

July 4, 1967

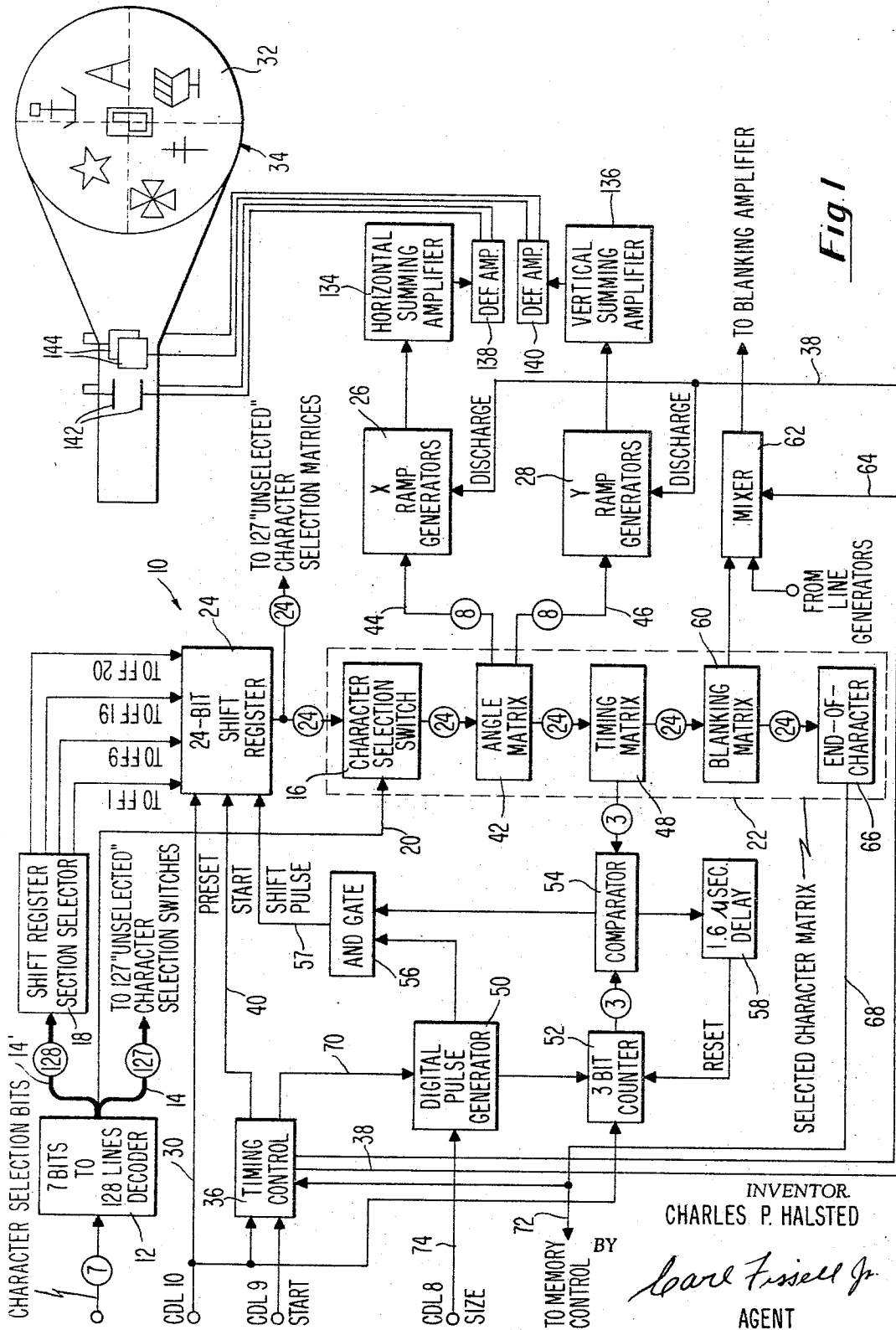
C. P. HALSTED

3,329,948

SYMBOL GENERATING APPARATUS

Filed May 5, 1963

7 Sheets-Sheet 1



July 4, 1967

C. P. HALSTED

3,329,948

SYMBOL GENERATING APPARATUS

Filed May 3, 1963

7 Sheets-Sheet 2

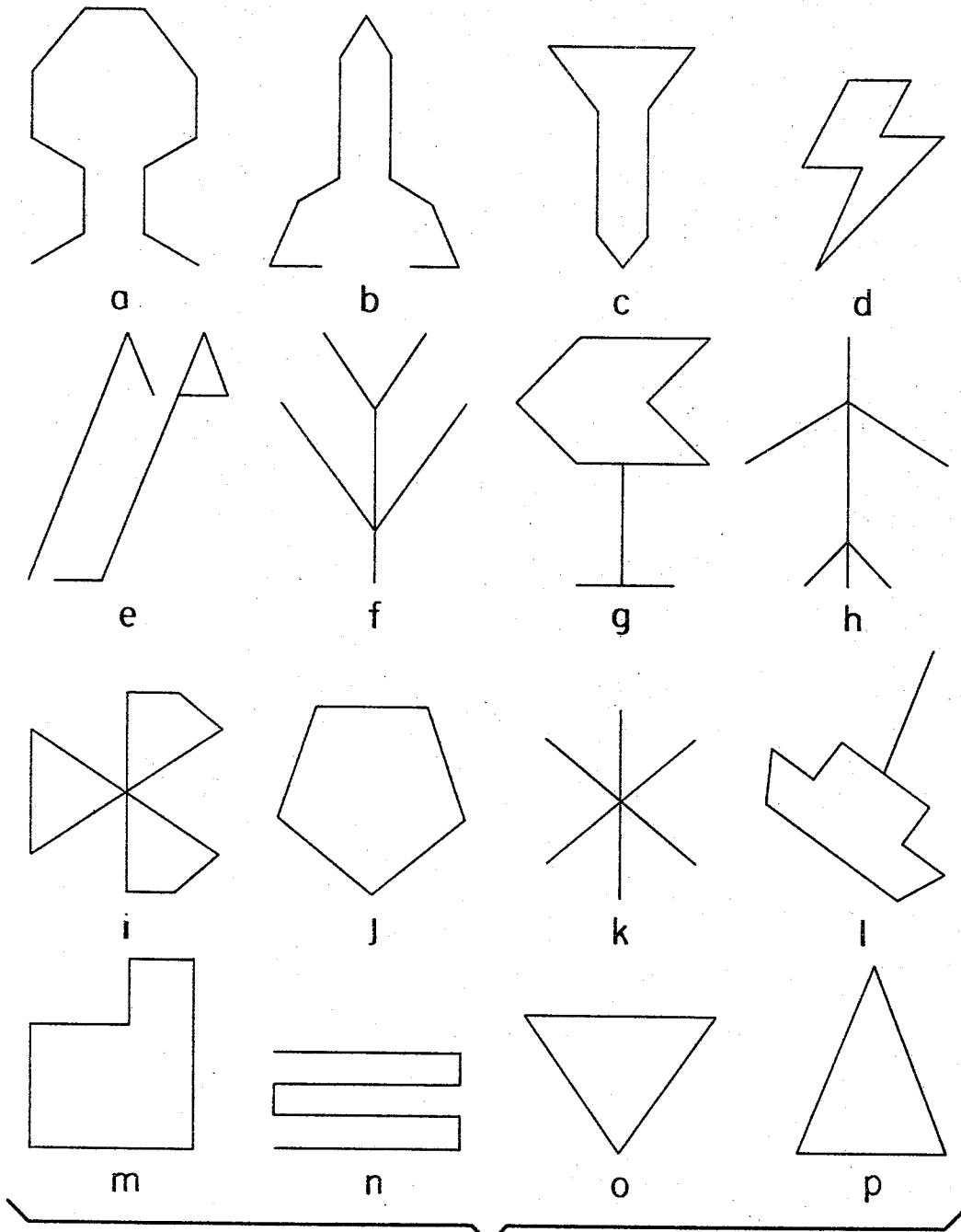


Fig. 1A

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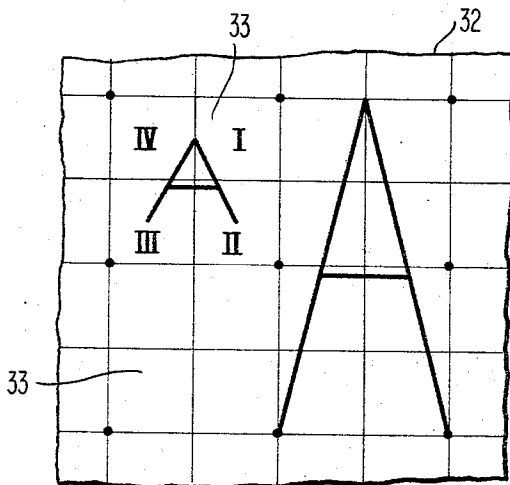
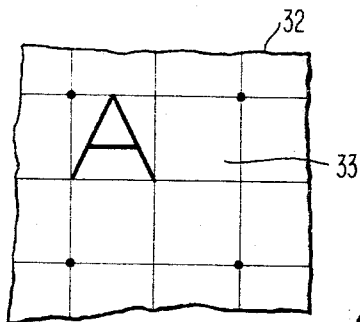
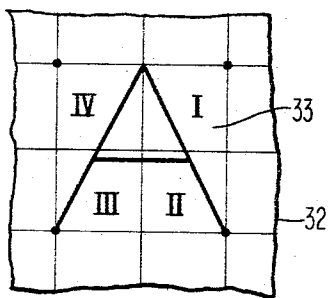
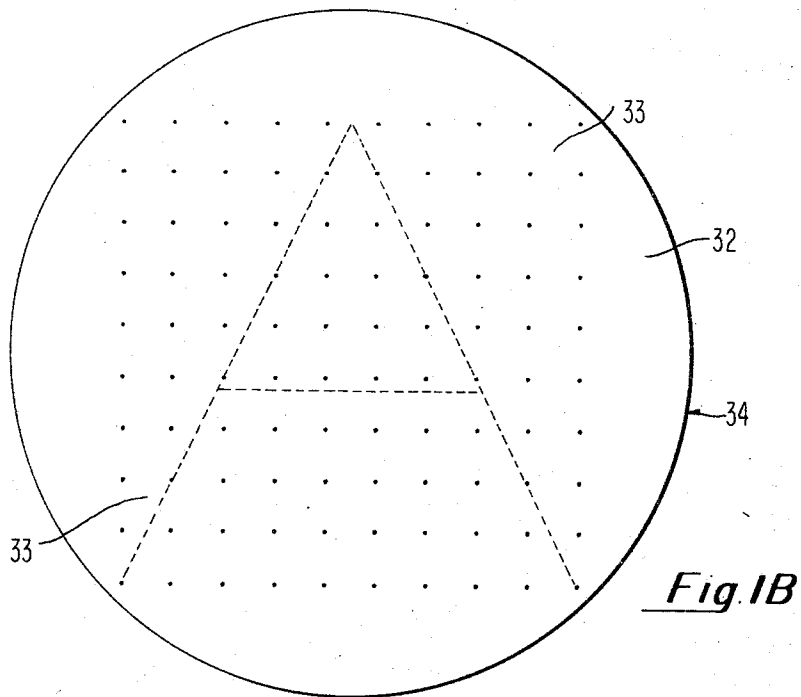
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7 Sheets-Sheet 3



