United States Patent

[11] 3,582,905

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[54] **CHARACTER GENERATION BY IMPROVED SCAN, STORAGE, AND DECODING APPARATUS**
8 Claims, 7 Drawing Figs.

[52] U.S. Cl. 340/172.5, 340/324
[51] Int. Cl. G11b 13/00
[50] Field of Search 340/172.5, 324; 235/157

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ABSTRACT: Characters are generated in a photoprinter by storing and decoding black and white segments for a raster scan. The raster scan is accomplished by a cathode ray tube. Light from the screen of the tube is focused onto photographic film so that the cathode-ray tube by raster scan can print a character on the film. The cathode-ray beam is controlled in two states of intensity so as to print black on white or white on black characters as desired. A given scan in the raster scan is thus broken into a series of blank or unblank segments for the intensity control g the cathode-ray tube. In the apparatus herein, these segments are defined by segment counts which indicate the length of each segment in a scan. A scan is made up of a sequence of blank and unblank segment counts. These segment counts are loaded into a series of counters. The counters are sequentially counted out as the cathode ray beam is moved along a scan. The counting out is synchronized with movement of the beam so that the time required to count out a segment count will specify the length of a segment printed on the film.

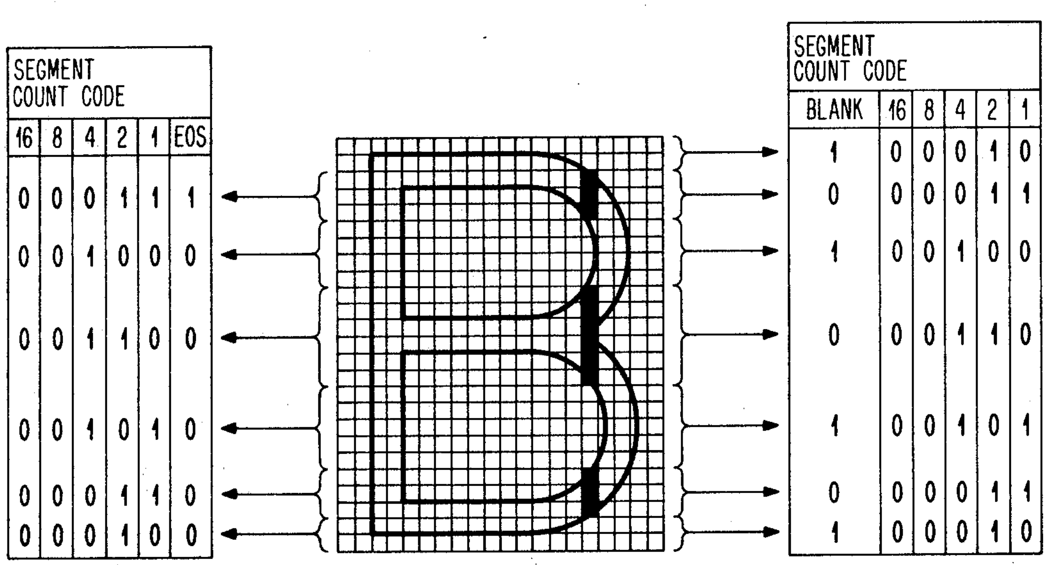


FIG. 1B

SEGMENT COUNT CODE					
16	8	4	2	1	EOS
0	0	0	1	1	1
0	0	1	0	0	0
0	0	1	1	0	0
0	0	1	0	1	0
0	0	0	1	1	0
0	0	0	1	0	0

FIG. 1A

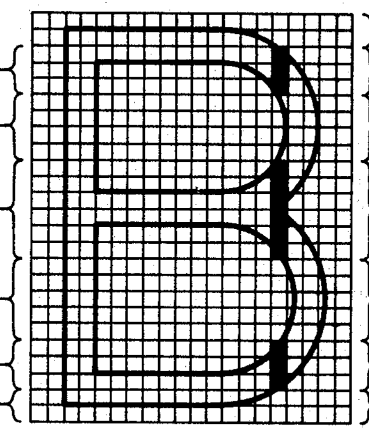
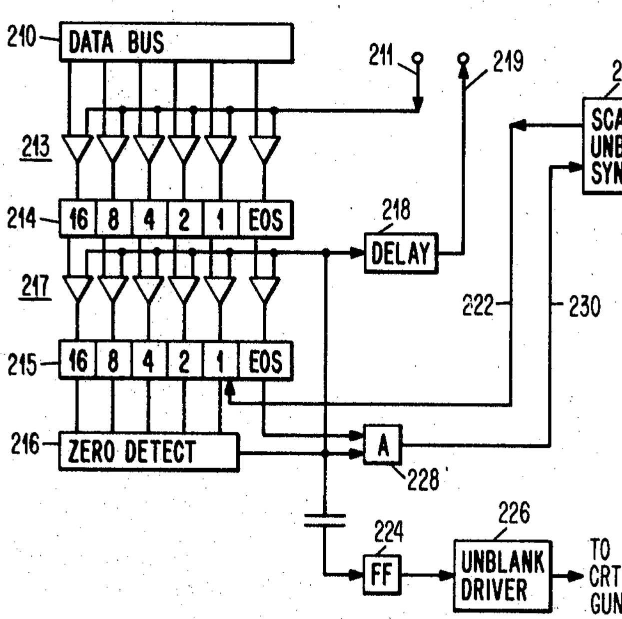


