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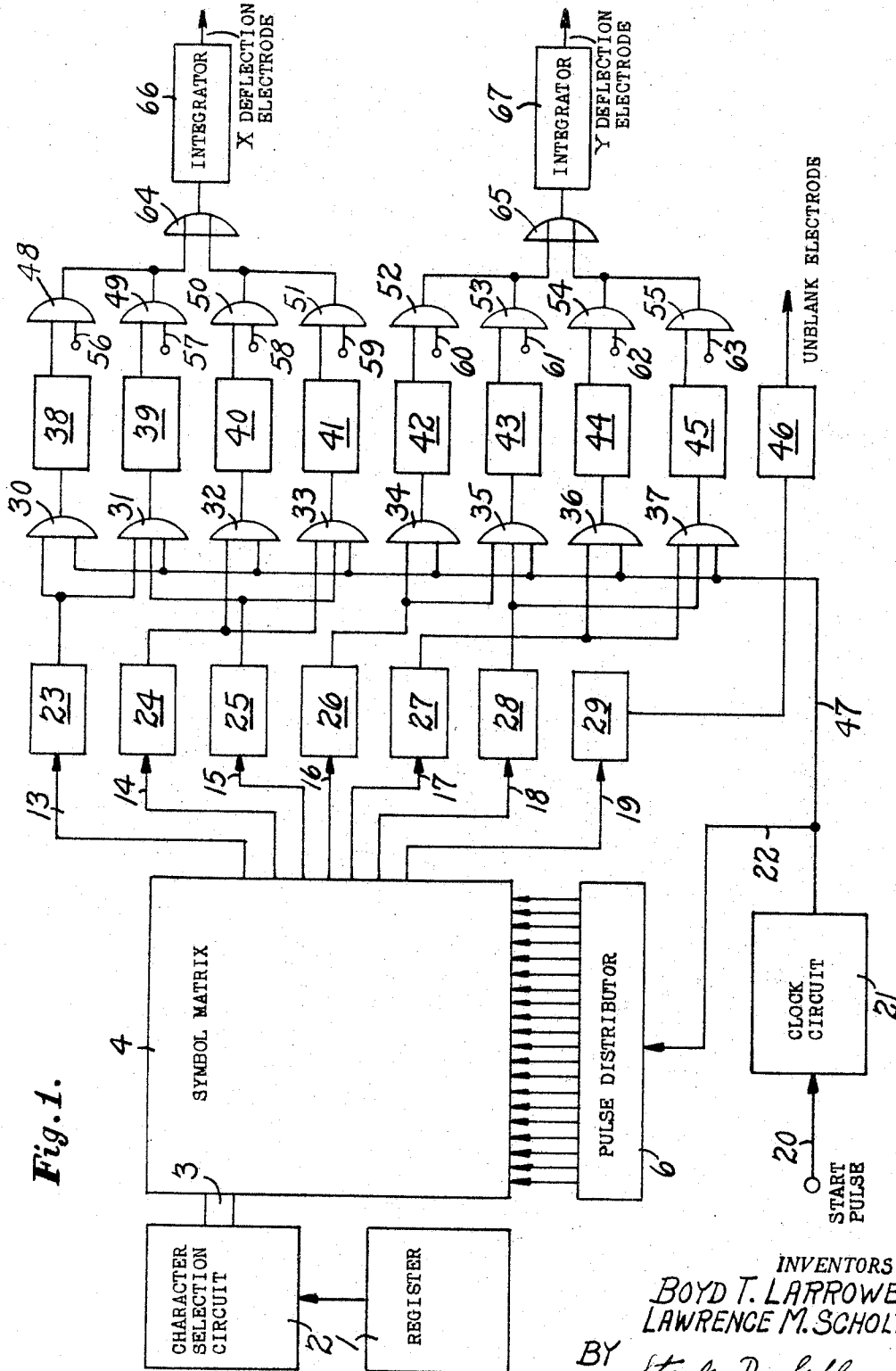
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3,329,947

