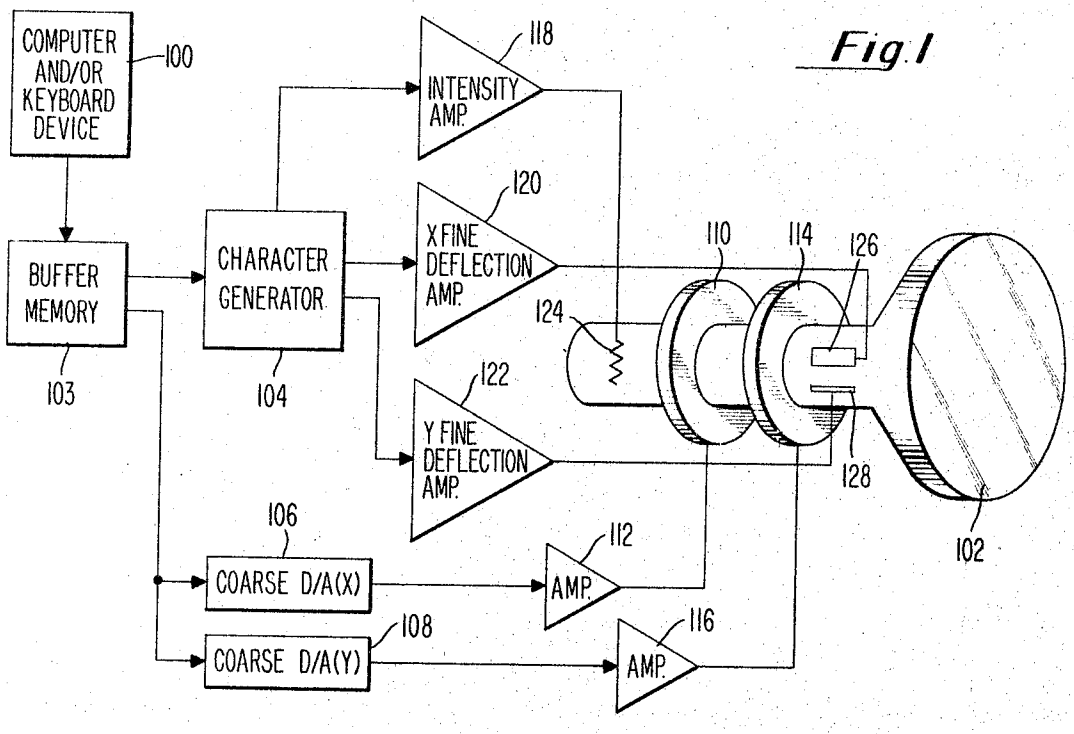
May 16, 1967 G. YANISHEVSKY 3,320,595

CHARACTER GENERATION AND CONTROL CIRCUITS

Filed June 16, 1964 3 Sheets-Sheet 1

Fig. 1



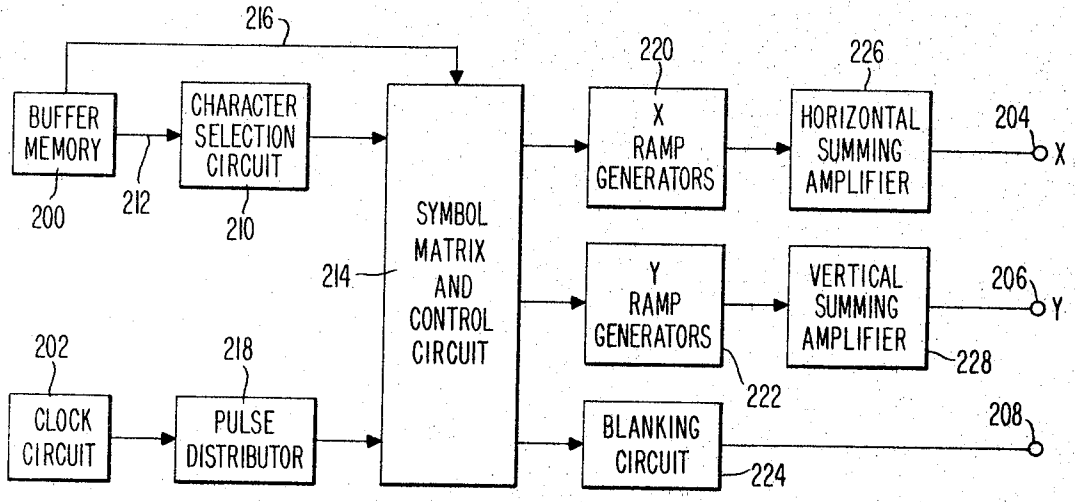


Fig. 2

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CHARACTER GENERATION AND CONTROL CIRCUITS

Filed June 16, 1964 3 Sheets-Sheet 2

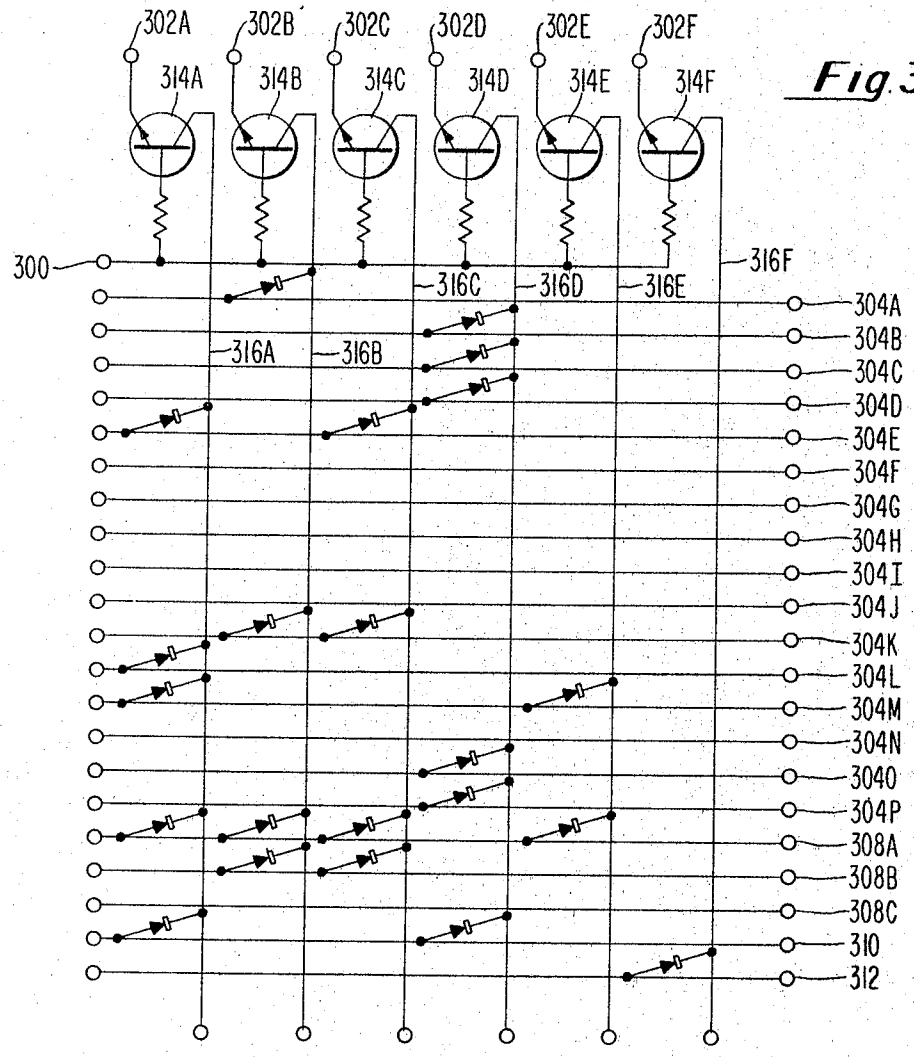


Fig. 3

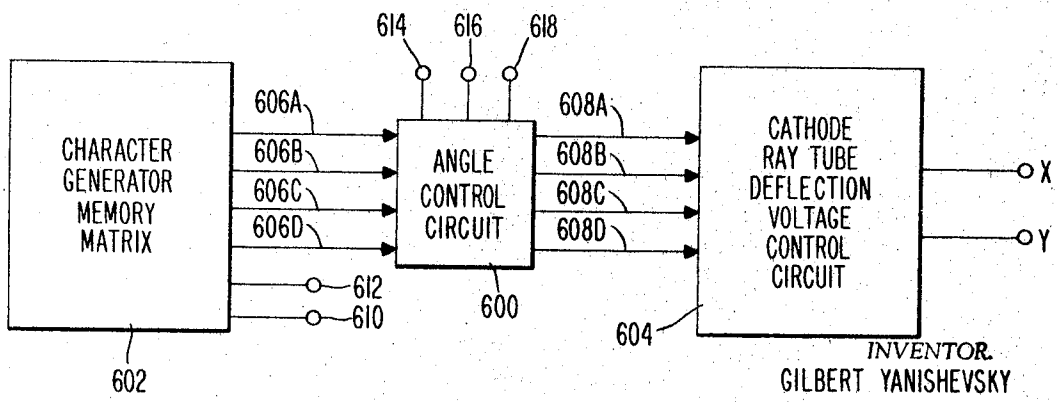


