Aug. 1, 1967 R. J. FOURNIER ETAL 3,334,304
ASYNCHRONOUS CHARACTER GENERATOR FOR SUCCESSIVE ENDPOINT DEFINITION
Filed March 1, 1965 3 Sheets-Sheet 1

FIG. 1

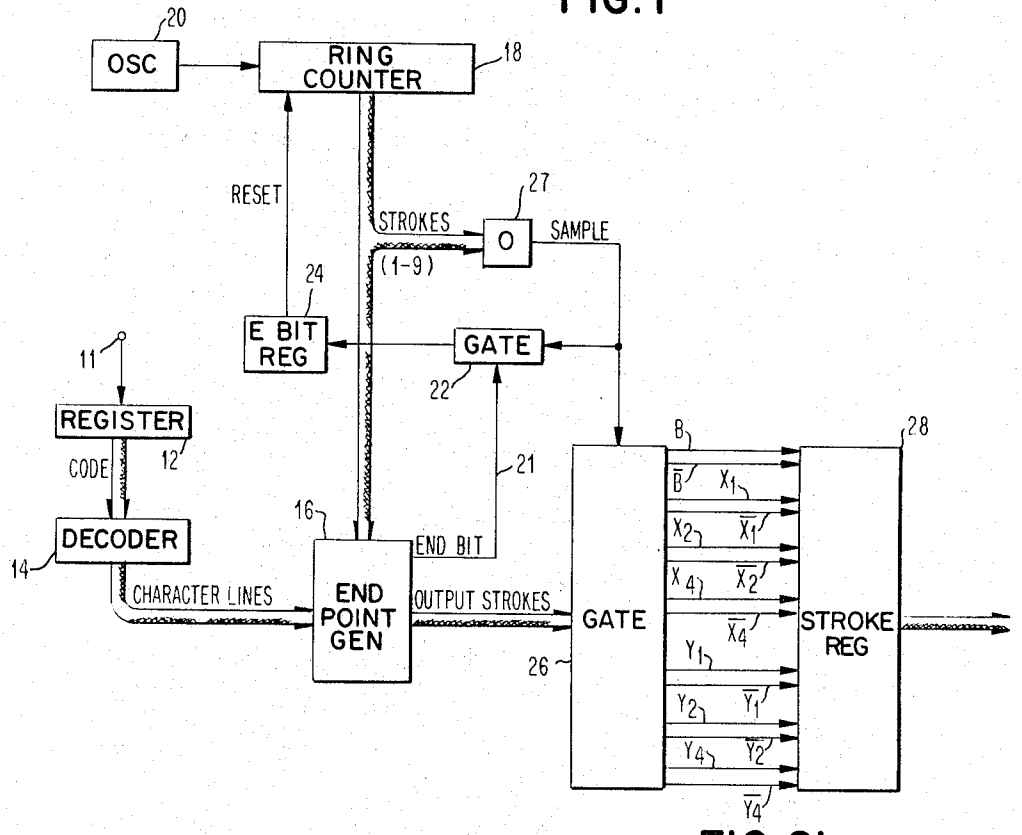


FIG. 2a

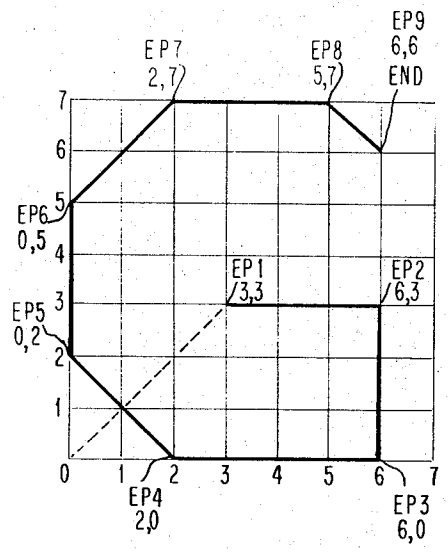
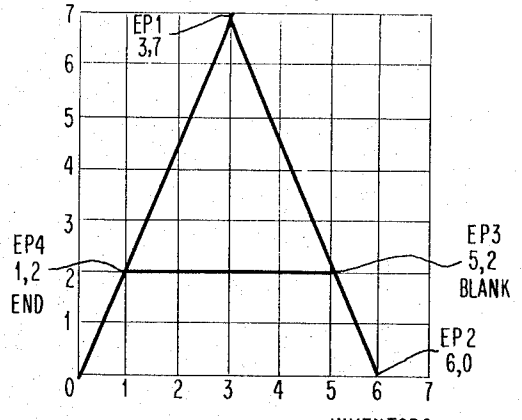