ELECTRONIC CHARACTER GENERATOR

Filed March 7, 1963

3 Sheets-Sheet 1



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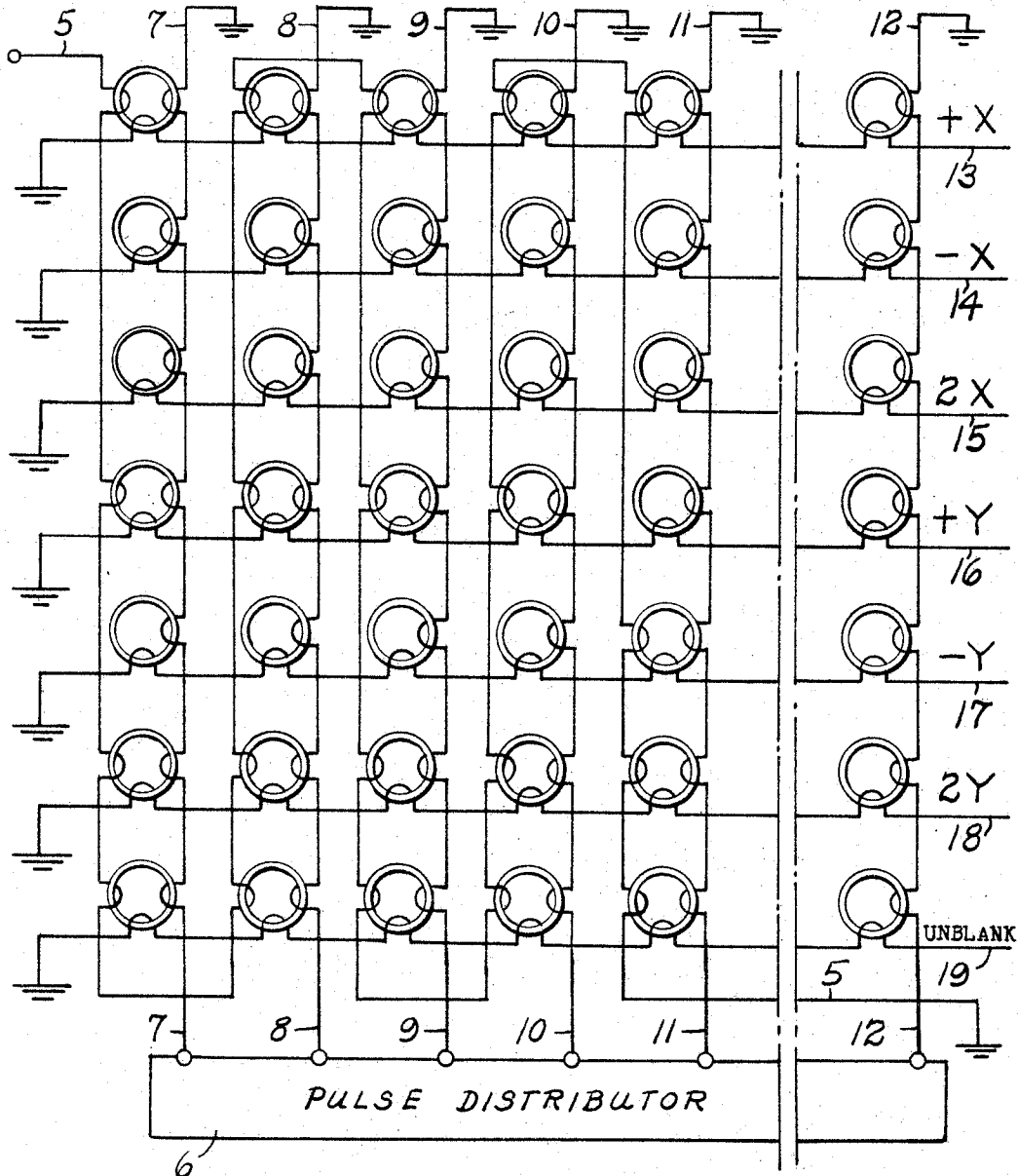
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Fig. 2.