Fig. 6

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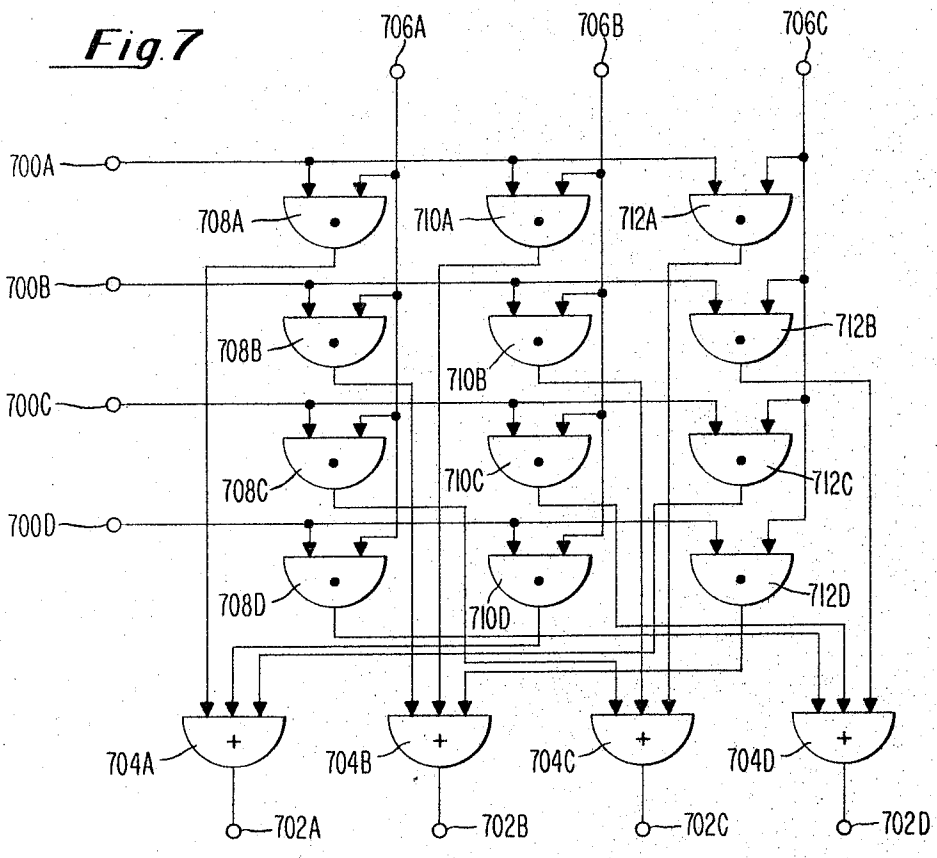
BY Vincent L. Carney

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CHARACTER GENERATION AND CONTROL CIRCUITS

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Fig. 7



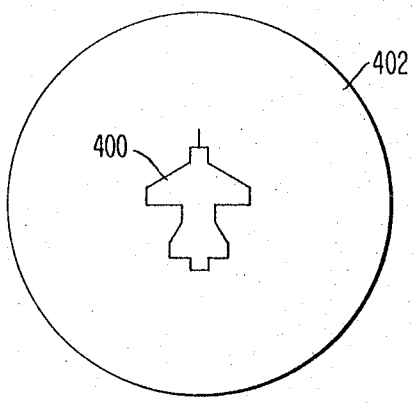


Fig. 4

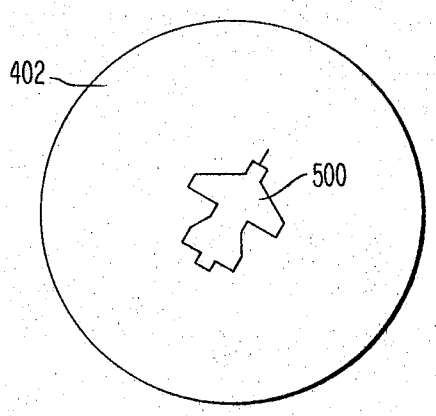


Fig. 5

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United States Patent Office 3,320,595 Patented May 16, 1967

3,320,595

CHARACTER GENERATION AND CONTROL CIRCUITS

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Filed June 16, 1964, Ser. No. 375,523
9 Claims. (Cl. 340—172.5)

This invention relates to apparatus for generating and displaying symbols such as numbers, letters and the like, and more particularly, to apparatus for changing the angular position of these symbols when they are displayed.