FIG. 1C

SEGMENT COUNT CODE					
BLANK	16	8	4	2	1
1	0	0	0	1	0
0	0	0	0	1	1
1	0	0	1	0	0
0	0	0	1	1	0
1	0	0	1	0	1
0	0	0	0	1	1
1	0	0	0	1	0

FIG. 4



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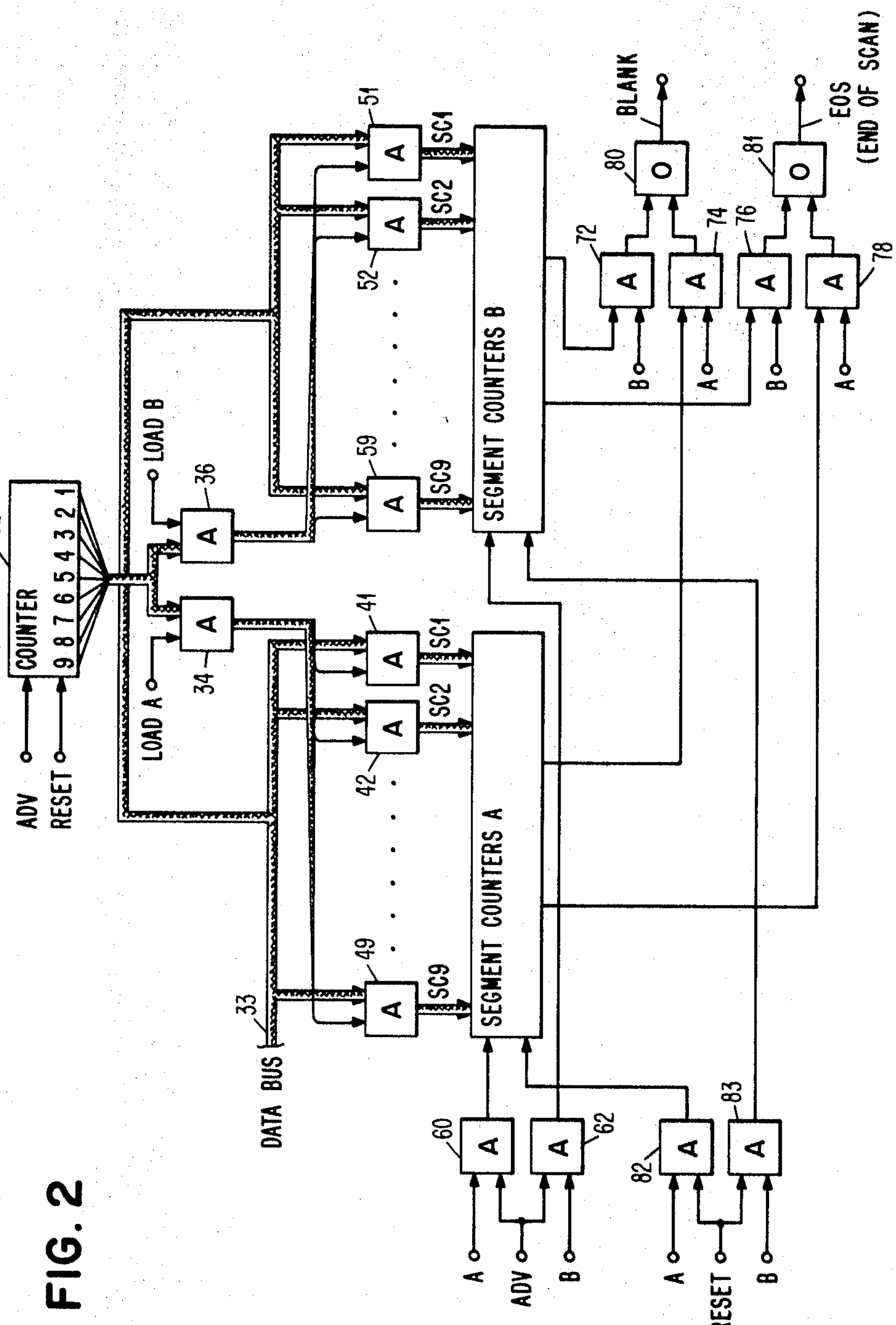
COUNTER
9 8 7 6 5 4 3 2 1
32
ADV
RESET
LOAD A
LOAD B
34
36
DATA BUS
33
A
41
42
49
51
52
59
SC1
SC2
SC9
SEGMENT COUNTERS A
SEGMENT COUNTERS B
60
62
82
83
72
74
76
78
80
81
O
BLANK
EOS
(END OF SCAN)
B
A