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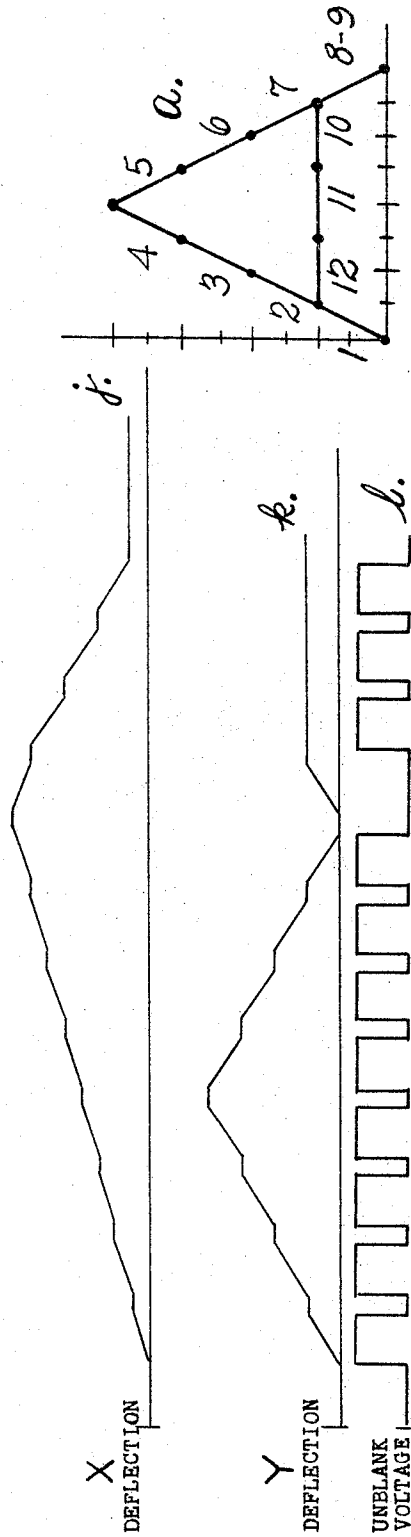
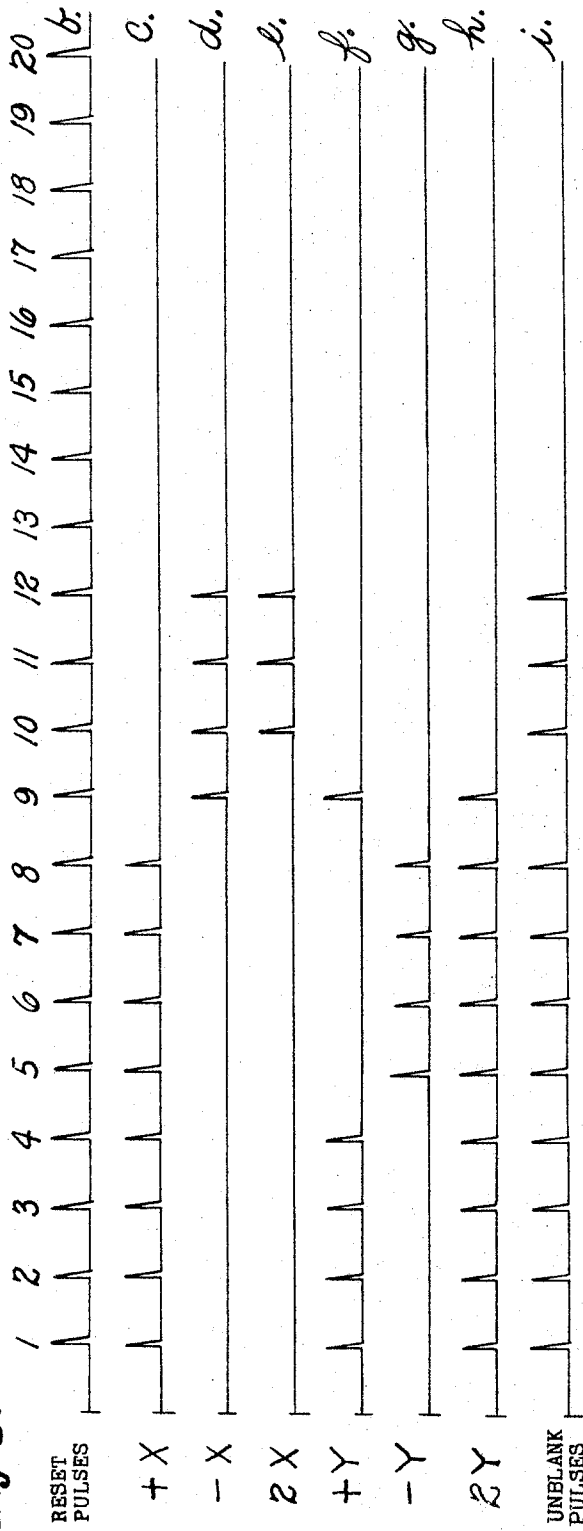
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Fig. 3.



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3,329,947

ELECTRONIC CHARACTER GENERATOR

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17 Claims. (Cl. 340—324)

The present invention relates to a means for producing deflection and intensity signals to enable a very large variety of geometric symbols to be drawn on the screen of a cathode ray tube utilizing a Cartesian coordinate deflection system.

With the development of high speed computers resulting in increased generating speed and storage capacity, it has become necessary to develop adequate display systems. The system which is selected must satisfy the requirements of reliability, economy, and compatibility with the data generating device as well as operate at a sufficiently high speed. Various electromechanical systems have been proposed in the past, but they have been either too cumbersome and slow or too complex. The present invention contemplates the use of a visual display in which the output of the data generating system is drawn on the screen of a visual display device such as a cathode ray tube.