FIG. 2b



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FIG. 3

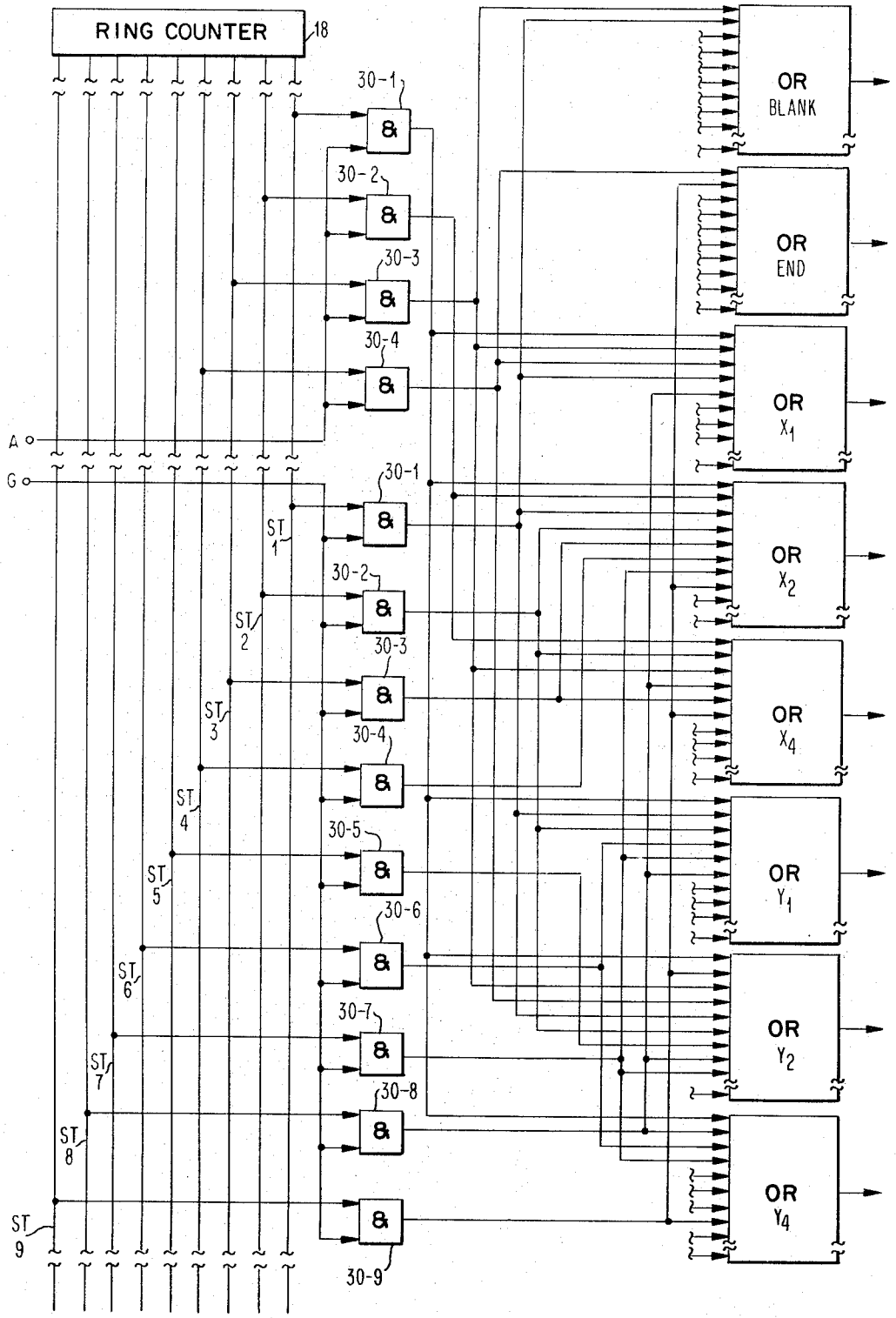
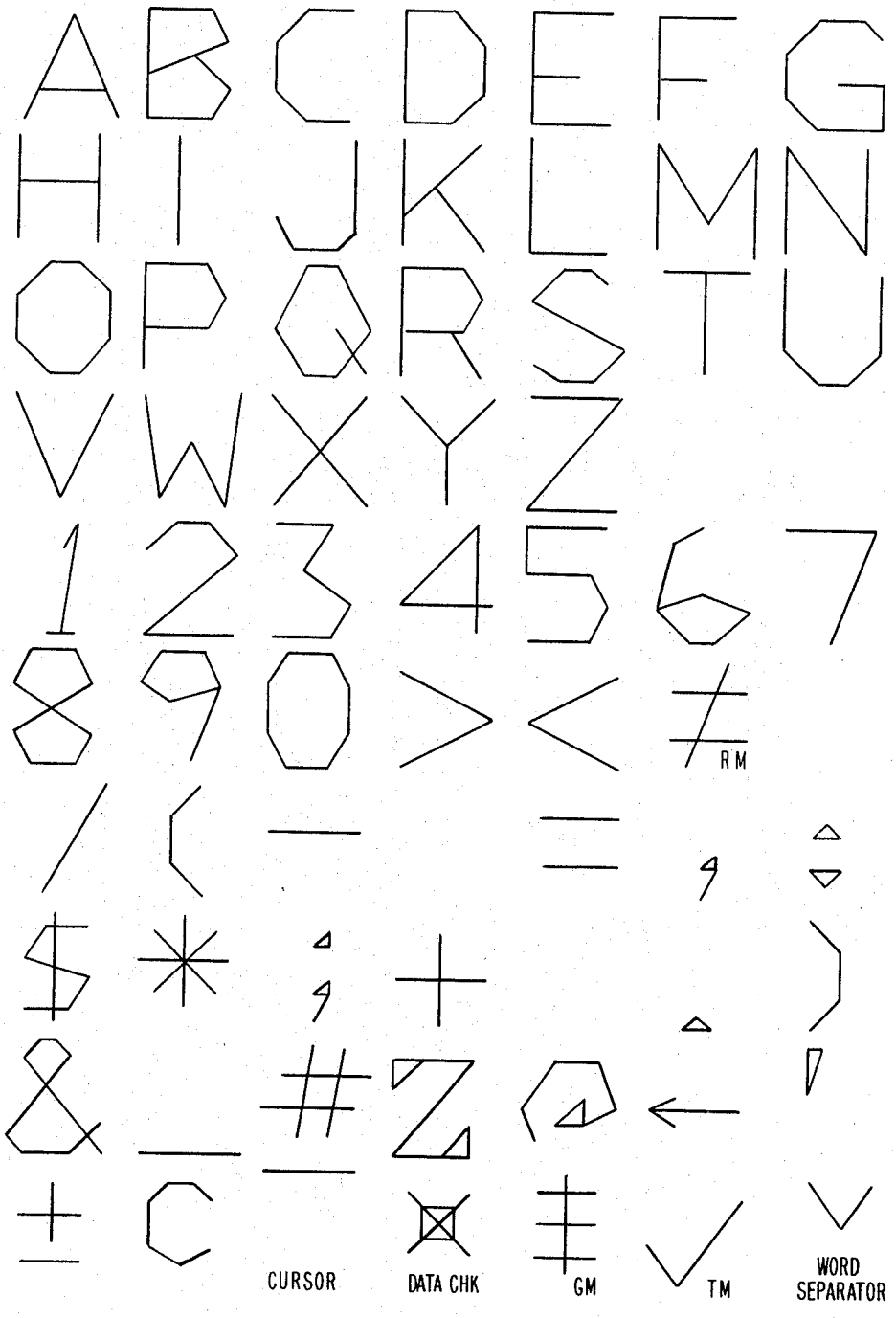