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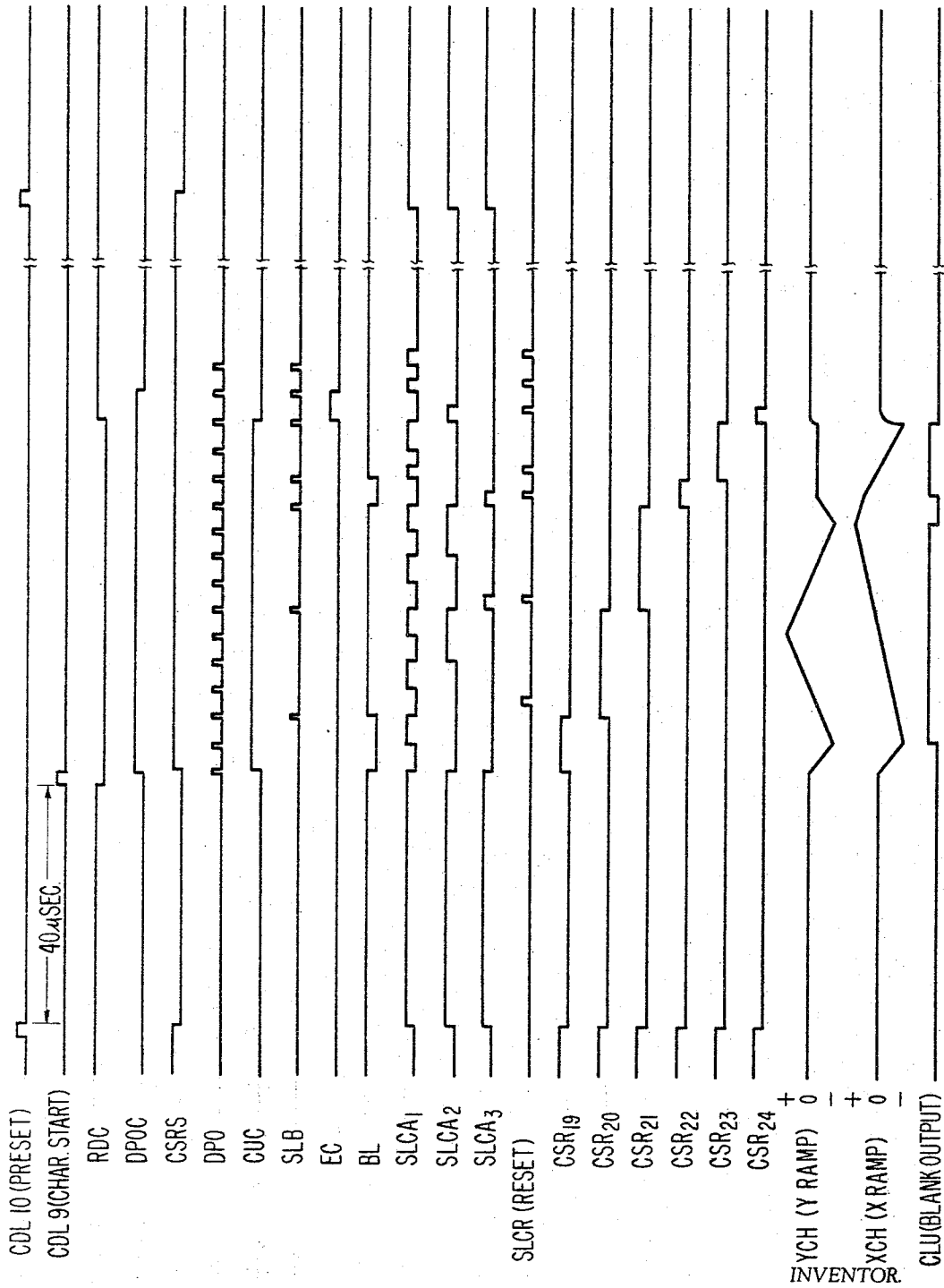


Fig. 2

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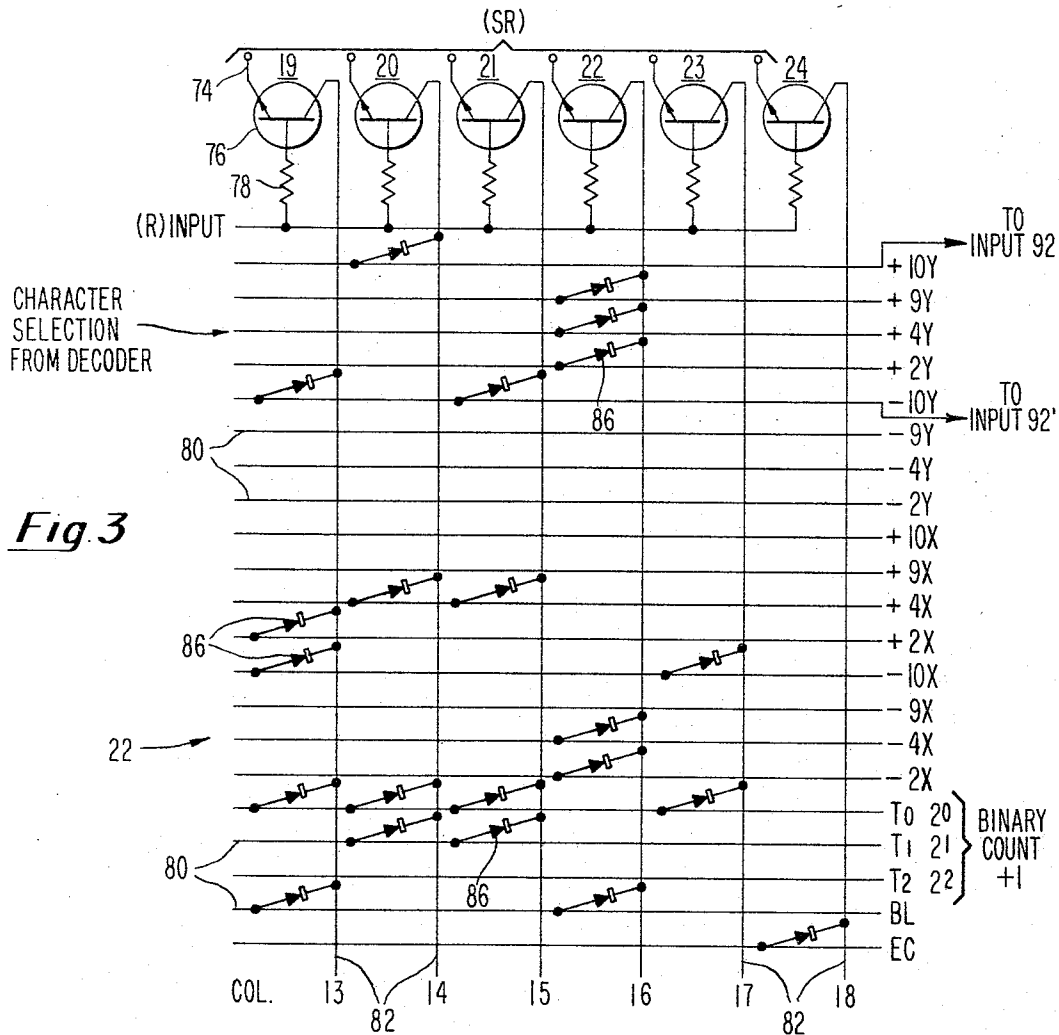
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SYMBOL GENERATING APPARATUS

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+10Y	+9Y	+4Y	+2Y	-10Y	-9Y	-4Y	-2Y	+10X	+9X	+4X	+2X	-10X	-9X	-4X	-2X	T ₀	T ₁	T ₂	STRO#	BL	EC	R	
•				•						•	•	•				•			1	•		A8	19
				•						•						•	•		2				20
	•	•	•											•	•	•	•		3				21
													•	•					4	•			22
											•					•			5				23
																			6		•		24

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DEGREES	Y								X							
	+10	+9	+4	+2	-10	-9	-4	-2	+10	+9	+4	+2	-10	-9	-4	-2
0.0									X							
11.25				X					X							
22.5			X						X							
33.75			X	X						X						
45.0		X						X		X						X
56.25		X									X	X				
67.5	X										X					
78.75	X											X				
90.0	X															
101.25	X															X
112.5	X														X	
123.75		X													X	X
135.0		X						X				X		X		
146.25		X	X	X										X		
157.5			X											X		
168.75				X										X		
180.0														X		
191.25								X						X		
202.5							X							X		
213.75						X	X								X	
225.0				X		X						X		X		
236.25						X									X	X
247.5					X										X	
258.75					X											X
270.0					X											
281.25					X							X				
292.5					X						X					
303.75						X					X	X				
315.0				X		X				X						X
326.25							X	X		X						
337.5							X		X							
348.75								X	X							
360.0																