The use of large capacity digital computers as decision-making devices requires a means for displaying information to the operator of the computer rapidly and in a form which can be easily understood. One system for displaying such information presents a graphic symbol on a display screen to the operator, which symbol indicates the desired information. It is formed by a unit in the computer called a "character generator."

One type of character generator receives information from the computer in the form of binary output words and selects a symbol in accordance with these binary output words for presentation upon a cathode-ray-tube screen. A character generator of this type is described in the application of Charles P. Halsted, Ser. No. 277,796, entitled, "Symbol Generating Apparatus," and assigned to the same assignee as the instant application.

In the character generator disclosed in the Halsted application, the symbols are stored in the form of a plurality of straight lines each indicated by a line length and a polar angle. The character generator moves the electron beam of the cathode ray tube in a series of straight lines to generate the symbol. Horizontal and vertical deflection voltages are provided to the cathode ray tube to cause the electron beam to sweep in the polar angle. The intensity of the electron beam is controlled for a period of time necessary to generate the proper length straight line.

Each symbol is stored in the character generator in an addressable memory. When a particular character is selected for read-out, the voltages for the succession of straight lines are read out in series to cause the cathode ray tube to generate the selected character at a fixed location and orientation upon the face of the cathode ray tube. However, in some applications it is desirable to rotate this character to give it a different angular position. The capacity of the addressable memory in the character generator would have to be greatly increased to store each symbol in a variety of different angular positions such that the computer would select an individual character and its angular position from a different portion of the memory of the character generator just as though they were all separate characters. Accordingly, it is an object of this invention to provide an improved character generator.

It is a further object of this invention to provide a simple and economical apparatus for selecting the angular position of a character provided to a display by a character generator.

It is a still further object of this invention to provide apparatus for rotating a symbol provided to a display by a character generator in the form of a series of line segments and polar angles by rotating each of the polar angles through the same number of degrees.

In accordance with the above objects a deflection voltage circuit for controlling the angle of sweep of the electron beam of a cathode ray tube is provided. This deflection-voltage control circuit has a plurality of terminals leading into it, each terminal capable of causing the deflection-voltage control circuit to generate a line having

a different polar angle by controlling the angle of movement of the electron beam in the cathode ray tube. The terminals have a linear progression so that each successive terminal causes the line to be generated at a fixed angular increment.

When a character has been selected in the character generation memory by the computer for display on the cathode ray tube, the addressable memory pulses a sequence of the input terminals to the deflection voltage control circuit to provide a series of lines having the proper angle to collectively form the desired character. The apparatus for changing the angular position of this character or for rotating this character on a cathode ray tube display surface is interposed between the addressable memory and a cathode ray tube deflection-voltage control circuit. This circuit changes the polar angle of each line which is to be displayed by a fixed angular increment to rotate the entire character. For example, if the input terminals to the cathode-ray-tube deflection-control circuit represent successive increments of five angular degrees of the polar angle, the angle control circuit may rotate the entire character by five degrees merely by causing activation of the next successive terminal in the increasing succession from that which the addressable memory would otherwise activate.

The angle control circuit includes a plurality of OR gates, each OR gate having its output electrically connected to a different one of the input terminals of the cathode-ray-tube deflection-control circuit. It also includes another gating arrangement having information inputs electrically connected to the outputs of the addressable memory and angle-control inputs for shifting the inputs from the addressable memory a fixed number of OR gates for each of the lines composing any one character.

This gating arrangement, for example, may include a series of AND gates and a control input terminal for causing a rotation of five degrees in the displayed character. In such an arrangement each AND gate has two inputs. One input is electrically connected to one of the outputs from the addressable memory and the other input is electrically connected to one control terminal through the angle control circuit. The outputs from these AND gates are electrically connected to the OR gates that are connected to the inputs to the deflection control circuit. Each control terminal opens those AND gates that connect the outputs from the addressable memory to the inputs of the deflection-control circuit in the same order but shifted by a number of input terminals equivalent to the angular rotation that is to be effected by the control terminal. Therefore, when the control terminal for a five degree rotation is activated, the polar angle for all the line segments making up the character provided by the addressable memory is shifted by five degrees, resulting in a five degree rotation of the entire character on the display surface of the cathode ray tube.

The invention and the above-noted and other features thereof will be understood more clearly and fully from the following description with reference to the accompanying drawings in which:

FIGURE 1 is a block diagram of a computer-display combination which may include an embodiment of the invention;

FIGURE 2 is a block diagram of a character generator which may include an embodiment of the invention;

FIGURE 3 is a schematic circuit diagram of a character generator memory which may be used in an embodiment of the invention;

FIGURE 4 is a pictorial representation of a character on a display;

FIGURE 5 is a pictorial representation of the character

shown on the display of FIGURE 4 but rotated by the angle control circuit;

FIGURE 6 is a block diagram showing the structural relationship between the angle control circuit, the character generator memory, and the cathode ray tube deflection-voltage-control circuit; and

FIGURE 7 is a schematic circuit diagram of an embodiment of the invention.