RING COUNTER
18
30-1
30-2
30-3
30-4
30-5
30-6
30-7
30-8
30-9
&
A
G
ST 1
ST 2
ST 3
ST 4
ST 5
ST 6
ST 7
ST 8
ST 9
OR BLANK
OR END
OR X1
OR X2
OR X4
OR Y1
OR Y2
OR Y4

FIG. 4



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3,334,304

ASYNCHRONOUS CHARACTER GENERATOR FOR SUCCESSIVE ENDPOINT DEFINITION

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1 Claim. (Cl. 328—119)

ABSTRACT OF THE DISCLOSURE

A character generator supplies digital signals defining successive endpoints of strokes required to draw characters on a cathode ray tube. Uniquely coded digital signals representing characters are decoded to a single unique line which conditions selected elements of an endpoint generator. A ring counter sequentially samples the endpoint generator.

This invention relates to electronic character generators and more particularly to electronic character generators suitable for use with cathode ray tubes for displaying the generated character.

Electronic character generation with cathode ray tubes may be advantageously employed as a computer input/output device in place of a printer in those instances where a permanent record is not desired. When so employed it provides relatively noise free reproduction which may be advantageous in certain application. However, in achieving this objective, the speed as well as the cost of generating the visual display must be maintained compatible with that of the conventional printer.

A number of different methods have been employed for generating alphanumeric information on a cathode ray tube. Each provides its own peculiar advantages and disadvantages.

One of the first methods utilized employed a conventional television scan in which beam blanking was employed to generate the character. These systems worked well, however, they require a great deal of processing equipment and are comparatively slow when compared with other types of reproducers which generate a complete character in less total time.

Another method employs a universal pattern scan technique with selective blanking to produce the desired character. In this system the beam must be moved through all the code positions regardless of the character being displaced and thus is wasteful of time when a relatively simple character is to be displayed. In addition, implementation of the system requires a large number of control circuits.

Numerous other methods have been used to achieve electronic character generation, however, each have suffered from either slow operating speed or a complexity of control circuits which, in most instances have been for other good and sufficient reasons.

It is therefore one object of this invention to provide a character generator which operates at high speeds and which utilizes shared circuitry to achieve simplicity.

Another object of the invention is to provide a character generator in which the signals defining each of the characters in the font are combined digitally to provide a single set of digital outputs for defining all characters.

A further object of the invention is to provide a reliable asynchronous character generator which is capable of high speed operation and which employs simple circuitry for processing the plurality of unique digital signals defining the different characters in the font to provide a single set of digital outputs defining all of the characters in the font.

The invention contemplates a character generator

which generates a character by defining a plurality of straight lines which when sequentially generated on a cathode ray tube results in the synthesis of the character. The lines are defined by generating signals indicative of the X and Y endpoint coordinates of each line in a sequence. Thus, the trace on the cathode ray tube is moved at a linear rate from its attained position to the defined endpoint. According to the invention a digital signal defining the character to be generated is applied to the generator which supplies in sequence digital X, Y coordinates of the successive endpoints of the character along with beam intensity information on a single set of output conductors for all characters in the font.

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

In the drawings:

FIGURE 1 is a block diagram of a novel character generator constructed according to the invention;

FIGURES 2*a* and 2*b* are graphic representations of two characters in the font generated by the novel generator shown in FIGURE 1;

FIGURE 3 is a detailed block diagram for illustrating the operation of the endpoint generator shown in block form in FIGURE 1; and

FIGURE 4 is a pictorial representation of the entire font generated by the novel generator illustrated in FIGURES 1 and 3.

In FIGURE 1 uniquely coded digital signals each representing a different character in the font to be displayed are applied to input terminal **11** of a register **12**. These signals may be supplied by a computer not shown or may originate in a keyboard also not shown.

Register **12** is a conventional parallel register and for the particular font disclosed must contain at least seven stages since sixty-six distinct codes are required. The output of register **12** is applied to a decoder **14** which provides a predetermined voltage level output on a different line for each different code applied. The details of decoder **14** have been omitted since this type of decoder is well known in the art.

The individual output lines from decoder **14**, one for each unique code, are applied to an endpoint generator **16** which will be described in full detail later in connection with the description of FIGURE 3. Generator **16** provides in time sequence the X, Y coordinates of the sequential vectors which when drawn in sequence provide the characters. It is provided with four classes of outputs.

The first class defines the X coordinate of the endpoint in process with three bits on three separate conductors; the second class is similar to the first and defines the Y coordinate of the endpoint; the third class defines the beam intensity i.e. blanked or unblanked; and the last class the status of the coordinates in process i.e. last character stroke or not last stroke.

Time control of generator **16** is provided by an oscillator **20** which runs a nine stage ring counter **18**. Since nine strokes is the maximum number required to generate the most complex character in the font a maximum of nine time sequential control signals are required. The nine conductors providing the nine time sequential signals from counter **18** are applied to generator **16** and time sequentially gate the endpoints and the other information, previously described, relative thereto.