Fig 5

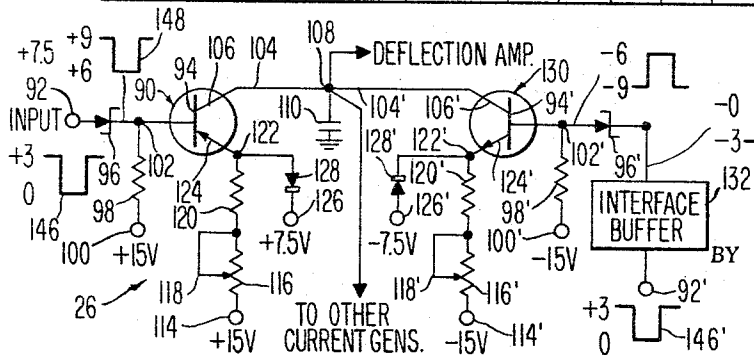


Fig 6

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SYMBOL GENERATING APPARATUS

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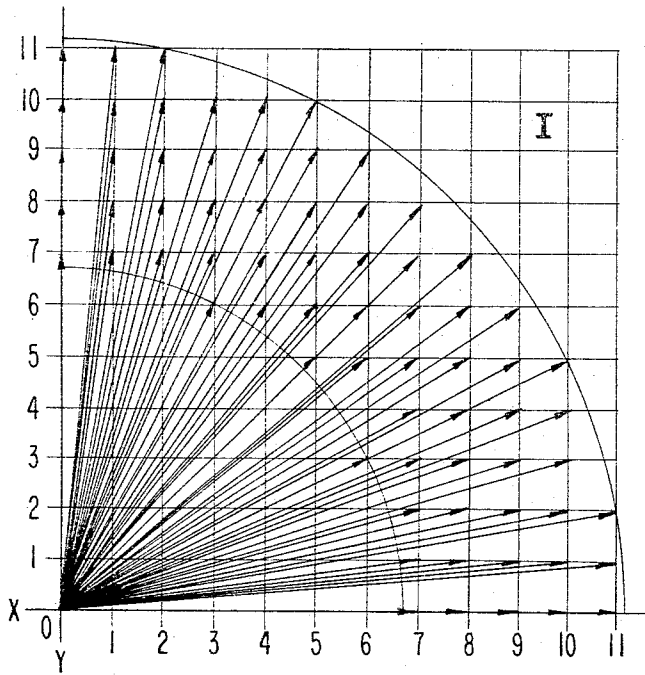


Fig 7

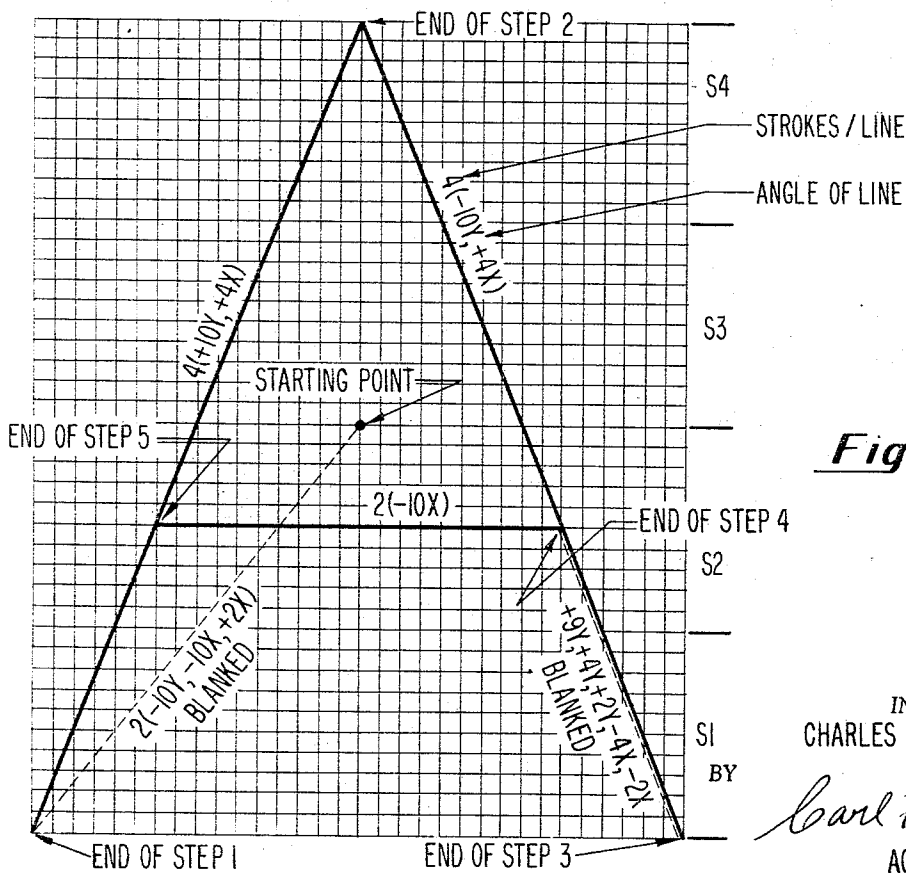


Fig 8

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SYMBOL GENERATING APPARATUS

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Filed May 3, 1963, Ser. No. 277,796
18 Claims. (Cl. 340-324)

The present invention relates to symbol generating apparatus and more particularly to electronic apparatus for producing a desired form, outline character or symbol upon the face of a cathode ray tube by controlling the electron beam of the tube so that the beam is caused to move along path or paths delineating the outline, form or character. With still greater specificity, the present invention has to do with symbol generating apparatus which is capable of producing a variety of unusual symbols, e.g., signs, in addition to letters, numbers, etc., not generally or ordinarily in common usage. In addition, the invention has to do with symbol generating apparatus of the type, including means for programming trigonometric functions of desired character or symbol forming angles relative to the cathode ray tube face plate productive of discrete elemental line formations effective to provide symbols of extremely high angular resolution and constant brightness.

The present invention is particularly useful where it is desired to display a form, character or message with maximum and constant brightness across the face of a cathode ray tube. The present invention has the capability of instantaneously producing capital and lower case letters of the alphabet including the ten Arabic digits normally used in the decimal numbering system as well as punctuation marks, commonly used symbols and other unique displays designed for use in specialized fields e.g., chemistry, medicine, mathematics, physics, etc.

Among the prior art types of alphanumeric symbol generating apparatus are those using photocells with a rotating shaped mask to generate the deflecting potentials on the X and Y deflecting plates of an electrostatic cathode ray tube. Another apparatus uses potentiometers, with sliding contacts on the wires, the contacts being linked by arms to movable pins. Other types employ perforated letter or symbol forming masks through which the CRT beam is projected. However, each of the known prior art devices has certain limitations or drawbacks e.g., with respect to either the lack of constant brightness of the characters, the lack of high operating speed, the ease with which the apparatus may be programmed for different varieties of characters, or the lack of programming flexibility with respect to the order of character which can be displayed, i.e., certain characters being illegible under certain circumstances, due to the confusing array of lines. Additional problems include the necessity in some apparatus of having to reprogram the device in instances where it is necessary or desirable to provide additional information other than that for which the apparatus was initially and originally designed. Each of the foregoing is not in and of itself particularly insurmountable but on the whole such problems require extra circuit design techniques which generally make the device unwieldy and raises the cost thereof disproportionately.

It is an important object of the present invention to provide electronic symbol generating apparatus which overcomes the foregoing objections and solves the aforementioned problems in a new and novel manner.

It is another object of the invention to provide a high speed symbol generating apparatus having means for programming trigonometric functions of desired character forming angles through which the cathode ray tube beam must move effecting an extremely high degree of angular resolution.

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Another object of the invention is to provide symbol generating apparatus wherein the CRT beam which traces the symbol or character is deflected at high speed in a novel manner producing symbols of extremely uniform and constant brightness, regardless of the length of the elemental lines or strokes which form the character.

A still further object of the invention is the provision of high speed symbol generating apparatus having maximum character-symbol forming flexibility with minimum programming whereby the apparatus may be continually up-dated in order to produce changes in characters or symbols as desired.

Still another object is to provide a more simplified and economic circuit arrangement for controlling symbol-character generating apparatus.

In accordance with the foregoing objects and as first briefly described, the present invention comprises electronic symbol generation apparatus having means for causing the electron beam of a cathode ray tube to move from one location to another location on the fluorescent screen of the tube so as to display a symbol forming line between two locations thereon wherein the motion between such locations is determined by a plurality of constant current generators operably associated with X and Y coordinate determining capacitors in a manner such that the current generators may be additively or subtractively valued thereby to provide an output therefrom in accordance with a predetermined program of trigonometric symbol forming angle information for achieving constant velocity of the beam at any desired angle, in any desired direction at substantially constant level of brightness.

The novel features which are believed to be characteristic of the invention both as to its organization and operation together with further objects and advantages thereof, will be better understood from the accompanying drawings in which an embodiment of the invention is illustrated by way of example. It is to be expressly understood however, that the drawings are for the purpose of illustration and description only, and are not intended as a definition of the limits of the invention. In the drawings:

FIG. 1 is a block diagram illustrating information flow in a preferred embodiment of the present invention;

FIG. 1A is a schematic illustration of the variety of symbols which are available with the present invention;

FIGS. 1B to 1E are schematic illustrations of the CRT face plate showing a typical arrangement of character-symbol forming portions or areas thereof for purposes of explanation;

FIG. 2 is a timing diagram for the apparatus of FIG. 1;

FIG. 3 is a diagram of a representative character matrix card for use with the present invention;

FIG. 4 is a programming chart for the diagram of FIG. 3;

FIG. 5 is a chart illustrating one example of the variety of angles of resolution which may be programmed in relation to the X and Y coordinates of the cathode ray tube by means of the present invention;

FIG. 6 is a schematic diagram of a pair of constant current generators for use with the present invention;

FIG. 7 is a chart showing one quadrant of a circle illustrating the high degree of angular resolution of the present apparatus, and

FIG. 8 is a diagram illustrating the manner in which the capital letter "A" is presented or displayed by the device of the present apparatus.