In accordance with the present invention, there is provided a system for synthesizing a character or symbol as a succession of straight lines on the screen of a cathode ray tube. The invention includes a character selection circuit which stores character selection signals. The character selection circuit has a plurality of output wires, each wire representing one of the symbols of characters of which the invention is capable of drawing on a cathode ray tube screen. Each output wire of the selection circuit is threaded in a unique pattern through a magnetic core symbol matrix. The character selection circuit causes a pulse to be applied to the wire representing the character to be drawn thereby causing the cores necessary to draw the desired character to be set. After setting the necessary cores, each column of the symbol matrix is sequentially sampled by means of a distributor applying reset pulses to the various columns beginning with the first and ending with the last thereby causing the previously set cores to produce output pulses. These output pulses are transferred through gating and current integrating circuits and ultimately supplied to the deflection electrodes of a cathode ray tube, causing the beam of the tube to trace the desired character.

One object of the invention is to provide a device which generates deflection and intensification voltage signals which control the drawing of various characters on a display surface.

Another object of the invention is to provide an apparatus for the drawing of various characters by the sequential generation of straight lines of varying length and slope.

Another object of the present invention is to provide a device for drawing various characters on the screen of a cathode ray tube without requiring that the beam of the tube be deflected through a many-lined raster or other complex pattern.

Another object of the invention is to provide a magnetic core matrix for the production of character drawing pulses in which each character which may be drawn is represented by a single wire threaded through the matrix in a unique pattern in order to alter the flux state of only those cores necessary to the drawing of a particular character.

Another object of the invention is to provide a matrix for producing separate, parallel pulse trains uniquely representing a particular character to be drawn, these

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pulses being applied to integrating circuits having outputs which control the movement of a drawing means.

Other objects and features of advantage of the invention will be found throughout the following detailed description. The novel features of the invention are defined in the appended claims. For a clear understanding of the invention and its mode of operation, the description may be considered in connection with the accompanying drawing, in which:

FIG. 1 is a block schematic diagram of a character generator constructed in accordance with the principles of the invention;

FIG. 2 is a diagrammatic representation of a core matrix in association with a suitable pulse distribution circuit used in the character generator of FIG. 1 for providing control pulses for generating character drawing deflection voltages;

FIG. 3 shows a family of curves, illustrating the potential waveforms required to draw the character "A."

Referring now to FIG. 1, a digital register 1 is provided for the storage of character selection signals. The input to register 1 may be connected to the output of a computer or similar device. The output of register 1 is applied to the input terminals of character selection circuit 2, which has an output consisting of a plurality of wires, each wire representing a different character which may be drawn by the character generator. Cable 3 represents this plurality of output wires of selection circuit 2. The character selection circuit operates to select, in response to information derived from digital register 1, the output wire representing the character to be drawn and applies a pulse thereto. Selection circuit 2 may be any circuit conventionally used to convert binary information to a single wire output. The number of different characters which the generator may draw is, of course, dependent on the digital storage capacity of register 1. Assuming that this register has a six bit capacity, the generator can draw sixty-four different characters and cable 3 will contain sixty-four wires.

Referring now to FIG. 2, there is illustrated the symbol matrix 4 of FIG. 1 which receives input pulses and produces parallel, independent trains of sequential output pulses which ultimately produce the potentials applied to the deflection electrodes of the cathode ray tube. Symbol matrix 4 utilizes bistable magnetic cores as the bistable elements but the invention is not limited to such devices and could employ other bistable circuit elements as well. These cores are made of any suitable magnetic material having two opposed stable states of magnetic remnance which are designated the 0 state and the 1 state in accordance with conventional terminology. Upon the initiation of operation of the character generator, all of the cores of the matrix are in the 0 state.

The state of each of the cores may be altered by the application of a magnetizing field applied to it by means of a set wire threaded or wound through the core. If a positive magnetizing field of sufficient intensity is applied to a core, it is switched from the 0 state to the 1 state. The subsequent application of a negative magnetizing field of sufficient intensity by means of a reset wire threaded through the core causes the core to be switched from the remnance condition representing the 1 state to the remnance condition representing the 0 state. When the core switches from the 1 to the 0 state, an output pulse is generated on an output or read wire also threaded through the core.

The magnetic cores employed in the control core matrix 4 are arranged in seven horizontal rows and twenty vertical columns. In the interest of clarity, only the first five and the last column are illustrated in FIG. 2. The sixty-four output wires of character selection circuit 2

are threaded through the symbol matrix as set wires, each in its unique pattern, to set the proper cores in the 1 state, one such set wire 5 being illustrated. The application of a pulse on set wire 5 causes a positive magnetizing field to be applied to the threaded cores.

Pulse distributor 6 has an output consisting of twenty reset wires which present negative magnetizing pulses sequentially to the columns of the symbol matrix in order beginning with the first column, the number of reset wires corresponding to the number of columns of the matrix. Six of these reset wires are illustrated in FIG. 2 as wires 7-12. These negative magnetizing pulses cause those cores in the 1 state to return to the zero state. Note that each reset wire is threaded through every core in the column with which it is associated. The cores which had not been set to the 1 state remain in the 0 state upon the application of the reset magnetizing field.