In FIGURE 1 a block diagram of a computer-display system that may include an embodiment of the invention is shown having a computer or keyboard device **100** which determines the character that is to be displayed on a cathode ray tube (CRT) **102**. The computer **100** sends digital information to the buffer memory **103**, which stores such information as character location, type of character, and size of character. A conventional drum or magnetic core memory may be used for the buffer memory **103**. This memory merely keeps sending the same information to the character generator over and over until new information is to be displayed. In practice the entire display is reproduced forty times a second to eliminate visible flicker. The buffer memory **103** is electrically connected to the character generator **104**, to the coarse digital-to-analog converter (coarse $D/A-X$) **106**, and to the coarse digital-to-analog converter ($D/A-Y$) **108**.

The coarse $D/A-X$ **106** is electrically connected to the coarse vertical deflection element **110** of the CRT **102** through the coarse deflection amplifier **112** and the coarse $D/A-Y$ **108** is electrically connected to the horizontal coarse deflection element **114** through the coarse deflection amplifier **116**.

The information that determines character location is sent from the buffer memory **103** to the two coarse D/A converters **106** and **108** of the coarse deflection system. The coarse $D/A-Y$ **108** determines the general vertical height (or line) upon which a character is to be displayed, while the D/A converter determines the general horizontal area (or place on the line) where the character is to be displayed.

The character generator **104** is electrically connected to the intensity amplifier **118**, to the X fine-deflection amplifier **120**, and to the Y fine-deflection amplifier **122**. The intensity amplifier **118** is electrically connected to the electron gun **124**; the X fine-deflection amplifier **120** is electrically connected to the fine-vertical deflection plate **126** of the CRT **102**; and the Y fine-deflection amplifier **122** is electrically connected to the horizontal fine deflection plate **128**.

The buffer memory **103** sends the character selection information to the character generator **104**. The character generator **104** sends analog information to the deflection amplifiers **120** and **122** to indicate the polar angle of the line segments that are to make up the selected character. They cause the electron beam in the cathode ray tube **102** to trace the straight lines across the face of the CRT having the polar angle of the line segments which together compose the selected character. The character generator sends intensity information from a timing circuit through the intensity amplifier **118** to the electron gun **124**. This information determines the true time or the limits of the lines which together compose the selected character.

Both magnetic and electrostatic deflection of the CRT **102** are used in the system of FIGURE 1. The coarse deflection amplifiers **112** and **116** go to the magnetic deflection yokes **110** and **114**. The fine deflection amplifiers **120** and **122** go to the electrostatic vertical deflection plates **126** and the horizontal electrostatic deflection plates **128** respectively. The ratio of the distance of vertical deflection to the distance of horizontal deflection at a given stroke determines the slope of the line to be displayed.

It is not necessary to use both magnetic and electrostatic deflection to form the characters on the oscilliscope **102**. The coarse and fine deflection information can easily be combined and used in either all-electrostatic or all-electromagnetic deflection systems. However, the character generation speed is reduced for all-electromagnetic deflection, since electrostatic deflection is faster in the present state of the art.

In FIGURE 2 a block diagram of the character generator is shown having a buffer memory **200**, a clock circuit **202**, a terminal **204** which is to be electrically connected to the horizontal deflection amplifier for the cathode ray tube, a terminal **206** which is to be electrically connected to the vertical deflection amplifier of the cathode ray tube, and a terminal **208** which is to be electrically connected to the blanking amplifier (not shown) for the cathode ray tube. The buffer memory **200** is electrically connected to the character selection circuit **210** through the line **212** and to the symbol matrix and control circuit **214** through the line **216**. The clock circuit **202** is electrically connected to the pulse distributor **218**. The symbol matrix and control circuit **214** receives inputs from the character selection circuit **210**, from buffer memory **200** and from the pulse distributor **218** and provides outputs to the X ramp generators **220**, to the Y ramp generators **222**, and to the blanking circuit **224**. The X ramp generators **220** provide an output to terminal **204** through the horizontal summing amplifier **226**; the Y ramp generators **222** provide an output to the terminal **206** through the vertical summing amplifier **228**; and the blanking circuit **224** provides an output to terminal **208**.