Endpoint generator **16** provides with the last stroke of each character an end bit signal E on a conductor **21**. This signal is passed through a gate **22** to a register **24** which is connected to the reset input of counter **18**. Thus, when a character of less than nine strokes has been generated the counter **18** is reset so that it is ready to process the next character.

The nine outputs from counter **18** are also applied to an "OR" circuit **27** which provides a sample output used to operate gate **22**. This sample output enables the gate with each stroke output from counter **18** to provide additional timing control.

The output, previously described, from generator **16**, with the exception of the end bit, are applied, via a gate **26** which is under the control of the sample pulse, to a stroke register **28** which provides seven bipolar outputs. The first bipolar output B indicates the beam intensity i.e. blank or unblank. The second, third and fourth outputs are indicative of the first second and third binary digits, respective of the X coordinate i.e. X_1, X_2 and X_4. The fifth, sixth and seventh bipolar outputs are indicative of the first second and third binary digits, respectively, of the Y coordinate i.e. Y_1, Y_2 and Y_4.

The intensity output of register **28** is connected to the intensity control circuit of a cathode ray tube, not shown, while the other outputs are applied to the deflection circuits of the tube via a digital to analog converter, also not shown. The cathode ray tube and digital to analog converter have not been illustrated since they are well known in the art and do not constitute part of the subject invention.

FIGURE 2*a* illustrates the time sequential generation of the character G of the font. Any character in the font may be generated by nine strokes. The character G was selected for illustration because it contains nine strokes or a full cycle of operation and in addition is provided with a blank stroke.

In operation the cathode ray tube is provided with two deflection circuits. A coarse position is manually or automatically applied to one deflection circuit to position the beam at coordinates (0, 0). These coordinates may be located anywhere on the screen where display is desired.

The character generator output is applied through suitable digital to analog circuits to the other deflection circuit and provides limited beam movement in the upper right quadrant to generate up to nine lines to define the desired character.

For the character G the first endpoint stroke EP1 moves the beam from 0, 0 to 3, 3 and provides beam blanking indicated by the dashed line connecting the points since display of this line is not desired. On the second endpoint stroke EP2 the beam moves from 3, 3 to 6, 3. This is repeated until the ninth endpoint stroke is completed and the character defined. On the last endpoint stroke an end stroke bit E is provided which resets the clock and restores the device to a condition in which it is ready to process the next character to be displayed.

FIGURE 2*b* is very similar to FIGURE 2*a*. Here, however, the character displayed is A which requires only four endpoint strokes for completion. Thus the last or end stroke bit E is provided with the fourth endpoint stroke to reset circuit timing. The beam is blanked when it travels from 6, 0 to 5, 2 on the third endpoint stroke since this area was previously generated on the next prior stroke.

The details of endpoint generator **16** are shown in FIGURE 3. Since the circuits are repetitive, only those necessary for generating the sequential endpoints for the characters G and A are shown. The necessary circuits for generating the remaining characters in the font will be quite obvious in view of the description of FIGURE 3 which follows taken in conjunction with the table below which sets forth all the information required to generate the specific characters of the font illustrated in FIGURE 4.

In FIGURE 3, the A line, this is the line from decoder **14** which, when energized, indicates to the endpoint generator **16** that the sequential endpoints of character A are to be generated, is connected to four AND gates **30–1**, **30–2**, **30–3**, and **30–4**. The character A requires 4 strokes for completion. Gate **30–1** is also connected to the stroke line ST1 from counter **18** and provides an output from gate **30–1** in the first stroke time whenever it is enabled by the A line from decoder **14**.

TABLE

STROKE									
1	2	3	4	5	6	7	8	9	
0	0	0	1						E
0	0	1	0						B
3	6	5	1						X
7	0	2	2						Y A
0	0	0	0	0	0	0	1		E
0	0	0	0	1	0	0	0		B
0	4	5	0	3	5	4	0		X
7	7	5	3	4	2	0	0		Y B
0	0	0	0	0	1				E
1	0	0	0	0	0				B
5	2	0	0	2	5				X
0	0	2	5	7	7				Y C
0	0	0	0	0	1				E
0	0	0	0	0	0				B
0	3	5	5	3	0				X
7	7	5	2	0	0				Y D
0	0	0	0	0	1				E
0	0	1	0	1	0				B
0	5	3	0	0	5				X
7	7	3	3	0	0				Y E
0	0	0	1						E
0	0	1	0						B
0	5	3	0						X
7	7	3	3						Y F