The block diagram of FIG. 1 indicates generally the flow of information into and through one embodiment of a high speed all electronic symbol-character generator incorporating the present invention. Each time a symbol or character is to be displayed means, hereinafter

described and identified, selects the desired character information storage matrix, and then the actual current values in a specified order are generated resulting in the selected character being "written," traced or displayed by the electron beam on the screen of the cathode ray tube.

Seven binary bits of information fed into the apparatus 10 from e.g. a computer not shown, are used as "character selection bits" indicated by the circled numeral 7 in the upper left of FIG. 1. Thus 2^7 or 128 different characters can be chosen one at a time. The seven bits are fed to a "7 bit binary to 128 lines decoder" 12 and thence over lines 14 to 128 character selection switches 16, only one of which is shown for purposes of clarity, and over lines 14' to shift register section selector 18. The decoder 12 decodes from binary to "one out of 128" in a conventional manner. Only a single line 20, to activate the selected character selection switch 16, is shown entering the selected character matrix card 22, dotted outline in the center of FIG. 1. (The remaining 127 lines are not illustrated.)

In the present embodiment of the invention there may be 128 printed circuit character cards 22 including diode matrix circuits that "program" the various characters only one of which will actually be described in detail hereinafter. The remaining 127 character selection switches are not activated at this time and therefore are not illustrated in the block diagram.

A 24 bit shift register 24 is employed with the present invention and is, for convenience of operation, divided into four sections for optimum loading thereof by the shift register section selector 18. From the selector 18 which determines which section of the register is to be used to form the character, lines FF1, FF9, FF19 and FF20 run to the register 24. Thus the writing of characters may start with flip-flop 1, 9, 19 or 20 in the shift register.

Before a character is written the X and Y ramp generators 26 and 28, which will be described more fully hereinafter, are preset over line 38 from timing control 36 to a specific starting point which corresponds to the center of the screen area 32 of the cathode ray tube 34 on the face of which the character will be written. This presetting is initiated by a pulse on the CDL 10 input line which causes an output from the timing control 36 over line 38 to quickly discharge capacitors in the ramp generators. In the present embodiment, forty microseconds after the pulse appears on the CDL 10 line a pulse on the CDL 9 line causes an output over line 40 to register 24 to start the writing of a character. This pulse from timing control 36, when applied to the shift register, activates the selected character angle matrix 42 through the character selection switch 16. The outputs of the angle matrix 42 applied over lines 44-46 to the ramp generators cause the latter to deliver charge or discharge currents into their respective capacitors as discussed hereinafter, and in this manner, move the cathode ray beam on the cathode ray tube screen in the proper direction for the first line. At the same time the outputs from the timing line matrix 48 are set up to determine which one of eight possible line lengths, as hereinafter described, will be drawn. Digital pulse generator 50 e.g., a blocking oscillator, sends pulses to a three bit binary stroke length counter 52 while a line is being drawn. When the number of pulses received by the counter 52 is equal to the number called for or set up in the timing matrix 48, a comparator 54, which receives the output from both the counter 52 and the matrix 48 and compares the two for correspondence therebetween, sends out a pulse to AND gate 56 to stop the generation or drawing of this particular line. The output of the AND gate 56 causes the shift register 24 to advance e.g., step-by-step or column-by-column and, in this fashion, to set up conditions in the selected angle matrix 42 for drawing the next line. The output of the comparator

54 simultaneously is sent through a 1.6 microsecond delay 58 to reset counter 52, so as to prevent time rate in the three bit counter loop.

The second line is drawn in the same manner as the first. The angle matrix 42 once again determines the direction of the line to be drawn while the timing matrix 48 determines the line length. The blanking matrix 60 is used to blank out character retrace lines. The signal is fed from matrix 60 through mixer 62 as shown, to a blanking amplifier, not shown. A signal from the timing control 36 over line 64 is also fed to the mixer to blank the electron beam when no characters are being drawn. A third input to this mixer comes from a line generator not shown. When the drawing of the character is completed, a pulse from the end of character matrix 66 is fed over line 68 to the timing control 36 which feeds an output over line 70 to the pulse generator to terminate its operation and blank the beam on the cathode ray tube and discharge the capacitors in the ramp generators. The end of character pulse also is fed back over line 72 to the "memory control" to indicate that the apparatus is ready for the next character to be drawn. The size of the characters that are drawn can be controlled by controlling the repetition rate of the pulse generator 50, through the presence or absence of appropriate bits on the CDL 8 size input line 74, which determines which of many available repetition rates is selected for the character being drawn. A slower repetition rate results in a larger character because the longer time interval between pulses gives the ramp generators 26 and 28 more time to move the electron beam. The speed at which the lines are drawn is essentially uniform, that is, of constant velocity, regardless of the pulse repetition rate, direction of lines, etc., as will be described in more detail hereinafter.

A typical character matrix card 22, e.g., a printed circuit board, used for character programming, is shown in schematic form only in FIG. 3, and in a practical example may measure 4 and $\frac{3}{16}$ inches by 8 and $\frac{1}{4}$ inches. Each character card is provided with circuitry on both sides. The outputs of the twenty-four bit shift register 24 are connected through printed circuit card receptacles (not shown) to input tabs 74 across the upper portion of the card. Provision is made for mounting eighteen switching transistors 76 and eighteen resistors 78 on the card. The printed wiring is arranged such that as many as three separate characters can be programmed on each card, if required. Twenty-one horizontal rows of circuitry, i.e., electrical conductors 80, are provided on the side of the card. There are also eighteen vertical columns of conductors 82 on the reverse side. The intersections of these rows and columns form a matrix which is programmed by placing diodes 86, as shown, in the proper intersections and soldering their leads to the printed wiring conductors.

The horizontal rows 80 of printed circuit conductors labeled +10Y, +9Y, +4Y and +2Y are used to turn on the Y or vertical ramp generators and are effective to move the electron beam upwardly on the CRT screen 32. The -10Y, -9Y, -4Y and -2Y generators are used to move the beam downwardly. The rows labeled +10X, +9X, +4X and +2X are used to turn on the X or horizontal ramp generators to move the electron beam to the right, while the rows -10X, -9X, -4X and -2X move the beam to the left. The rows labeled T₀, T₁ and T₂ are programmed to control the time during which a line is drawn or traced which also determines its length, as will be described shortly. Up to eight different line lengths are made possible by programming these three lines. The row labeled BL is used whenever the beam of the cathode ray tube is to be blanked out. The row labeled EC is used to signify the end of character.

When a character selection signal is received from decoder 12 that specifies that a capital "A" is to be written, the diode matrix 22 is activated, i.e., provided with suitable potentials on the "R" input line FIG. 3, enabling the six transistors 76 to act as closed switches. As shown in

the partial schematic diagram of the circuitry for a capital "A" in FIG. 3, the last six vertical printed circuit columns on the card, i.e., columns 13 through 18, connect to bits 19 through 24 of shift register 24 through these switches. A suitable voltage level from the shift register is applied as an output to the emitter of transistor 76 of column 19 via tabs 74 of the matrix to initiate formation of the "A." The voltage is switched by the shift register in a known manner, from line to line (19-24) until terminated at line 24. Each time a transistor 76 is turned on the electron beam of the CRT 34 that draws the "A" is moved in a straight line.

Referring briefly to FIGS. 1B-1E, it is seen that an aspect ratio of approximately 4 to 3 has been chosen for the preferred embodiment of the present invention.

The tube face 32 can be considered as being arbitrarily divided up into character display areas 33 each one of which can be further considered as being subdivided into four quadrants identified in a clockwise direction as I, II, III and IV, respectively. In the manner hereinafter described the desired symbol or character may be displayed in any portion or the whole of any character area or the character-symbol may occupy more than a single character area depending on its size and/or complexity. It is of course to be understood that the particular aspect ratio is a matter of design choice and the invention is not to be limited thereby. It is quite apparent that other aspect ratios can be chosen within the inventive concept without departing therefrom.

The present invention is capable of making characters of varying line length. Thus the line length may vary from that of an alphanumeric character, such as the letters of the alphabet or the Arabic numerals from 0 through 9, to an outline of a map for example, or a particular symbol such as one of the symbols shown for example in FIG. 1A. The matter of the length of the line is again a choice of design, and is not limiting as far as the inventive concept is concerned.

For the purpose of the present description a line, so-called, is divided into individual subunits called strokes. In the present instance the individual stroke unit is the shortest incremental, visible line that the apparatus is designed to draw, display or trace by virtue of movement of the cathode ray tube beam. This stroke length is determined by the time between pulses of the digital pulse generator 50. The distance that the cathode ray beam moves in this minimum amount of time is equal to one stroke. A "line" is made up of from one to eight strokes or units of time. Thus the digital pulse generator 50 specifies a specific pulse time, i.e., the time between any two individual pulses. For example, in the digital pulse generator used with the present symbol generator the stroke length is made equivalent to three-tenths of a microsecond. Thus one stroke is equal to the distance the beam will move in three-tenths of a microsecond. Therefore, it follows that a line is drawn in one to eight times three-tenths of a microsecond. Thus it is seen that the stroke length is established by one clock period of the pulse generator, i.e., the time between pulses.

It is important that the time of each line be variable and to this end, a series of timing prefixing diodes for establishing the line length are employed, electrically connected to three lines which are characterized in FIG. 3 by the letters T_0 , T_1 , T_2 .

A one, two, four binary code is used in the timing of the lines for the present invention wherein the line length is determined by the particular binary count plus one:

- No timing diodes used=one unit of length,
- T_0 adds an additional 1,
- T_1 adds an additional 2,
- T_2 adds an additional 4.