The buffer memory **200** sends information to the character selection circuit **210** which in turn selects the particular character which is to be displayed from the addressable matrix stored in the symbol matrix and control circuit **214**. The buffer memory **200** may also select the angle of rotation of the symbol which is to be displayed through the line **216**. However, this may be done directly from a keyboard if desired. Once the particular character has been selected by the character selection circuit **210**, the pulse distributor **218** causes each of the line polar angles making up the desired character to be read out of the addressable storage matrix in sequence and synchronized by the clock circuit **202**. Each line is read out in the form of pulses on one of the pluralities of lines which determine the rate of change of the voltages provided to terminals **204** and **206** by the ramp generators and summing amplifiers. This in turn determines the slope of the line or in other words, the polar angle. A timing portion of the addressable matrix controls the line length. The blanking circuit **224** provides signals to terminal **208** to blank out the retrace lines of the CRT.

In FIGURE 3 a schematic circuit diagram of a memory matrix containing the information necessary for one character is shown having a selection terminal **300**, six line selection terminals **302A–302F**, sixteen angle deflection output terminals **304A–304P**, three timing signal output terminals **308A–308C**, a blanking signal output terminal **310**, and an end-of-character output terminal **312**.

Each of the six line-selection terminals **302A–302F** are electrically connected to a corresponding one of the emitters of the six NPN transistors **314A–314F**. Each of the bases of the transistors **314A–314F** is electrically connected to the selection terminal **300** through a different one of six base resistors. Each of the collectors of the six transistors **314A–314F** is electrically connected to corresponding ones of the six line conductors **316A–316F**.

Information is stored in the circuit of FIGURE 3 by electrically connecting diodes at selected locations with their cathodes electrically connected to a selected one of the line conductors **316A–316F** and their anodes electrically connected to a selected one of the output terminals.

The character matrix of FIGURE 3 is selected for read out by applying a voltage to the terminal **300**. This causes the transistors **314A–314F** to act as closed switches. The line selection terminals **302A–302F** are

electrically connected to a pulse distributor indicated as 218 in FIGURE 2 from which they receive voltage pulses in sequence so as to progressively energize the line conductors 316A–316F one at a time.

Each time one of the line conductors 316A–316F is energized, information is read out to the display, which information is sufficient to generate one line of the desired character stored in the matrix of FIGURE 3. The slope of this line is determined by the choice of angle deflection output terminals 304A–304P that are programmed through a connecting diode. Each of these output terminals represent an equal angular increment in the slope of the line.

The length of the line is controlled by the diode connection between the line conductors and the timing output terminals 308A–308C. These terminals determine the period of time that the CRT traces across its display surface. The terminal 310 provides a blanking voltage to a blanking amplifier to prevent display of the retrace sweeps of the electron beam of the CRT. The terminal 312 provides an end-of-character signal to the computer or keyboard, which may then select another character for display.

The operation of this matrix and the character operator in which it is used is disclosed more fully and completely in the above-identified patent application, Ser. No. 277,796, to Charles P. Halsted. The remainder of this discussion will be concerned primarily with the outputs from the deflection terminals 304A–304P, which determine the slope of the lines that are read out of the character matrix. The outputs from these terminals are altered in a controlled manner so as to rotate the character upon the display under the control of the computer or under the control of an operator.

In FIGURE 4 a symbol 400, for example, is shown upon the face of a display surface 402 in the position in which it may be read out of a character matrix such as that in FIGURE 3. It is desired at times to rotate this symbol indicated as 500 in FIGURE 5 to a new angular position without requiring a different character matrix.

In FIGURE 6 a block diagram showing the relationship of the angle control circuit 600 to the character generator matrix memory 602 and to the CRT deflection-voltage control circuit 604 is shown. The angle deflection output terminals 606A–606D are electrically connected to the angle control circuit 600 which in turn is electrically connected to the cathode ray tube deflection voltage control circuit through the lines 608A–608D. The timing output terminals 610, and the end of word terminal 612 are electrically connected to the computer (not shown). The angle control circuit 600 has three inputs 614, 616 and 618.

If an input pulse is applied to terminal 614 line 606A is electrically connected to line 608A; line 606B is electrically connected to line 608B; line 606C is electrically connected to line 608C; and line 606D is electrically connected to line 608D. In such a case, the character generated on the cathode ray tube is not rotated. However, if a voltage is applied to terminal 616, line 606A is electrically connected to line 608B, line 606B is electrically connected to line 608C, line 606C is electrically connected to line 608D; and line 606D is electrically connected to line 608A. In this case, the character is rotated by one increment. Similarly, if the pulse is applied to terminal 618, line 606A is electrically connected to line 608C; line 606B is electrically connected to line 608D; line 606C is electrically connected to line 608A; and line 606D is electrically connected to line 608B. The angle control circuit 600 in this way provides a simple means for rotating the character by changing one of the deflection voltages for each line that is generated onto the display surface.