TABLE

STROKE									
1	2	3	4	5	6	7	8	9	
0	0	0	0	0	0	0	0	1	E
1	0	0	0	0	0	0	0	0	B
3	6	6	2	0	0	2	5	6	X
3	3	0	0	2	5	7	7	6	Y G
0	0	0	0	1					E
0	1	0	1	0					B
0	0	5	5	5					X
7	4	4	7	0					Y H
0	1								E
1	0								B
2	2								X
7	0								Y I
0	0	0	0	1					E
1	0	0	0	0					B
0	1	4	5	5					X
2	0	0	1	7					Y J
0	0	0	0	1					E
0	1	0	1	0					B
0	5	0	2	5					X
7	7	2	4	0					Y K
0	0	1							E
1	0	0							B
0	0	5							X
7	0	0							Y L

TABLE

STROKE									
1	2	3	4	5	6	7	8	9	
0	0	0	1						E
0	0	0	0						B
0	3	6	6						X
7	2	7	0						Y M
0	0	1							E
0	0	0							B
0	6	6							X
7	0	7							Y N
0	0	0	0	0	0	0	0	1	E
1	0	0	0	0	0	0	0	0	B
2	0	0	2	4	6	6	4	2	X
0	2	5	7	7	5	2	0	0	Y O
0	0	0	0	1					E
0	0	0	0	0					B
0	4	5	4	0					X
7	7	5	3	3					Y P
0	0	0	0	0	0	0	0	1	E
1	0	0	0	0	0	0	1	0	B
2	0	2	4	6	4	2	4	6	X
0	3	7	7	3	0	0	3	0	Y Q
0	0	0	0	0	0	1			E
0	0	0	0	0	1	0			B
0	4	5	4	0	3	5			X
7	7	5	3	3	3	0			Y R

TABLE

STROKE									
1	2	3	4	5	6	7	8	9	
0	0	0	0	1					E
1	0	0	1	0					B
0	3	6	3	3					X
7	4	7	4	0					Y Y
0	0	0	1						E
1	0	0	0						B
0	6	0	6						X
7	7	0	0						Y Z
0	0	0	0	1					E
1	0	0	1	0					B
3	4	3	2	4					X
5	7	0	0	0					Y 1
0	0	0	0	0	1				E
1	0	0	0	0	0				B
0	2	4	6	0	6				X
5	7	7	5	0	0				Y 2
0	0	0	0	1					E
0	0	0	0	0					B
4	5	2	4	0					X
0	2	4	7	7					Y 3
0	0	0	1						E
1	0	0	0						B
5	5	0	6						X
0	7	2	2						Y 4

TABLE

STROKE									
1	2	3	4	5	6	7	8	9	
0	0	0	0	0	0	0	1		E
1	0	0	0	0	0	0	0		B
0	2	4	6	0	2	4	5		X
1	0	0	2	5	7	7	6		Y S
0	0	0	1						E
1	0	1	0						B
0	6	3	3						X
7	7	7	0						Y T
0	0	0	0	0	1				E
1	0	0	0	0	0				B
0	0	2	4	6	6				X
7	2	0	0	2	7				Y U
0	0	1							E
1	0	0							B
0	3	6							X
7	0	7							Y V
0	0	0	0	1					E
1	0	0	0	0					B
0	1	3	5	6					X
7	0	4	0	7					Y W
0	0	1							E
0	1	0							B
6	0	6							X
7	7	0							Y X

TABLE

STROKE									
1	2	3	4	5	6	7	8	9	
0	0	0	0	0	1				E
0	0	0	0	0	0				B
4	6	4	0	0	6				X
0	2	4	4	7	7				Y 5
0	0	0	0	0	0	0	1		E
1	0	0	0	0	0	0	0		B
3	1	0	2	4	6	3	0		X
7	6	2	0	0	2	3	2		Y 6
0	0	1							E
1	0	0							B
0	6	3							X
7	7	0							Y 7
0	0	0	0	0	0	0	0	1	E
1	0	0	0	0	0	0	0	0	B
5	4	1	0	5	4	1	0	5	X
2	0	0	2	5	7	7	5	2	Y 8
0	0	0	0	0	0	1			E
1	0	0	0	0	0	0			B
5	2	0	1	4	5	3			X
5	4	5	7	7	5	0			Y 9
0	0	0	0	0	0	0	0	1	E
1	0	0	0	0	0	0	0	0	B
1	0	0	1	4	5	5	4	1	X
0	2	5	7	7	5	2	0	0	Y 0