The seven rows of the control core matrix 4 have the seven read wires 13-19 threaded therethrough, each wire being threaded through all twenty of the cores in its associated row. When the reset pulses are sequentially applied by pulse distributor 6 to the twenty columns, those cores in each column which are reset from the 1 state to the 0 state produce an output pulse on those of wires 13-19 which are threaded through a reset core. The seven read wires 13-19 are designated respectively as +X, -X, 2X, +Y, -Y, 2Y, and unblank as the pulses applied thereto ultimately will cause the potentials which are applied to the X, Y, and unblank electrodes of the cathode ray tube to draw a character.

The manner in which the various characters are drawn by the present invention may be understood by reference to FIGS. 1-3 together. The line segments drawn on the CRT screen may each have a displacement along the X axis of 0, 1, or 2 increments of length and a displacement along the Y axis of 0, 1, or 2 increments. These segments are sequentially generated so that the terminal point of one segment is coincident with the initial point of the succeeding segment. The length of a drawn segment is, of course, dependent upon the length of its projections on the X and Y axes and is equal to the square root of the sum of the squares of these projections. Each column of the control core matrix 4 is used to generate the read pulses which will ultimately draw one of these line segments on the CRT screen. Since there are twenty columns in matrix 4, the number of characters which can be drawn is limited to those which require twenty or less segments. However, an almost unlimited number of characters, including all alpha- numerics and many symbols, may be approximated by these twenty line segments. If it were desired to draw characters that are so complex that more than twenty segments are required, the number of columns of matrix 4 could be increased or the time allotted to the drawing of a particularly complex character could be increased. Also, by increasing the number of rows in matrix 4, the variations of length and slope of the drawn line segments may be increased. The obviousness of these expedients in order to increase the complexity of the characters which may be drawn will be apparent as the explanation proceeds.

Read pulses impressed upon these wires are transferred through gating and standardizing circuits to ultimately produce input pulses to the two current integrators in the device. Each integrator produces an output voltage which is applied to one of the deflection electrodes of the CRT. A read pulse on wire 13 causes a line segment of one increment of length to be drawn in the positive X direction. A read pulse on wire 14 causes a line segment of one increment of length to be drawn in the negative X direction. In accordance with the logic of the system, the drawing of a line segment of two increments of length in either the +X or -X direction requires wire 15 to transmit a pulse simultaneously with either wire 13 or 14. Read wires 16-18, associated with deflection of the beam along the

Y axis function identically. A pulse on wire 19 causes the beam to be unblanked.

Sloped lines are drawn by the simultaneous generation of X and Y read pulses which ultimately apply deflection voltages simultaneously to the X and Y deflection electrodes of the cathode ray tube. For example, simultaneous read pulses on wires 13 and 16 cause a line to be drawn with a slope of +1. If wires 13, 15, and 16 simultaneously transmit pulses, the voltages applied to the deflection electrodes cause the beam to be deflected two increments in the positive X direction and one increment in the positive Y direction. Thus, a line segment with a slope of $+1\frac{1}{2}$ is drawn. In a similar manner, lines may be drawn in any one of sixteen directions from an initial point by the proper generation of read pulses.

FIG. 3 graphically illustrates the pulses applied to the seven read wires to cause the drawing of a representative character. The character "A," selected for purposes of illustration only, is drawn by twelve line segments on the screen of the cathode ray tube as shown at FIG. 3a. FIG. 3b graphically shows in time sequence the twenty reset pulses applied to the twenty columns of matrix 4. FIGS. 3c-i show, in proper time sequence, the pulses impressed upon read wires 13-19 respectively by the resetting of the

cores. Prior to the application of reset pulses to the matrix the proper cores have been set by the application of a pulse on the output wire 5 of selection circuit 2 representing the character "A." The first segment of the "A" is a straight line having a slope of +2. The first reset pulse causes pulses to be simultaneously produced on the +X, +Y, 2Y, and unblank read wires. This combination causes a segment to be drawn having a slope of +2. Referring back to FIG. 2 wire 5 is threaded only through the +X, +Y, 2Y, and unblank cores of the first column. The second segment of the "A" is also a line having a slope of +2 with an initial point coincident with the terminal point of the first line segment. FIGS. 2 and 3 show that identical read pulses are generated for the first four line segments.

The fifth segment of the "A" is a line having a slope of -2. FIG. 3 shows that the fifth reset pulse causes only the +X, -Y, 2Y, and unblank cores of the fifth column to produce read pulses. FIG. 2 shows that wire 5 is threaded through the cores of column 5 which will produce pulses on the +X, -Y, 2Y, and unblank read wires. Columns 6-8 cause successive contiguous lines to be drawn having a slope of -2.