In FIGURE 7 a logical gating arrangement which is utilized in the angle control circuit is shown having terminals 700A–700D for receiving angle deflection signals from the character generator memory matrix and four output terminals 702A–702D for connecting the rotated angle deflection voltages to the cathode-ray-tube deflection voltage control circuit. Each of the four output terminals 702A–702D is electrically connected to the output of a corresponding one of the four OR gates 704A–704D. The embodiment of FIGURE 7 has three angle selection input terminals 706A, 706B and 706C for providing a zero degree angular rotation, an eleven and one-half degree angular rotation and a twenty-three degree angular rotation respectively. The zero degree angular rotation terminal 706A is electrically connected to one of the two inputs of each of the four zero degree rotation AND gates 708A–708D; the eleven and one-half degree rotation input terminal 706B is electrically connected to one of the two input terminals of each of the four eleven and one-half degree rotation AND gates 710A–710D; and the twenty-three degree rotation selection terminal 706C is electrically connected to one of the two input terminals for each of the four twenty-three angle rotation AND gates 712A–712D.

The AND gates 708A, 710A, and 712A each have the other of their two inputs electrically connected to a terminal 700A from which they may receive an angle deflection signal from the same output of the memory matrix in the character generator. However, their outputs are electrically connected to different ones of the OR gates leading to the cathode-ray-tube deflection-voltage control circuits. The outputs of the AND gates 708A, 710A and 712A are electrically connected to inputs to the OR gates 704A, 704B and 704C respectively so that when a pulse is provided to terminal 700A by the memory matrix an output is provided to the cathode-ray-tube deflection circuit on either terminal 702A, 702B or 702C, depending on whether the angle selection terminals 706A, 706B or 706C has been pulsed.

Similarly, the AND gates 708B, 710B and 712B have the other of their two inputs electrically connected to input terminal 700B and have their outputs electrically connected to the inputs of the OR gates 704B, 704C and 704D, respectively, so that an output may be applied to either terminal 702B, 702C or 702D whenever an output appears at terminal 700B, depending on whether or not terminal 706A, 706B or 706C is pulsed. In a like manner AND gate 708C, 710C and 712C have their other input electrically connected to terminal 700C and their output electrically connected to OR gate 704C, 704D or 704A respectively, and AND gates 708D, 710D and 712D have their other input electrically connected to terminal 700D and their output electrically connected to OR gate 704D, 704A, and 704B, respectively. It can be seen, for example, that if the angle selection terminal 706B is pulsed while a character is displayed upon the cathode ray tube, the slope of each of the line segments making up that character is rotated by eleven and a half degrees regardless of whether the angle deflection voltage which selects the X and Y deflection voltages that determine that slope is indicated by the memory matrix on terminal 700A, 700B, 700C or 700D.

It can be seen that the above circuit enables characters to be stored and displayed in the character generator without requiring a separate memory matrix for each position of the character. The gating circuit which is used to rotate the circuit is simple and inexpensive. It can readily be applied to existing equipment.

Obviously, many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. The combination comprising:

memory means, adapted to be addressed by a selection circuit, for selectively providing signal outputs representing a radius vector and a polar angle that is

stored in said memory means to memory-means output terminals; and

control means electrically connected to said memory means, for selectively changing the value of said polar angle.

2. The combination according to claim **1** in which said memory means comprises:

a plurality of memory output terminals, electrically connected to said control means, each of which correspond to a different increment of a polar angle; and

switch means, electrically connected to said plurality of memory output terminals and adapted to be addressed by said selection circuit, for activating said memory output terminals that correspond to the increments of polar angle stored in the part of said memory to be addressed by said selection circuit, whereby said increments of said polar angle are represented by the arrangement of said memory output terminals that are activated.

3. The combination according to claim **2** in which said control means comprises:

a plurality of gate input terminals each of which is electrically connected to a different one of said memory output terminals;

a control input terminal;

a plurality of control output terminals; and

gate means, electrically connected to said plurality of gate input terminals, to said control input terminal, and to said plurality of control output terminals, for activating said control output terminals according to a function of said gate input terminals that are activated, and for changing the arrangement of said control output terminals which are activated in response to an input voltage on said control input terminal.