Thus when there are no diodes in the T_0 , T_1 or T_2 timing lines a count of one, e.g., one stroke is produced. One diode in the T_0 line gives a count of two, and so on for

a count of 8 for diodes in all three timing lines (T_0 , T_1 , T_2).

The ramp generators (current generators and associated capacitors) whose inputs are labeled 10, 9, 4, and 2 for the plus and minus X and Y coordinates in FIG. 3 establish an arbitrarily determined inter-relationship such that if the $+10Y$ generator is 10 ma. of current then the remainder are 9, 4, and 2 ma. respectively.

As an aid to both the understanding of the operation of the present apparatus as well as to aid the programmer in programming the diodes which together with the character selection switches, angle matrix, timing matrix, blanking matrix and end of character circuits form the particular character, reference is now had to FIG. 8 wherein there is shown the individual steps which form the capital letter "A."

For purposes of the present description it is assumed that the face plate 32 of the tube 34 is arbitrarily arranged in a pattern of vertical and horizontal lines spaced equidistantly in both directions (40 spaces high and 32 spaces wide) forming a grid. Ten of the individual spaces are considered equal to one stroke hereinbefore defined. It is possible by referring to a chart of the type illustrated in FIG. 5 to program the matrix for any particular angle which is desired, enabling the generation or formation of any desired symbol, character or outline.

FIG. 4 constitutes a programming chart showing the location of the diodes in the matrix of FIG. 3, for producing the outline of the capital letter "A" as shown in FIG. 8. Although a diode matrix is specified in the present invention it is understood that other types of matrices could be employed, e.g., core, resistor, etc., without departing from the inventive concept. The starting point, generally speaking, although not required, is or may be at the center of the character. The six steps that form the "A" are briefly described hereinbelow with reference to FIGS. 3 and 8. A more detailed description of the electrical operation of the invention follows hereinafter. It is desired that the starting point for all characters be at the center of the area in which the character is to be drawn. However, the symbol may be put at any corner if desired as seen more clearly in FIGS. 1B-1E.

Assume that a character matrix card similar to that shown in FIG. 3 has been wired in accordance with the diagram of FIG. 4, so that there are diodes 86 in the rows and columns shown. At the time the shift register pulse appears at the line 19 (R) input, the transistor 76 in column 13 is turned on and conducts. There are five diodes connected to column 13 of the matrix. The diode on row $-10Y$ causes the beam to be deflected downwardly a distance of ten units, FIG. 8, while the diodes on rows $-10X$ and $+2X = -8X$ cause the beam to move to the left eight units. However, since there is a diode in row T_0 all lines are caused to become twice their basic length as hereinbefore explained, therefore the beam actually moves down twice ten or twenty units while it moves to the left twice eight times or sixteen units. The ratio of $-10Y$ and $-8X$ determines the angle of deflection while the diodes on the T lines determine the line length. The diode in row BL causes the beam to be blanked out and this condition is indicated by the dashed diagonal line in this figure. At the end of the first step the beam is in position to start writing the visible portion of the capital "A."

After the first step is completed the shift register applies a pulse to the transistor 76 in column 14 to start the second step. Four diodes are connected to column 14 of the matrix, the diode on row $+10Y$ causes the beam to be deflected upwardly while the $+4X$ diode causes the beam to be deflected to the right. The diodes in rows T_0 and T_1 cause the line to become four times its basic length. The beam moves upward while it moves to the right. Thus the first visible line is drawn starting at the lower left portion of the area assigned to the capital

"A" and moves steadily to the center of the upper portion of the assigned area.

The shift register pulse is next applied to column 15 of the matrix. Four diodes connected to column 15 are placed the same as for the second step except that the diode that was connected to +10Y is now connected to -10Y, therefore the beam continues to move to the right at the same speed but now moves downward to the lower right corner of the assigned area as indicated, in this figure.

The shift register pulse for the fourth step is applied to column 16 to which six diodes are connected. Diodes at +9Y, +4Y and +2Y move the beam upward 15 units while diodes in -4X and -2X move the beam to the left six units. The diode on line BL causes the movement of the beam to be blanked during this step as indicated by the dashed diagonal line. The end of this step finds the beam aimed at the point where the last line will be started.

In the fifth step the shift register pulse is applied to column 17. Only two diodes are connected to column 17. The diode at -10X causes the visible beam to move to the left, ten units, while the diode at T₀ causes the line length to double. Thus the horizontal portion of the capital "A" starts on the one leg of the "A" and ends on the other leg as indicated in FIG. 8. In the sixth and final step, the shift register pulse is applied to column 18. A single diode is used in this step on line EC. This diode causes the beam to be blanked and returned to its starting point as the character-symbol generator 10 prepares to write another character.

For the signal timing involved in constructing the letter "A" reference may be had to FIGS. 1 and 2. The first pulse to appear is CDL 10, the preset pulse. At the trailing edge of CDL 10 the shift register 24 start control level CSRS is removed. Voltage levels are applied to the three bit parallel stroke length counter 52 (the three bit SLCA's). Levels are removed from the six lines CSR 19-24 of the shift register 24, representing the six steps in the construction of the letter "A." Forty microseconds after CDL 10, during which time the ramp generator capacitors are discharged (trailing edge of RDC ramp discharge control pulse), the character start pulse CDL 9 appears. The leading edge of the CDL 9 turns off the ramp generator discharge control RDC pulse over line 38 (FIG. 1). The trailing edge of CDL 9 through timing control 36, initiates the various activities involved in forming the letter "A," e.g., turning on the digital pulse oscillator or generator 50 and digital pulse oscillator control DPO and DPOC and for the first movement of the beam, the blanking pulse BL.

The shift register start control pulse CSRS over line 40 from the timing control 36 in FIG. 1, is also initiated and starts the generation of the character. The character unblanking control pulse unblanks the blanking amplifier, not shown. The stroke length pulse SLB over line 57 shifts the register 24 in accordance with the line length for the character being drawn.

This pulse determines the length of the lines which form the character or symbol. The SLCA pulses resets the three bit counter 52 after each line through the 1.6 microsecond reset delay 58. Formation of the letter "A" proceeds in accordance with the steps shown in FIG. 8. Each step utilizes a different CSR pulse 19-24 inclusive. The end of character pulse EC generated by the shift register 24 turns on the ramp generator discharge control RDC and turns off the digital pulse oscillator control DPOC which turns off the digital pulse oscillator DPO 50, in readiness for another character.

The flexibility of the present character-symbol generator is such that practically an unlimited variety of different types of characters or symbols can be programmed as desired. New symbols or different fonts for letters of the alphabet, etc., can be programmed by insertion of diodes into the proper portions of the appropriate charac-

ter card matrix. Up to eighteen different straight lines may be used to draw a character, if such is programmed on one card. An extremely complex character could be programmed using the full capacity of the shift register to draw up to twenty-four straight lines. If there was a need, even a greater number of bits could be put into the shift register. The number of angles at which the lines can be drawn depends on the number of ramp generators used. The present apparatus uses eight ramp generators for the X axis and eight for the Y axis. The combining of all sixteen ramp generators in various configurations allows up to 54 different angles to be programmed per quadrant, as indicated by FIG. 7. Extending this capability to the four quadrants, a line may be drawn from any given point in any one of 216 different directions. The basic length of the lines that are drawn are kept within the limits of the two curved lines as shown in FIG. 7, to keep variation in line velocity small enough to provide characters in which all lines are of constant brightness. However, these basic lengths may be multiplied by any integer up to eight by using the three bit counter. Therefore each line shown in FIG. 7 can be drawn at least eight different lengths. The arrowheads in the figure indicate that lines drawn in the X or Y axis only can be up to forty different lengths (five arrowheads times eight) while lines 30° from this axis can be of twenty-four different lengths, while still maintaining constant brightness of the line. Thus, for an entire circle there is the possibility of over two thousand total possible variations in slope and length of lines per stroke available for the present apparatus, for creating complex letters and symbols. The timing lines out of the matrix 48 (FIG. 1) may be fed directly to the digital pulse generator 50 eliminating the need for the three bit counter 52 and the comparator 54 where lower accuracy of line length is permissible or desirable.

As earlier pointed out herein, an important feature of the present invention is the means for providing constant brightness of the line or stroke which forms the symbols or characters regardless of its length or direction. The electron beam of the CRT must be deflected in both the X and Y axis, FIG. 8, in order to draw a symbol as noted herein. Electrostatic deflection requires a certain voltage while electromagnetic deflection utilizes a prescribed current for the operation. In electrostatic deflection the speed with which the electron beam is deflected back and forth from one plate to another plate is a function of the time rate of change of voltage between the plates. If this time rate of change is made to be linear then it follows that the electron beam will travel at constant velocity between the plates. If the beam is travelling at a varying velocity or rate e.g., if travelling faster at the start of the line than at the termination of the line, the beginning of the line will be dimmer in contrast to the termination of the line, producing an apparent and visible variation in brightness. Therefore, by providing means that will achieve a constant rate of change of voltage with respect to time, and by applying this resultant to the deflection elements or circuitry of the cathode ray tube, the beam can be made to traverse any particular portion of the screen at a constant velocity thereby producing a line, stroke or element of constant brightness. If a constant current is passed into a capacitor the rate at which the voltage builds up across the terminals of the capacitor is constant. Thus a capacitor electrically coupled to and fed from a source of constant current, in accordance with the equation $i = Cde/dt$ where i is constant current, C is capacitance, e is voltage and t is time, will produce a constant rate of change of voltage with respect to time. The output from the capacitor when applied to the deflection circuits of the CRT can be made to move the electron beam at constant velocity producing lines or strokes of constant brightness on the face plate of the cathode ray tube.

Basically, a constant current generator is a device in

which the load can vary and the current remains constant. Solid state semi-conductor devices, e.g., transistors, lend themselves quite admirably to such apparatus. In the present instance, a plurality of transistors are used in combination with resistances in a manner to be described later on herein to provide an output potential from the capacitor of the ramp generators for application to the CRT deflection circuits.