In order to draw the horizontal portion of the "A" it is necessary to retrace line segment 8. This retracing is done by segment 9 while the beam is blanked as shown by the absence of an unblanking pulse at FIG. 3i for this segment. The blanking of a segment which retraces a previously drawn segment is done to prevent undue brightness of one portion of the character. The ninth segment is traced by the blanked beam from the termination of the eighth segment by the simultaneous production of pulses on the -X, +Y, and 2Y read wires. The horizontal portion of the "A" comprising segments 10-12 is drawn by pulses on the -X, 2X, and unblank read wires. FIGS. 3j-l will be discussed in connection with current integrators 66 and 67.

After the drawing of a character, the beam must be repositioned so that the characters may be sequentially drawn and not be superimposed on each other. This repositioning is accomplished by a gross positioning circuit which has not been illustrated because such circuits are well-known in the electronic character generating art. One such manner of supplying gross positioning signals to the deflection electrodes of a cathode ray tube is to thread a read wire through a core in the last column of the symbol matrix used to draw the character so that a pulse is generated upon the completion of an individual character. The gross positioning circuit, utilizing this pulse, generates the proper deflection voltages to cause the beam to be moved to a new reference position from

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which the tracing of a succeeding character is begun. Conventionally, a reference position from which to begin the tracing of a character is the lower left-hand corner of the space allocated to the particular character. This convention has been employed in the present invention as can be seen by referring to the initial point of the first line segment of the "A" of FIG. 3a. Upon the completion of a line of characters, the gross positioning circuit would then return the beam to the left-hand position of the succeeding line in which characters are to be drawn.

The tracing of a character begins when register 1 applies an input signal to character selection circuit 2 indicating the character to be drawn. One of the output or set wires of circuit 2 has a pulse applied thereupon which sets the appropriate cores of the symbol matrix. Register 1 also applies at the same time a start pulse over conductor 20 to clock circuit 21. Clock circuit 21 is of conventional design and is triggered into producing a square wave output by the trailing edge of the start pulse. The circuit parameters may readily be designed so that the time duration of the start pulse is sufficiently long to permit the proper cores to be set. The output pulses of the clock circuit are applied over conductor 22 to the pulse distributor.

Pulse distributor 6 is a conventional circuit which consists essentially of a plurality of sequentially connected bistable devices, wherein the bistable devices are rendered On successively by successive output pulses from clock circuit 21. As the bistable devices of the various stages are turned On, a reset pulse is applied to the associated reset wire causing a read pulse to be generated for that column. After the twenty stages of the pulse distributor have been successively turned On, the character will have been drawn and the pulse distributor is returned to its initial condition whereby the reception of a clock pulse at the first stage will initiate the drawing of a new character. Since the drawing of many characters does not require an entire drawing period, the pulse distributor need not be cycled through all twenty pulses but may be returned to its initial condition upon the completion of a character. This may easily be accomplished by connecting a read wire from a core in the last column to be utilized in the drawing of a character to a reset terminal on the pulse distributor. Such circuitry is well-known and is therefore not illustrated or discussed.

The seven read wires 13-19 constituting the outputs of the symbol matrix are connected to the input terminals of buffer storage circuits 23-29. The outputs of buffer storage units 23-28 are connected in a unique manner to one of the inputs of each of AND gates 30-37. Buffer storage circuit 29, which receives the unblank read pulse is not connected to an AND gate but is connected directly to standardizing circuit 46 for a purpose to be seen later. The output of storage circuit 23 is connected to one of the inputs of each of gates 30 and 31. The output of circuit 24 is connected to one of the inputs of each of gates 32 and 33. The output of circuit 25 is connected to one of the inputs of each of gates 31 and 33. The outputs of buffer storage circuits 26-28 associated with deflection along the Y axis are connected to gates 34-37 in an identical manner.

AND gates 30-37 are enabled by clock pulses applied simultaneously to one of the input terminals of each gate over conductor 47. In order to cause deflection of the tube beam of two increments, the outputs of two gates must be added. Assume that the beam is to be deflected two increments in the positive X direction, pulses from the +X and the 2X read wires are simultaneously passed by gates 30 and 31 respectively. When the clock pulse is impressed on one input of gate 30, this gate passes the +X pulse. The three inputs of gate 31 simultaneously receive a +X pulse, a 2X pulse, and a clock pulse and also passes an output pulse. If the beam is to be deflected only one increment in the positive X direction, gate 30 will pass a pulse but gate 31 will not as no 2X pulse will

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be applied to one of the input terminals. The remaining gates 34-37 operate in the same manner to cause a beam deflection of either one or two increments along the other coordinate axes.