TABLE

STROKE

1	2	3	4	5	6	7	8	9	
0	1								E
1	0								B
6	2								X
7	0								Y /
0	0	0	1						E
1	0	0	0						B
4	2	2	4						X
7	5	2	0						Y (
0	1								E
1	0								B
0	6								X
4	4								Y —
0	0	0	1						E
1	0	1	0						B
1	6	1	6						X
5	5	2	2						Y =
0	0	0	0	1					E
1	0	0	0	0					B
3	4	4	3	4					X
0	2	3	2	2					Y ,
0	0	0	0	0	0	0	1		E
1	0	0	0	1	0	0	0		B
2	3	4	2	2	4	3	2		X
4	5	4	4	2	2	1	2		Y :

TABLE

STROKE

1	2	3	4	5	6	7	8	9	
0	0	0	0	0	1				E
1	0	1	0	1	0				B
2	5	6	1	1	6				X
0	7	5	5	2	2				Y ≠
0	0	0	0	0	0	0	1		E
1	0	0	0	0	0	1	0		B
1	4	5	1	2	5	3	3		X
1	1	3	4	6	6	7	0		Y $
0	0	0	0	0	0	0	1		E
1	0	1	0	1	0	1	0		B
1	5	3	3	5	1	0	6		X
2	6	7	1	2	6	4	4		Y *
0	0	0	0	0	0	0	1		E
1	0	1	0	1	0	1	0		B
3	3	1	5	5	1	1	5		X
1	7	6	6	4	4	2	2		Y ≠
0	0	0	0	0	0	0	0	1	E
1	0	0	0	1	0	0	0	0	B
3	4	4	3	4	3	4	4	3	X
5	6	5	5	2	2	3	2	0	Y ≠
0	0	1							E
1	0	0							B
0	2	6							X
3	0	6							Y √

TABLE

STROKE

1	2	3	4	5	6	7	8	9	
0	0	0	0	0	0	0	0	1	E
1	0	0	0	0	0	0	0	0	B
6	4	1	0	4	3	2	1	6	X
2	0	0	1	6	7	7	6	0	Y &
1									E
0									B
7									X
0									Y —
0	0	0	0	0	0	0	1		E
1	0	1	0	1	0	1	0		B
2	3	5	4	6	0	1	7		X
1	7	7	1	3	3	5	5		Y #
0	0	0	0	0	0	0	1		E
0	0	0	0	1	0	0	0		B
5	0	0	2	3	5	5	3		X
6	6	4	6	0	2	0	0		Y %
0	0	0	0	0	0	0	0	1	E
1	0	0	0	0	0	0	0	0	B
1	0	2	5	6	4	2	4	4	X
1	3	6	6	3	2	2	4	2	Y @
0	0	0	0	1					E
1	0	1	0	0					B
0	6	2	0	2					X
3	3	4	3	2					Y ←

TABLE

STROKE

1	2	3	4	5	6	7	8	9	
0	0	0	1						E
1	0	1	0						B
0	6	3	3						X
3	3	6	0						Y +
0	0	1							E
1	0	0							B
2	4	6							X
7	4	7							Y v
0	0	0	1						E
1	0	0	0						B
2	4	3	2						X
0	0	1	0						Y .
0	0	0	1						E
1	0	0	0						B
2	4	4	2						X
7	5	2	0						Y)
0	1								E
0	0								B
6	0								X
3	6								Y <
0	0	1							E
1	0	0							B
6	0	6							X
6	3	0							Y >

TABLE

STROKE										
1	2	3	4	5	6	7	8	9		
0	0	0	1						E	
1	0	0	0						B	
2	2	3	2						X	
4	7	7	4						Y	'
0	0	0	0	0	1				E	
1	0	1	0	1	0				B	
1	5	5	1	3	3				X	
1	1	4	4	6	2				Y	±
0	0	0	0	0	0	0	0	1	E	
1	0	1	0	0	0	0	0	0	B	
3	3	5	4	2	1	1	3	5	X	
0	7	5	6	6	5	2	1	2	Y	¢
1									E	
1									B	
0									X	
0									Y	(BLANK)
0	1								E	
1	0								B	
0	7								X	
7	7								Y	—
0	0	0	0	0	0	0	0	1	E	
1	0	1	0	1	0	0	0	0	B	
1	5	1	5	4	2	2	4	4	X	
2	6	6	2	3	3	5	5	3	Y	⊠