In the present apparatus of the display device, i.e., cathode ray tube, it is necessary for the electron beam to be deflected in the vertical as well as the horizontal axis in both the plus and the minus or positive and negative directions, so that the beam of the tube may be enabled to write both left and right and up and down. In this manner the beam effectively can circumscribe a circle traversing the whole area of the tube face plate.

By means of suitable programming as hereinafter set forth, it is possible to develop a variety of individual angular positions or paths through which the CRT beam may be made to travel and by means of which a character requiring high angular resolution may be formed for presentation on the face of the cathode ray tube. In the diagrammatic illustration of FIG. 7 (the plus I quadrant) as hereinabove described, the vertical axis is arbitrarily designated by the Y and the horizontal axis by X while the intersection is designated the zero "0" reference. For the sake of simplicity both ordinate and abscissa have been divided into 11 substantially equal parts labeled 0 through 11.

Assume that an arbitrary amplitude is chosen in the +Y direction and designated "unit velocity." In a similar fashion an arbitrary amplitude is chosen for the X axis and designated "unit velocity." Turning to trigonometry, if an arcuate line is now drawn connecting these two points and a straight line projection is made at some angle e.g., 45° from the zero reference to this line, the point at which the straight line intersects the curved line is unit velocity. It is then a simple matter of projecting backwardly along the horizontal and vertical axis to derive the vector components 0.7 ($\sqrt{2}/2$) of unit velocity for the X and 0.7 ($\sqrt{2}/2$) of unit velocity for the Y, which when added together will give the vector resultant of unit velocity at a 45° angle. It should be readily apparent that the greater number of parts into which each of the quadrants I, II, III, IV is divided, the greater will be the angular resolution provided by the apparatus.

It is unnecessary to use a constant current generator for each of the angles or each of the vector components of an angle. A simpler method is the choice of a mathematical code, the combination of elements of which will produce the various angles which are desired to be resolved between any two points. One such code is that which is employed herewith designated as ten, nine, four and two. These numbers are derived by noting the repetition frequency of certain individual digits and employing those which are repeated most frequently as the basis of the particular code being used. This code designation can be applied in a suitable manner to the angular points of a circle from 0 to 360° and depending on the desired degree of angular resolution more or less angles can be designated. For the sake of convenience in the present application the angles shown in FIG. 5 will suffice.

The degree of angular resolution available is a function of the number of current generators which are used. Thus, in the present apparatus an extremely high degree of angular resolution is provided by utilizing eight current generators for each of the X and Y axes. (Four plus and four minus current generators for the X and four plus and four minus current generators for the Y.) Since each of the current generators is substantially identical with every other current generator except for current value used therewith, only two, a plus and a minus, for the X axis, have been illustrated in FIG. 6. For purposes of the present description the term X and Y ramp generators includes the means for generating the currents used to-

gether with the capacitor through which the derived potentials are applied to the CRT and the means (not shown) to discharge the apparatus. The magnitude of the current determines the rate of change of voltage applied to the X and Y capacitors in accordance with the equation $i = Cde/dt$. Thus each of the currents has a different relative magnitude and the ratio of the magnitudes of the currents is related as 10, 9, 4 and 2. These ratios are adjustable relatively as will be hereinafter set forth. Let it be assumed that 10 is representative of unit velocity. In the particular instance set forth in FIG. 6, "ten" could represent 10 mils of current, in which case, the remaining currents would be 9 mils, 4 mils, and 2 mils. The actual values of current which are selected are always related (FIGS. 5 and 7) such that the vector resultant is unit velocity. Although not shown or described herein in reference to FIG. 6, in the actual apparatus involving the present invention there are eight current generators and two discharge circuits for the two associated (X and Y) capacitors used therewith. The three additional sets of two (plus and minus) current generators are interconnected as seen in FIG. 6, by means of the line designated "to other current gens.," only two (plus and minus Y coordinate) current generators being shown for clarity of illustration and description.

The current generator 26, FIG. 6, is seen to include a PNP transistor 90 with an input 92 to its base 94 through a Zener diode 96. A resistance 98 from a plus fifteen volt (+15 v.) supply 100 is connected to the junction 102 between the base 94 and the diode 96, and output line 104 connects the collector 106 to junction 108 with capacitor 110. The opposite terminal of capacitor 110 is maintained at ground potential. A plus fifteen volt (+15 v.) supply 114 is connected through rheostat 116 and wiper arm 118 to a fixed resistance 120, the opposite end of which is connected through junction 122 to the emitter 124 of transistor 90. A plus seven and one-half volt (+7½ v.) supply 126 is connected through a diode 128 to junction 122.

Transistor 130, which is of the NPN type, is provided with an input 92' to its base 94' through an interface buffer 132 described hereinafter, and a Zener diode 96'. One end of a resistance 98' is connected between a minus fifteen volt (-15 v.) supply 100' to the junction 102' between base 94' and diode 96' respectively. Output line 104' connects the collector 106' to the junction 108 with capacitor 110. A minus fifteen volt (-15 v.) supply 114' is connected through rheostat 116' and wiper arm 118' to fixed resistance 120', the opposite end of which is connected through junction 122' to the emitter 124'.

A minus seven and one-half volt (-7½ v.) supply 126' is connected through diode 128' to emitter 124' through junction 122'. The sign of the current generators has been arbitrarily determined. Thus, depending upon which way the transistors are circuit oriented, the output therefrom, which is fed from junction 108 through the horizontal and vertical summing amplifiers 134 and 136 and X and Y deflection amplifiers 138 and 140 (FIG. 1) to the deflection plates 144 and 142, respectively, will be positive or negative with respect to ground, i.e., current flows either into or out of the capacitor associated therewith.

Assume that the PNP transistor 90 is circuit oriented as shown to the left in FIG. 6. This type transistor conducts when the base is more negative than the emitter. If the base 94 is more positive than seven and one-half volts, then the current originating at the plus fifteen volt supply and entering the circuit through the variable resistance 116 and the fixed resistance 120 will pass through the diode 128 to the seven and one-half volt supply 126. The magnitude of the current that is going to flow is determined by the voltage drop across this total resistance. It is apparent therefore that if the current flows through the diode 128, then the transistor, which in this instance is acting as a current switch, can be considered

to be "off" and thus the capacitor 110 voltage is unchanged. In order that the current flow through the transistor 90 rather than the diode 128, it is necessary to make the base 94 of the transistor negative with respect to the seven and one-half volt supply 126.

To this end, an input logic signal 146 for triggering the current generators is provided by computer equipment not shown, and swings between a level of zero and plus three volts. It is desirable that the transistor 90 be biased "off" when there is a plus three volts present at the input terminal 92. A logical "one" is that state in which the current generator is "on" while the logical "zero" is the "off" state of the current generators. For the purpose of this description therefore, a logical "one" is zero volts while the logical "zero" is plus three volts. In order to cause the current to flow through transistor 90, the junction point 102 and base 94 must be negative relative to the plus seven and one-half volt supply. This seven and one-half volt reference potential is derived by means of D.C. translation which is accomplished with the six volt Zener diode 96 which places the signal 148 at a seven and one-half volt level, i.e., (six volts + 1½ mean value). Therefore, the transistor is biased "on" and produces a voltage causing flow into the capacitor 110. The current generator in this fashion modifies the rate of change of voltage with respect to time on capacitor 110. The voltage at the capacitor is amplified through the deflection amplifier 140 (FIG. 1) and applied to the deflection plates 142 of the CRT causing the electron beam to move in the chosen, i.e., plus Y direction. From the foregoing it is seen that so long as there is a constant current flowing into the capacitor 110, there will be a constant rate of change of voltage with respect to time and thus a constant rate of change of motion on the screen in the plus Y direction (disregarding for the moment the fact that the X capacitor voltage may change), and thus constant brightness of the symbol forming lines.

For the beam of the CRT to travel in a minus Y direction it is seen (at the right in FIG. 6) that the signal 146 (zero and plus three) is applied to the NPN transistor 130 through an interface buffer 132 which both inverts and translates so as to change the reference voltage from a plus three to a minus three (i.e., -3 to zero) to produce the minus voltage which is utilized therein for the negative coordinate. An NPN transistor conducts or is on when the base is more positive than the emitter. Again, since there is only a three volt swing (plus and minus one and one-half volts) it is necessary, in order to have the NPN transistor switch operate, that there be a seven and one-half volt mean value. To this end, a six volt Zener diode 96' is introduced between the output of the interface buffer 132 and the base 94' of the transistor 130 to produce a seven and one-half volt mean value at junction 102'. Thus when the input pulse 146 moves to minus three which is the more negative of the two (0 and -3) transistor 130 will be at minus nine and in this instance, the transistor will not conduct, i.e., is "off." Thus when the base 94' is more positive relative to the emitter 124', i.e., minus six volts from the Zener diode 96', the transistor 130 conducts causing current to flow out of the capacitor 110 in the manner heretofore described. The rate of change of voltage relative to time is then amplified as before and finally applied to the CRT deflection plates to move the CRT beam at a constant velocity along a minus Y coordinate.

The remaining X and Y current generators of the 10, 9, 4 and 2 arrangement provide other and different rates of change of voltage with respect to time (i.e., different capacitor charging rates) by virtue of the differences in resistance of the circuit components 116-120 and 116'-120'. Suitable values of these elements being chosen to provide constant current in the ratio of 10, 9, 4 and 2.

It is apparent therefore that by proper choice and combination of 10, 9, 4 and 2 current generators, in accordance with the chart of FIG. 5 for the X and Y axes, and in the plus and minus direction, it is possible to derive any, some,

one or all of the vector resultant angles set forth in FIG. 7. The rheostats 116-116' of the PNP and NPN transistors, respectively, are adjustable so as to provide the relationships of 10, 9, 4 and 2 in terms of electrical current ratio for application to the deflection plates of the cathode ray tube in accordance with the equation $i = Cde/dt$ thereby producing constant velocity CRT beam resolution characters or symbols of constant brightness.