The circuit parameters may be so selected that the pulses of clock 21 are not required to synchronize the enabling of the gates. In this case, the inputs from the buffer storage circuits are sufficient to control the enabling of the gates. This expedient would simplify the circuit design as those gates not connected to either the 2X or 2Y storage circuits could be eliminated.

Standardizing circuits 38-46 are connected respectively to the outputs of gates 30-37 and storage circuit 29. These standardizing circuits are of conventional design and provide rectangularly shaped pulses which are free of undesirable transients which may appear on the pulses applied to their inputs.

The outputs of circuits 38-45 are connected to one of the input terminals of AND gates 48-55 respectively. Each of gates 48-55 has a second input which is connected to a constant current source of either positive or negative polarity. Inputs 56, 57, 60 and 61 are connected to a positive constant current source and inputs 58, 59, 62 and 63 are connected to a negative constant current source. These current sources, while differing in polarity, are equal in absolute magnitude. The rectangular output pulses of the standardizing circuits drive the gates to which they are applied and cause a constant current pulse of rectangular configuration to be switched to the outputs of these gates. Standardizing circuit 46 connected directly to buffer circuit 29 provides sharp definition between the blank and unblank drawing periods.

The current outputs of gates 48 and 49 are connected together to form one of the inputs of OR gate 64. The outputs of gates 50 and 51 are connected together to form the other input of gate 64. The outputs of gates 52 and 53 are connected together as are the outputs of gates 54 and 55. These connected outputs form the inputs to OR gate 65.

If the beam of the cathode ray tube is to be deflected one increment of length in the positive X direction, the only current input to OR gate 64 is the output of constant current source 56. If the beam is to be deflected two increments of length in the positive X direction, gates 48 and 49 will both pass a constant current and these currents will be summed due to their common connection. OR gate 65, producing an input current which controls deflection of the beam in the Y direction, operates in the same manner.

The outputs of OR gates 64 and 65 are connected to current integrators 66 and 67 respectively. Each integrator is essentially a capacitance circuit which produces an output voltage which is the integral of the input current applied thereto. The output of each integrator is applied to one of the deflection electrodes of the cathode ray tube.

FIGS. 3j and k show the voltage waveforms produced by integrators 66 and 67 respectively in the tracing of the character "A." These output voltages obtained by integrating substantially rectangular pulses cause the beam to be deflected linearly. During the tracing period for the first light segments, the Y deflection is increased at twice the rate of the X deflection, the first four segments having a deflection in the positive Y direction and the last four having a deflection in the negative Y direction. When the ninth segment is traced, no unblanking pulse is produced as shown at FIG. 4i. Note that the deflection of the beam for each segment occurs in a period which is slightly less than the time period between read pulses. During this short switching period, the various circuit elements are returned to their initial condition in order to receive a succeeding pulse.

What is claimed is:

1. Apparatus for producing electrical signals representative of predetermined characters comprised of a succession of straight line segments of varying slope and

lengths to be displayed on a drawing device having signal integrating deflection control means comprising:

first and second groups of signal conductors, each of said conductors relating to a different deflection distance along a Cartesian coordinate of the character to be displayed;

character matrix signal generating means having a matrix of elements arranged in rows and columns, a row conductor electrically coupled to the elements of each row of the matrix and to one of said signal conductors, and means for actuating successive columns of the matrix for applying successive sets of logic pulses to selected one of said conductors, each set of said logic pulses relating to a predetermined line segment to be drawn; and

means responsive to the pulses applied to the conductors of each of said groups for producing and conducting to said deflection control means first and second parallel series of control pulses, each pulse of which corresponds in size to the magnitude of a coordinate component of one of said line segments.

2. Apparatus for synthesizing predetermined characters represented by a succession of straight line segments of varying slope and length on a display device having signal integrating deflection control means comprising:

a first plurality of conductors for signals relating to different deflections along a Cartesian coordinate; a second plurality of conductors for signals relating to different deflections along a second Cartesian coordinate;

controllable pulse generating means electrically coupled to each of said conductors for developing and applying successive sets of current pulses relating to component lengths of line segments to selected ones of said conductors for the character to be synthesized,

each set of said pulses relating to a predetermined line segment to be drawn; and

current summing means electrically connected to said conductors for producing first and second series of control pulses for conduction to said deflection control means.

3. The apparatus for synthesizing predetermined characters of claim 2 wherein in each conductor is preselected for conducting signals relating to a different length line segment component and the deflection control means comprises first and second deflection control electrodes and signal integrating means electrically connected between the output of the current summing means and said deflection control electrodes.

