positive pulse 406 is initiated by the action of the storage element 309, and the positive pulse 406 continues until the end of this character period. The timing pulses TP23 through TP40 decrement the X counter 260 in FIG. 4 thereby to move the electron beam from the point 153 in FIG. 3 toward the point 155. The electron beam is unblanked for the duration of the positive pulses 403 and 407 in FIG. 6E. During the positive pulse 403 the electron beam is intensified as it moves from the point 151 in FIG. 3 to the point 152 as pointed out above, and during the positive pulse 407 the electron beam is intensified as it moves from the point 153 in FIG. 3 to the point 155. The election beam is blanked upon termination of the positive pulse 407 in FIG. 6E which occurs at timing pulse TP36. It is seen that storage elements are used in FIG. 5(1) to provide control signals on the lines 290 through 294 whenever there is a change in the X or Y direction of the beam during the generation of a character and (2) to unblank the electron beam at selected times to cause the character to be intensified on the face of the cathode ray tube.

The use of storage elements in the matrix of FIG. 5 to generate control signals (1) when, and only when, there is a change in the X or Y direction of the beam or (2) a change in intensity of the electron beam results in the use of relatively fewer storage elements for generating the letter T. This readily may be seen by comparing the number of storage elements in the matrix array in FIG. 5 with the number of storage elements in the matrix array in FIG. 5 with the number of storage elements in the matrix array of FIG. 2. The storage matrix in FIG. 2 uses 40 storage elements; whereas, the storage array in FIG. 5 uses 12 storage elements. Hence the storage array in FIG. 5 provides a substantial decrease in the number of storage elements employed for generating the character T over the number of storage elements employed in the matrix array of FIG. 2 for generating the character T. It is pointed out that a separate storage array is provided for each character in the arrangements of FIGS. 1 and 4. It is noted further that not every one of the arrays 216 through 218 in FIG. 4 provides the same degree of reduction in storage elements over the corresponding array in FIG. 1. A more favorable reduction in storage elements is obtained over the corresponding array in FIG. 1 for those arrays in FIG. 4 which generate characters having substantially straight lines such as X, T, I, and the like. These characters involve a minimal number of changes in direction of the electron beam of the cathode ray tube. Character planes in FIG. 4 which generate characters having a substantial number of changes in the X and Y directions of the electron beam provide a substantially less favorable reduction of storage elements over the corresponding plane in FIG. 1, and in some characters there may be no saving in storage elements at all over the character arrays of FIG. 1. For example, characters such as Q, O, G and the like require constant changes in the X and Y directions of the electron beam, and such character planes in FIG. 4 require a substantial number of storage elements. However, if the number of character planes included in FIGS. 1 and 4 provide for the generation of the letters A through Z and the numbers 0 through 9, then the total number of storage elements employed in the planes of FIG. 4 become substantially less than the total number of storage elements employed in the planes of FIG. 1.

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 is claimed is:

1. A display device composed of a cathode ray tube and a character generator coupled thereto for generating characters on the face of the cathode ray tube, the character generator including:

a plurality of character planes, selection means coupled to the plurality of character planes for selecting any one of the character planes, each character plane including a matrix array of vertical lines and horizontal lines, said horizontal lines including first, second, third, fourth, and fifth horizontal lines, a plurality of storage elements, said storage elements being disposed only at such coordinate intersections of the vertical and horizontal lines where a change in the horizontal deflection, a change in the vertical deflection, or a change in intensity are required for controlling the electron beam of the cathode ray,

pulse generator means connected to the vertical lines for applying timing pulses sequentially to the vertical lines of a selected character plane, each storage element responding to a timing pulse on the associated vertical line to provide a control pulse on the corresponding horizontal line, first, second, third, fourth and fifth bistable storage devices, means interconnecting the first and second bistable storage devices to inhibit operation of both of these bistable storage devices at the same time, means interconnecting the third and fourth bistable storage devices to inhibit operation of both of these bistable storage devices at the same time, means coupling the first, second, third, fourth and fifth horizontal lines of each character plane to the respective first, second, third, fourth and fifth bistable storage devices,

first, second, third, and fourth gates, means connecting the first, second, third, and fourth bistable storage devices to the respective first, second, third, and fourth gates, means connected between the pulse generator means and said gates for supplying each timing pulse delayed in time to each of said gates,

said cathode ray tube having vertical deflection means and horizontal deflection means,

first means connected between the horizontal deflection means and the first and second gates for controlling the horizontal deflection of the electron beam of said cathode ray tube,

second means connected between the vertical deflection means and the third and fourth gates for controlling the vertical deflection of the electron beam of the cathode ray tube, and

intensity control means connected between the cathode ray tube and the fifth bistable storage device for controlling the intensity of the display on the face of the cathode ray tube.

2. The apparatus of claim **1** wherein the bistable storage devices are flip-flops, the first means is an up-down X counter, and the second means is an up-down Y counter.

3. The apparatus of claim **2** wherein said means connected between the timing pulse generator and said gates includes an Or circuit and a delay circuit serially connected between the pulse generator means and said gates.

4. A display device including:

a cathode ray tube, said cathode ray tube having vertical deflection means and horizontal deflection means,

first means connected to the horizontal deflection means for controlling the horizontal deflection of the electron beam of said cathode ray tube, second means connected to the vertical deflection means for controlling the vertical deflection of the electron beam of the cathode ray tube,

first and second gates connected to said first means, third and fourth gates connected to said second means,

first and second bistable storage devices connected to the respective first and second gates, third and fourth bistable storage devices connected to the respective third and fourth gates, means interconnecting the first and second bistable storage devices to inhibit operation of both of these bistable storage devices at the same time, means interconnecting the third and fourth bistable storage devices to inhibit operation of both of these bistable storage devices at the same time,

a plurality of character planes, selection means coupled to the plurality of character planes for selecting any one of the character planes, each character plane including a matrix array of vertical lines and horizontal lines, said horizontal lines including first, second, third, fourth, and fifth horizontal lines, a plurality of storage elements, said storage elements being disposed at such coordinate intersections of the vertical and horizontal lines only where a change in the horizontal deflection, a change in the vertical deflection, or a change in intensity are required for controlling the electron beam of the cathode ray tube,

pulse generator means connected to the vertical lines for applying timing pulses sequentially to the vertical lines of a selected character plane, each storage element responding to a timing pulse on the associated vertical line to provide a control pulse on the corresponding horizontal line,

intensity control means connected to said cathode ray tube, a fifth bistable storage device connected to said intensity control means,

means connecting the first, second, third, fourth, and fifth horizontal lines of each character planes to the respective first, second, third, fourth, and fifth bistable storage devices, and

an Or circuit and a delay circuit connected in series, said Or circuit being connected to said pulse generator means to supply all timing pulses to said delay circuit, and said delay circuit being connected to said first, second, third, and fourth gates to supply all timing pulses delayed in time to said gates.

5. The apparatus of claim **4** wherein the first means is an up-down X counter, the second means is an up-down Y counter, and the bistable storage devices are flip-flops.

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