The symbol generation apparatus hereinabove described is capable of producing each of the capital and lower case letters of the alphabet, the ten digits used in the decimal numbering system as well as punctuation marks, commonly used symbols and special symbols designated particularly for specified applications.

What is claimed is:

1. Symbol-character generating apparatus for a cathode ray tube display comprising:

- (a) means for receiving symbol information signals,
- (b) means to decode said received information signals coupled to the signal receiving means,
- (c) a matrix for each symbol and character to be generated,
- (d) a plurality of different magnitude ramp generators for each coordinate by which the symbols and characters are defined, means selectively electrically connecting the ramp generators to the matrices,
- (e) summing means connecting said ramp generators to the corresponding deflection control elements of a cathode ray tube,
- (f) and, means to apply a decoded symbol information signal to the symbol matrix identified by the received information signals thereby to cause the ramp generators to produce a resultant potential output for application to said deflection control elements of said cathode ray tube effective to cause the cathode ray beam to display a symbol of substantially constant brightness on the screen of the tube.

2. Symbol-character generating apparatus for a cathode ray tube display comprising:

- (a) means for receiving coded symbol information signals,
- (b) means to decode said information signals coupled to the signal receiving means,
- (c) a plurality of different magnitude ramp generators for each coordinate by which the symbols and characters are defined,
- (d) a plurality of symbol-character matrices electrically coupled to different predetermined combinations of said ramp generators,
- (e) means coupled to the decoding means to select a matrix and the associated predetermined combination of ramp generators,
- (f) common output means connecting said ramp generators to the corresponding deflection control elements of a cathode ray tube,
- (g) and, means to cause the predetermined ramp generator combination with which a selected matrix is associated to apply a potential to said deflection control elements effective to cause the cathode ray beam of the tube to draw a symbol of substantially constant brightness across the screen thereof.

3. Symbol-character generating apparatus for a cathode ray tube display comprising:

- (a) means for receiving coded symbol information signals,
- (b) means to decode said coded information signals electrically coupled to said signal receiving means,
- (c) a plurality of character-symbol matrices coupled to the decoding means,
- (d) means to selectively shift the decoded symbol information signal within the matrix identified by said coded information signals,
- (e) a plurality of different magnitude constant current generators for each coordinate by which the symbols and characters are defined, means selectively

electrically connecting in a predetermined manner, the current generators to said character matrices,

(f) integrating means coupled to said constant current generators producing a constant rate of change of voltage with respect to time,

(g) and, means coupling the output of said last means to the corresponding deflection control elements of a cathode ray tube thereby to cause the predetermined current generators with which the selected matrix is associated to apply a potential to said deflection control elements of said cathode ray tube effective to cause the cathode ray beam to draw a symbol of substantially constant brightness across the screen of the tube.

4. Symbol-character generating apparatus for a cathode ray tube display comprising:

(a) coded symbol means for receiving representative information bits,

(b) means to decode said coded information bits coupled to said bit receiving means,

(c) one or more character-symbol line forming matrices coupled to the decoding means,

(d) means for producing an output having a constant rate of change of voltage with respect to time including a plurality of different magnitude current generators for each coordinate by which the symbols and characters are defined, means selectively electrically connecting said voltage producing means to said character matrices,

(e) means connecting the constant rate of change of voltage output of said voltage producing means to the deflection control elements of a cathode ray tube,

(f) means responsive to a start signal to shift the symbol information signal within the matrix identified by said coded information bits thereby to cause the particular current generators with which the selected matrix is associated to develop a potential on said deflection control elements of said cathode ray tube effective to cause the beam of the cathode ray tube to draw a symbol of substantially constant brightness across the screen of the cathode ray tube,

(g) and, means coupled to the decoding means responsive to information bits and electrically coupled to the cathode of the cathode ray tube for varying the length of time that the cathode ray beam is active thus to vary the effective length of the character-symbol forming lines.

5. An electronic symbol-character generating apparatus comprising:

(a) a cathode ray tube including means for deflecting the beam within said tube along two orthogonal axes substantially perpendicular to one another,

(b) means for receiving symbol-character line describing information signals,

(c) a plurality of symbol-character angle matrices,

(d) a plurality of symbol-character line length matrices,

(e) means for producing an output having a constant rate of change of voltage with respect to time, including at least one constant current generator for each of said orthogonal axes electrically coupled to the angle and line length matrices,

(f) a shift register electrically coupled to the signal receiving means for selectively applying said line information to said angle matrices and said line length matrices effective to control said current generators,

(g) means applying the output from said current generators to the deflection elements of said tube by which the vertical and horizontal movement of the cathode ray tube beam within said tube is controlled, the beam forming a symbol or character of substantially constant brightness regardless of the length of the line which forms the character,

(h) and, means responsive to a size control signal and electrically coupled to said shift register for controlling the duration of application of the generator

outputs to said deflection elements effective to cause said beam to travel a longer or shorter distance thereby forming the desired symbols or characters on different lengths and sizes.

6. An electronic symbol-character generating apparatus comprising:

(a) a cathode ray tube including means for deflecting the beam within said tube along two orthogonal axes substantially perpendicular to one another,

(b) means for receiving symbol-character line describing information signals,

(c) one or more symbol-character angle matrices,

(d) one or more symbol-character line length matrices,

(e) means for producing an output having a constant rate of change of voltage with respect to time, including a constant current generator for each of said orthogonal axes electrically coupled to said angle and line length matrices,

(f) a shift register electrically coupled to the signal receiving means for selectively applying said line information to said angle and said line length matrices effective to control said current generators,

(g) means applying the output from said current generators to the deflection elements of said tube by which the vertical and horizontal movement of the cathode ray beam within said tube is controlled, the beam forming a symbol or character of substantially constant brightness regardless of the length of the lines which form the character,

(h) and, means responsive to a size control signal and electrically coupled to said shift register for controlling the duration of application of the generator outputs to said deflection elements effective to cause said beam to travel a longer or shorter distance thereby forming desired symbols or characters on different lengths and sizes.

7. An electronic symbol-character generating apparatus comprising:

(a) a cathode ray tube including means for deflecting the beam within said tube along two orthogonal axes substantially perpendicular to one another,

(b) means for receiving symbol-character line describing information bits,

(c) a plurality of symbol-character angle matrices,

(d) a plurality of symbol-character line length matrices,

(e) a ramp generator for each of said orthogonal axes electrically coupled to said angle and line length matrices,

(f) a shift register electrically coupled to the bit receiving means for selectively applying said line information to said angle and said line length matrices effective to control said ramp generators,

(g) means applying the output from said ramp generators to the deflection elements of said tube by which the vertical and horizontal movement of the cathode ray beam within said tube is controlled, the beam forming a symbol or character of substantially constant brightness regardless of the length of the lines which form the character,

(h) and, means responsive to a size control signal and electrically coupled to said shift register for controlling the duration of application of the generator outputs to said deflection elements effective to cause said beam to travel a longer or shorter distance thereby forming the desired symbols or characters on different lengths and sizes.

8. An electronic symbol-character generating apparatus comprising:

(a) a cathode ray tube including means for deflecting the beam within said tube along two orthogonal axes substantially perpendicular to one another,

(b) means for receiving symbol-character line describing information signals,

(c) a symbol-character angle matrix,

(d) a symbol-character line length matrix,

- (e) a constant current generator for each of said orthogonal axes generally coupled to the angle and line length matrices,
 - (f) a shift register electrically coupled to the signal receiving means for selectively applying said line information to said angle matrix and said line length matrix effective to control said current generators,
 - (g) means applying the output from said current generators to the deflection elements of said tube by which the vertical and horizontal movement of the cathode ray beam within said tube is controlled, the beam forming a symbol or character of substantially constant brightness regardless of the length of the lines which form the character,
 - (h) means responsive to a size control signal and electrically coupled to said shift register for controlling the duration of application of the generator outputs to said deflector elements effective to cause said beam to travel a longer or shorter distance thereby forming the desired symbols or characters on different lengths and sizes,
 - (i) and, means for blanking said cathode ray beam during retrace or repositioning of said beam.
9. Electronic symbol-character generating apparatus for a cathode ray tube display comprising:
- (a) means for receiving a plurality of coded bits of symbol line describing information,
 - (b) for decoding the coded bit information signals into a single bit of information for each respective character to be displayed,
 - (c) a character matrix for each character to be displayed having a plurality of input terminals,
 - (d) a shift register having a plurality of sections each having individual outputs for successively applying the decoded symbol information bit signals to the input terminals of the respective character matrices,
 - (e) a shaft register section selector coupled to the signal decoding means and said shift register for selecting the outputs of the shift register in a prescribed order for each of the characters thereby providing equal loading of said shift register for the desired number of characters to be displayed,
 - (f) a plurality of horizontal and vertical coordinate constant current generators coupled to, and responsive to the information from said character selection matrices for generating a constant current output for deflecting the cathode ray beam in different angular directions,
 - (g) means electrically coupled to said current generators for controlling the time interval during which the cathode ray beam is moved by the generator outputs thereby determining the length of the line drawn by said beam in the chosen direction,
 - (h) and means coupled to said shift register and to the bit receiving means for indicating the end of each character thereby conditioning the apparatus for the production of a new symbol-character.

10. Electronic symbol-character generating apparatus for operating cathode ray tube display apparatus comprising:

- (a) means for receiving symbol-character lines describing information signals,
- (b) means selectively determining the angle or angles required to form a selected character or symbol on the face of a cathode ray tube,
- (c) means determining the length of the line or lines forming the selected character,
- (d) at least one constant current generator for the horizontal coordinate of said cathode ray tube,
- (e) at least one constant current generator for the vertical coordinate of said tube,
- (f) means electrically interconnecting said angle and length determining means with said constant current generators and responsive to the application of said

- symbol information thereto for successively deriving a current related to each of said desired angles,
- (g) capacitive means operably associated with each of said constant current generators effective to derive a resultant constant rate of change of voltage with respect to time for each of said coordinates,
- (h) and means applying said rate of change of voltage to the horizontal and vertical deflection elements of said cathode ray tube causing said cathode ray beam to move at a resultant angle at constant velocity tracing the selected character at a substantially constant level of brightness on the face of the tube.