4. The apparatus for synthesizing predetermined characters of claim 3 wherein the current pulses applied to selected ones of the conductors by the controllable pulse generating means correspond to incremental line segment lengths substantially equal in magnitude and the pulse generating means further comprises unblanking signal generating means.

5. Display beam deflection control apparatus for drawing information representations comprised of a plurality of line segments on a plotting device having signal integrating deflection control means comprising:

a plurality of electrical conductors, each conductor relating to a component length of beam deflection in the plotting device;

means for deriving and applying a unique pattern of parallel pulse trains of substantially uniform pulse amplitude to said plurality of conductors for each representation to be drawn,

concurrent pulses of the parallel pulse trains relating to the same line segment; and

pulse responsive means electrically connected to said plurality of conductors for generating and conducting to said signal integrating deflection control means a train of control pulses, each pulse of which relates

to and corresponds in shape to the length of one of the line segments to be drawn.

6. The electron beam deflection control apparatus of claim 5 wherein the pulse deriving means comprises a matrix of columns and rows of bistable elements each capable of being set in one of two stable states, the elements of each row being coupled to a different one of the plurality of conductors, means for altering the state of predetermined ones of said elements in accordance with the information representation to be displayed, and means sequentially energizing the column conductors of the matrix causing each altered element to produce a pulse on its associated row conductor; and the deflection control means comprises a deflection control electrode and signal integrating means having an output terminal electrically connected to the deflection control electrode and an input terminal electrically connected to said pulse responsive means, whereby successive line segments of the information representations are made connecting.

7. The deflection control apparatus of claim 6 wherein the bistable elements of the matrix are comprised of magnetic cores each coupled to one of the row conductors and to one of the column conductors of the matrix, and further comprising buffer storage means electrically connected between said row conductors and said pulse responsive means.

8. Display beam deflection control apparatus for drawing information representations comprised of a plurality of successive line segments on a plotting device having signal integrating deflection control means comprising:

a positive deflection signal conductor and a negative deflection signal conductor for each orthogonal coordinate of the line segments to be drawn;

a segment length signal conductor for each of the coordinates of the display;

means electrically coupled to each of said conductors for deriving and applying to said conductors and deflection control signal and a segment length signal for each line segment to be drawn; and

deflection signal control means electrically connected to the signal deriving means and to the segment length signal conductors for controlling the length of the line segments drawn on the device.

9. The display beam deflection control apparatus of claim 8 wherein the deflection control signal deriving means comprises means for producing current pulses corresponding to different components of the line segments to be drawn, summing means electrically connected thereto for producing the deflection control signals, and unblanking signal generating means.

10. Display beam controlling apparatus for synthesizing symbol representations comprised of a plurality of successive line segments on a display device having signal integrating deflection control means comprising:

a plurality of line segment component signal conductors;

signal generating means electrically coupled to said conductors for selectively applying thereto successive sets of pulses for each symbol representation to be drawn,

each conductor relating to a component line segment length and each set of pulses relating to a different line segment to be drawn;

current source means;

logic means coupled to the conductors and to said current source means for producing a series of current pulses in response to the pulses applied to said conductors; and

means for summing current pulses relating to the same line segment for producing and conducting to the deflection control means a series of deflection control pulses.

11. The display beam controlling apparatus of claim 10 wherein the pulses applied to one of the line segment component signal conductors signify a unit length line

segment and the logic means comprises means gating pulses from another of the conductors with the unit length pulses for producing one of the series of current pulses.

12. The apparatus of claim 11 wherein the logic means further comprises gated constant current conducting means having a gate terminal connected for receiving the output of the pulse gating means and having an output terminal electrically connected to the current pulse summing means.

13. The display beam controlling apparatus of claim 10 wherein the plurality of line segment component signal conductors comprises first and second groups of conductors and the signal generating means is electrically coupled for applying successive sets of pulses to each group of conductors relating to beam deflection in one of two directions on the display device.

14. The display beam controlling apparatus of claim 13 wherein the pulses applied to one of the line segment component signal conductors of each group signifies a unit length line segment and the logic means comprises means gating pulses from another of the conductors of the same group therewith for producing one of the series of current pulses.

15. The beam controlling apparatus of claim 14 wherein the signal generating means applies successive sets of pulses for each symbol representation to be drawn to each group of conductors relating to beam deflection along a Cartesian coordinate of the line segments on the display device.

16. The beam controlling apparatus of claim 14 where-

in the current source means and logic means develop a series of positive and negative current pulses corresponding to the sets of pulses received by the first and second groups of conductors relating, respectively, to beam deflection in one of two opposite directions on the display device.

17. The apparatus of claim 16 wherein the logic means further comprises gated constant current conducting means having gate terminals connected for receiving the outputs of the pulse gating means and having output terminals electrically connected to the current pulse summing means.

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