4. In a memory for storing characters composed of a plurality of straight lines each indicated by a radius vector and a polar angle and having a plurality of memory angle output terminals for reading out said polar angles of said straight lines in a parallel digital code in which successive terminals indicate larger angles, apparatus for rotating the characters by uniformly changing each of said polar angles comprising:

a plurality of input terminals each of which is adapted to be electrically connected to a different one of a plurality of said memory angle output terminals;

a plurality of selection terminals adapted to receive voltage pulses indicating the amount of rotation of said characters;

a plurality of angle-control output terminals; and

gate means, electrically connected to said plurality of input terminals, to said plurality of selection terminals, and to said plurality of angle-control output terminals, for electrically connecting each of said input terminals which receives a voltage pulse from said memory angle output terminals indicating a polar angle to the angle-control output terminal that corresponds in a succession indicating larger polar angles to the polar angle indicated by the pulsing memory angle output terminal added to the angular increment represented by the selection terminal which is activated at that time, whereby said stored character is rotated on said display by the angular increment indicated by said selection terminal.

5. In a memory for storing characters for display composed of a plurality of straight lines each indicated by a radius vector and a polar angle and having a plurality of memory angle output terminals for reading out said polar angles of said straight lines in a parallel digital code in which successive terminals indicate larger angles, apparatus for rotating the characters by uniformly changing each of the polar angles in accordance with claim **4** in which said gate means comprises:

a first plurality of AND gates;

each AND gate of said first plurality of AND gates having one of its two input terminals electrically connected to a first of said angle section terminals and having its second input terminal electrically connected to a different one of said input terminals;

each of said AND gates of said first plurality of AND gates having its output terminal electrically connected to said plurality of angle control output terminals in the same sequence as its second one of its input terminals is electrically connected to said input terminals;

a second plurality of AND gates each having one of its two input terminals electrically connected to a second one of said angle selection terminals and having its second input terminal electrically connected to a different one of said input terminals;

each of said AND gates of said second plurality of AND gates having its output terminal electrically connected to a different one of said plurality of angle control output terminals in the same sequence as the second one of its input terminals is electrically connected to said plurality of input terminals but one angle control output terminal further in the succession of said output terminals from each of said output terminals to which is electrically connected the corresponding one of said first plurality of AND gates, whereby characters represented by a series of input pulses on said input terminals are rotated by one increment when said second one of said angle selection terminals is pulsed from the position of the character when said first one of said angle selection terminals is pulsed.

6. In a memory for storing characters composed of a plurality of straight lines each indicated by a radius vector and a polar angle having a plurality of memory angle read output terminals for reading out said polar angles of said straight lines in parallel digital code in which successive terminals indicate larger angles, apparatus for rotating the characters by uniformly changing each of said polar angles in accordance with claim **5** in which said gate means further comprises a plurality of OR gates electrically connecting the outputs from said AND gates to said angle control output terminals.

7. A character generator comprising:

a memory matrix means for storing a character in the form of line-segment length information and line-segment polar-angle information;

said memory matrix having a plurality of columns each of which has stored in a different position said line-length information and said polar-angle information for one of said line segments which form said character;

counting means, electrically connected to said character memory matrix means, for applying a voltage pulse to each of said columns in sequence, whereby said line length information and said polar angle information for the line segments composing said character are read out in parallel form from the rows of said matrix in said sequence;

decoding means, preprogrammed within said character memory matrix, for providing a substantially constant predetermined charging current to respective X and Y axis capacitors for each row position indicating a polar angle which charging current is of a selected magnitude for each row position;

gating means, electrically connected to said decoding means and having a plurality of angle control input terminals, for conducting said charging current to predetermined ones of said X and Y axis capacitors in accordance with information applied to said angle control input terminals;

a cathode ray tube, including means for deflecting the cathode ray beam therein in the horizontal and vertical directions;

coupling means coupling the horizontal deflecting means of said cathode ray tube to the X axis ca-

pacitors and the vertical deflection means of the cathode ray beam to the Y axis capacitors, whereby energization of the desired combination of X and Y capacitors causes said cathode ray tube to trace a selected line segment on the face thereof having a slope determined by said charging currents; and

timing means, electrically connected to the timing row positions of said character memory matrix and to said cathode ray tube, for determining the length of said line segment traced upon said cathode ray tube.

8. A character generator in accordance with claim 7 in which said gating means comprises:

a plurality of angle input terminals electrically connected to the row positions of said polar angle information portion of said character memory matrix, a plurality of output terminals electrically connected to said decoding means and a plurality of angle control input terminals; and

shifting means for connecting said angle input terminals to different output terminals in the same sequence in response to a change in the angle selection terminal which is energized.

9. A character generator in accordance with claim 8 in which said shifting means comprises an AND gate decoding matrix.

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O. E. TODD, *Assistant Examiner.*