11. Electronic symbol-character generating apparatus for driving a cathode ray tube display comprising:

- (a) means for receiving symbol-character line describing information signals,
- (b) means selectively determining the angle or angles required to form a selected character or symbol on the face of a cathode ray tube,
- (c) means determining the length of the line or lines forming the selected character,
- (d) one or more constant generators for the horizontal coordinate,
- (e) one or more constant current generators for the vertical coordinate,
- (f) means electrically interconnecting said angle and length determining means with said constant current generators and responsive to the application of said symbol information thereto for successively deriving angle related currents therefrom,
- (g) capacitive means operably associated with each of said constant current generators effective to derive constant rate of change of voltage with respect to time for each of said coordinates,
- (h) and means applying said constant rate of change of voltage to the horizontal and vertical deflection elements of said cathode ray tube causing said cathode ray beam to move in the selected angular direction at constant velocity tracing the desired character at a substantially constant level of brightness on the face of the tube.

12. Electronic symbol-character generating apparatus for driving a cathode ray tube display comprising:

- (a) means for receiving a plurality of binary bits of symbol-character line describing information,
- (b) means for decoding said binary bit information into a single bit of information for each respective character to be electronically displayed,
- (c) a plurality of character angle defining matrices, one for each character to be displayed,
- (d) a shift register having a plurality of outputs for different columns of the angle selection character matrices for successively applying the decoded symbol information to the columns of a selected character matrix,
- (e) a shift register section selector coupled to the information decoder and said shift register for selecting the outputs of the shift register in a prescribed order for each of the characters thereby providing equal loading of said shift register for the desired number of characters to be displayed,
- (f) a plurality of horizontal and vertical coordinate current generators responsive to angle-representing signals received from said character angle selection matrix for generating a constant current output for application to the deflection elements of a cathode ray tube for deflecting the cathode ray beam in a selected angular direction at constant velocity,
- (g) means controlling the time during which the cathode ray beam travels at said constant velocity thereby determining the length of the line drawn by said beam in the chosen direction at substantially constant brightness,
- (h) and, means coupled to said shift register and to the bit receiving means for indicating the end of a

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character, thereby conditioning the apparatus for the production of a new symbol or character.

13. Electronic symbol-character generating apparatus for driving a cathode ray tube display comprising:

- (a) means for receiving a plurality of binary bits of symbol-character line describing information, 5
- (b) means for decoding said binary bit information into a single bit of information for each of the respective characters to be displayed,
- (c) a character angle matrix for each character to be displayed, 10
- (d) a shift register having a plurality of outputs for different columns of the character matrices for successively applying the decoded symbol information bit to the columns of the corresponding character matrix, 15
- (e) a shift register section selector for selecting the outputs of the shift register in a prescribed order for each of the characters thereby providing equal loading of said shift register for the desired number of characters to be displayed, 20
- (f) a plurality of horizontal and vertical coordinate current generators responsive to the information from said character angle selection matrix for generating a constant current output for application to the deflection elements of the cathode ray tube for deflecting the cathode ray beam in a selected angular direction at substantially constant velocity, 25
- (g) means controlling the time during which the cathode ray beam travels at said constant velocity thereby determining the length of the line drawn by said beam in the chosen angular direction, 30
- (h) and, means for blanking the cathode ray beam at specified intervals on demand electrically coupled to said character matrices. 35

14. A symbol display system comprising:

- (a) one or more character matrices and a column selecting circuit electrically coupled to each of said matrices, 40
- (b) means receiving information signals and enabling a selected one of said matrices in accordance with signals identifying a desired symbol to be displayed,
- (c) sequencing means causing said column selecting circuit to activate said selected matrix in column-by-column fashion, 45
- (d) an X axis capacitor and a Y axis capacitor and decoding elements preprogrammed within said selected matrix providing a constant predetermined charging current for application to respective X and Y axis capacitors for each columnar energization, 50
- (e) constant rate deflection voltage producing means coupled to said decoding elements, said charging current being of selected magnitudes for each such column and controlling symbol line segment lengths as a result of the length of time each capacitor is permitted to charge during a respective column energization, 55
- (f) a cathode ray tube electrically coupled to said deflection voltage producing means including means for deflecting the cathode ray beam therein in the horizontal and vertical direction, 60
- (g) and, means coupling the horizontal deflection means of said tube to the X axis capacitor, and the vertical deflection means of the tube to the Y axis capacitor effective upon energization of the desired combination of decoding elements to cause said cathode ray beam to trace a selected symbol on the face of said tube at a constant predetermined velocity and with substantially constant brightness. 65

15. A symbol display system comprising:

- (a) a plurality of character matrices and a column selecting circuit electrically connected to each of said matrices, 70
- (b) means receiving information signals and enabling a selected one of said matrices in accordance with 75

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signals identifying a desired symbol to be displayed,

- (c) sequencing means causing said column selecting circuit to activate said selected matrix in column-by-column fashion,
- (d) an X axis capacitor and a Y axis capacitor and decoding elements preprogrammed within said selected matrix providing a constant predetermined charging current for application to respective X and Y axis capacitors for each columnar energization,
- (e) constant rate deflection voltage producing means coupled to said decoding elements, said charging current being of selected magnitudes for each such column and controlling symbol line segment lengths as a result of the length of time each capacitor is permitted to charge during a respective column energization,
- (f) a cathode ray tube electrically coupled to said deflection voltage producing means including means for deflecting the cathode ray beam therein in the horizontal and vertical direction,
- (g) and means coupling the horizontal deflecting means of said cathode ray tube to the X axis capacitor, and the vertical deflection means of the cathode ray beam to the Y axis capacitor whereby energization of the desired combination of decoding elements causes said cathode ray beam to trace a selected symbol on the face thereof at a constant predetermined velocity and with substantially constant brightness of the display.

16. A symbol display system comprising:

- (a) a plurality of character matrices and a column selecting circuit electrically coupled to each of said matrices,
- (b) means receiving information signals and enabling a selected one of said matrices in accordance with signals identifying a desired symbol to be displayed,
- (c) sequencing means coupled to the column selecting circuit for causing said column selecting circuit to activate said selected matrix in column-by-column fashion,
- (d) a timing decoder controlled by said signals causing said sequencing means to move to the next succeeding column,
- (e) an X axis capacitor and a Y axis capacitor and decoding elements preprogrammed within said selected matrix providing a constant predetermined charging current to respective X and Y axis capacitors for each columnar energization,
- (f) constant rate deflection voltage producing means coupled to said decoding elements, said charging current being of selected magnitudes for each such column and controlling symbol line segment lengths by the time each capacitor is permitted to charge during a respective column energization,
- (g) a cathode ray tube electrically coupled to said deflection voltage producing means including means for deflecting the cathode ray beam therein in the horizontal and vertical direction,
- (h) and means coupling the horizontal elements of said cathode ray tube to the X axis capacitor, and the vertical deflection elements of the cathode ray tube to the Y axis capacitor whereby energization of the desired combination of decoding elements causes said cathode ray beam to trace a selected character on the face thereof at a constant predetermined velocity and with substantially constant brightness of the display.

17. A symbol display system comprising:

- (a) a plurality of character matrices and a column selecting circuit electrically coupled to each of the matrices,
- (b) means receiving information and timing signals and enabling a selected one of said matrices in accordance with signals identifying a desired symbol to be displayed,
- (c) shift register means for shifting said column select-

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- ing circuit in response to a decoded timing signal thereby to activate said selected matrix in a column-by-column fashion,
- (d) an X axis capacitor and a Y axis capacitor and decoding elements preprogrammed within said selected matrix providing a constant predetermined charging current to respective X and Y axis capacitors for each columnar energization, 5
- (e) constant rate deflection voltage producing means coupled to said decoding elements, said charging current being of selected magnitudes for each such column and controlling symbol line segment lengths as a result of the time each capacitor is permitted to charge during a respective column energization, 10
- (f) a cathode ray tube electrically coupled to said deflection voltage producing means including means for deflecting the cathode ray beam therein in the horizontal and vertical direction, 15
- (g) and, means coupling the horizontal deflecting means of said cathode ray tube to the X axis capacitor, and the vertical deflection means of the cathode ray beam to the Y axis capacitor whereby energization of the desired combination of decoding elements causes said cathode ray beam to trace a selected character on the face thereof at a constant predetermined velocity and with substantially constant brightness of the display. 20 25
18. A symbol display system comprising:
- (a) one or more symbol matrices further comprising
- (b) an angle determining matrix, 30
- (c) a timing matrix,
- (d) a column selecting circuit and means coupling said angle and timing matrices to the column selecting circuit,
- (e) a counter, 35
- (f) means feeding timed pulses to said counter,
- (g) a comparator coupled to said counter and said

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- timing matrix for causing said column selecting circuit to move from column to column in said symbol matrices when the information in said timing matrix corresponds to the information fed to said counter,
- (h) an X and a Y axis capacitor and decoding elements preprogrammed within the angle matrix providing a constant predetermined charging current to respective X and Y axis capacitors for each columnar energization,
- (i) constant rate of deflection voltage producing means coupled to said decoding elements, said charging current being of selected magnitudes for each such column and controlling symbol line segment lengths as a result of the time each capacitor is permitted to charge during a respective column energization,
- (j) a cathode ray tube electrically coupled to said deflection voltage producing means including means for deflecting the cathode ray beam therein in the horizontal and vertical direction,
- (k) and means coupling the horizontal deflecting means of said cathode ray tube to the X axis capacitor, and the vertical deflection means of the cathode ray beam to the Y axis capacitor whereby energization of the desired combination of decoding elements causes said cathode ray beam to trace a selected character on the face thereof at a constant predetermined velocity and with substantially constant brightness of the display.

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