Referring to the table, the X coordinate of the first endpoint of character A is 3. Therefore, the output of AND gate **30–1** is connected to the X_1 and X_2 OR gates to provide the necessary outputs to the register **28** for energizing the bipolar X_1 and X_2 stages. Gate **26** intervenes and provides for proper strobing and in addition generates the negations of each of the outputs whereby register **28** may be properly reset with each successive stroke from counter **18**.

The Y coordinate of the first endpoint of character A is **7**; thus, the output of gate **30–1** is also connected to the Y_1, Y_2 and Y_4 OR gates to provide the necessary outputs to register **28** for energizing the bipolar Y_1, Y_2 and Y_4 stages. Since the first stroke is not an end or last stroke nor a blanked stroke, indicated by the 0 in the table, AND gate **30–1** is not connected to the "Blank" or "End" OR gates.

The third stroke of the A character is however blanked so it is connected to the "Blank" OR gate as well as the X_1, X_4 and Y_2 OR gates to provide X coordinate 5 and Y coordinate 2.

In a similar manner a plurality of gates **30–1** etc. are provided for the other characters in the font as needed, where for practical purposes the number of inputs to any one gate is excessive, conventional gate extension techniques may be employed to accommodate all the required inputs.

It should be obvious from the above that the table shown above provides the necessary wiring information for each of the characters listed in the table. The table gives the number of strokes, the X and Y coordinates for each stroke, beam intensity information for each stroke and the end bit or last stroke information necessary to reset counter **18**.

This circuit arrangement provides a substantial reduction in the logical function which must be performed to generate the disclosed character font. A consideration of the number of strokes required to generate the alphabetic characters only will illustrate this point.

In order to generate the first stroke of each of the twenty-six alphabetic characters only ten unique logical functions need be performed thus for twenty-six strokes only ten logical functions are required. On the second stroke eighteen unique functions are required for the twenty-six characters. Only twenty-five characters require a third stroke and these can be reduced to seventeen unique logical functions. Twenty-one characters require a fourth stroke which can be accomplished with eighteen unique logical functions. Sixteen characters require a fifth stroke and fifteen unique logical functions are required. No reduction is possible on the sixth through ninth strokes however there are only twenty-four unique logical functions required in all.

The entire alphabetic font of twenty-six characters requires a total of one hundred and thirty-eight strokes which according to the invention can be completed with one hundred and two unique logical functions, thus reducing the complexity of circuit design by more than twenty-six percent.

In summary, the circuit operates as follows. The coded signal is applied to register **12** and decoded in decoder **14** to a single unique line output which is applied to generator **16** which provides the endpoints for all of the strokes required to generate the character. The ring counter **18** under the control of oscillator **20** gates the end points out of generator **16** in predetermined sequential order into a stroke register **28** via a gate **26**. Thus, the digital signal representative of the character is converted to a plurality of time sequential digital signals which define the successive endpoints of a plurality of vectors which when drawn in succession on a cathode ray tube synthesize the character entered into register **12** in coded format.

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

What is claimed is:

A character generator comprising,

first means responsive to signals representative of the characters in a font to be generated for providing a unique output signal for each character in the font,

a plurality of AND gates, at least one for defining each unique vector endpoint in the font, said endpoints being unique only when at least one of the following parameters differ from another endpoint; the coordinates, the beam intensity, the vector number and the last vector of a character,

circuit means responsive to the first means for conditioning only those AND gates which define the vector endpoints of the character represented by the signal applied to the first means,

timing circuit means providing *n* sequential signals, where *n* is an integer and equals the maximum number of vectors required to generate the most complex character in the font, for actuating the conditioned AND gates in a predetermined time sequence for each character to be generated,

a first register responsive to the predetermined sequence of output signals from said AND gates for providing successive digital output signals defining successive vector endpoints of the character in process, and

a second register responsive to those AND gates defining the last vector of a character for providing an end character signal to reset the timing circuit means.

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