FIG. 2

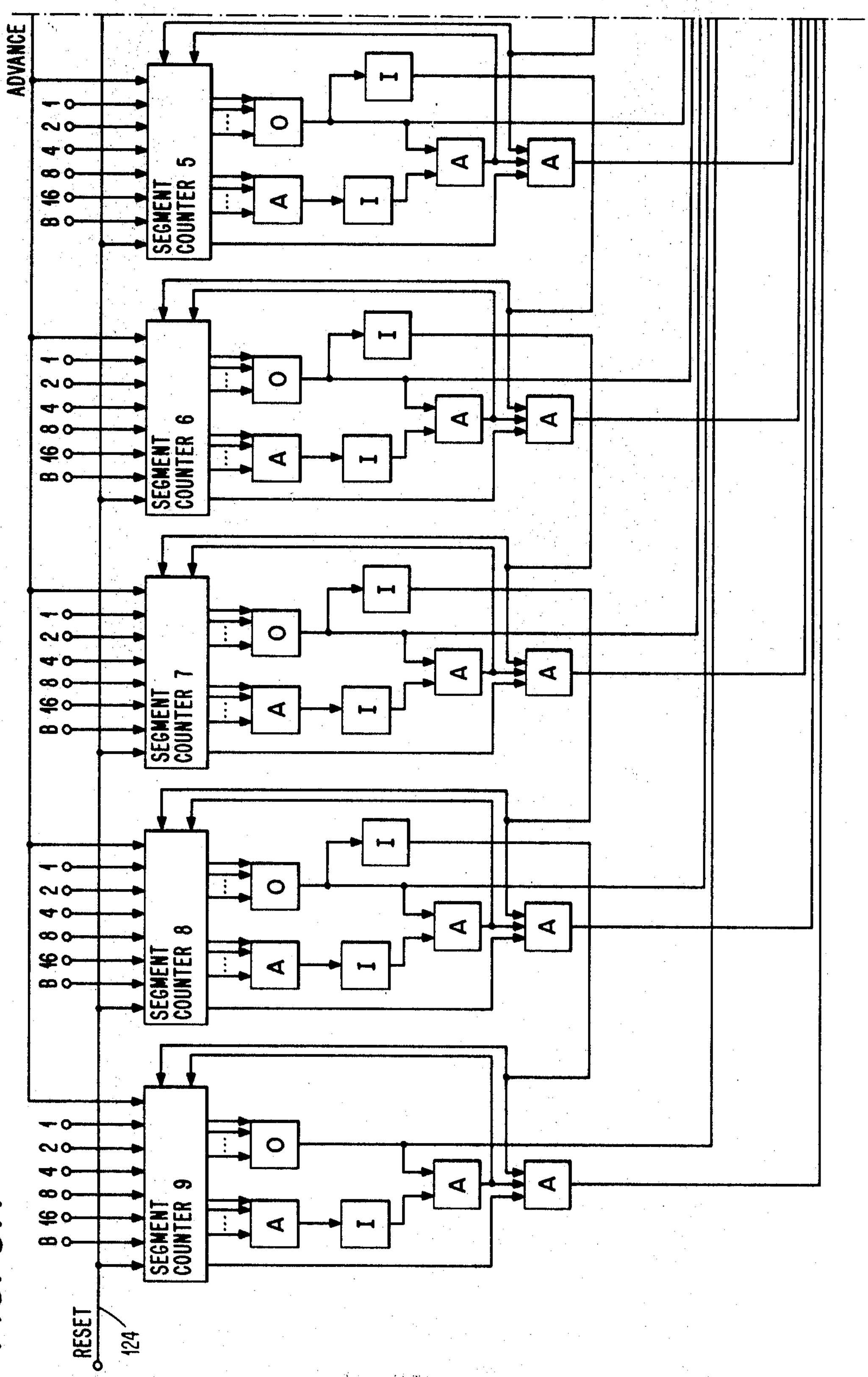
ADVANCE
B 16 8 4 2 1
SEGMENT COUNTER 5
SEGMENT COUNTER 6
SEGMENT COUNTER 7
SEGMENT COUNTER 8
SEGMENT COUNTER 9
O
I
A
RESET
124

FIG. 3A

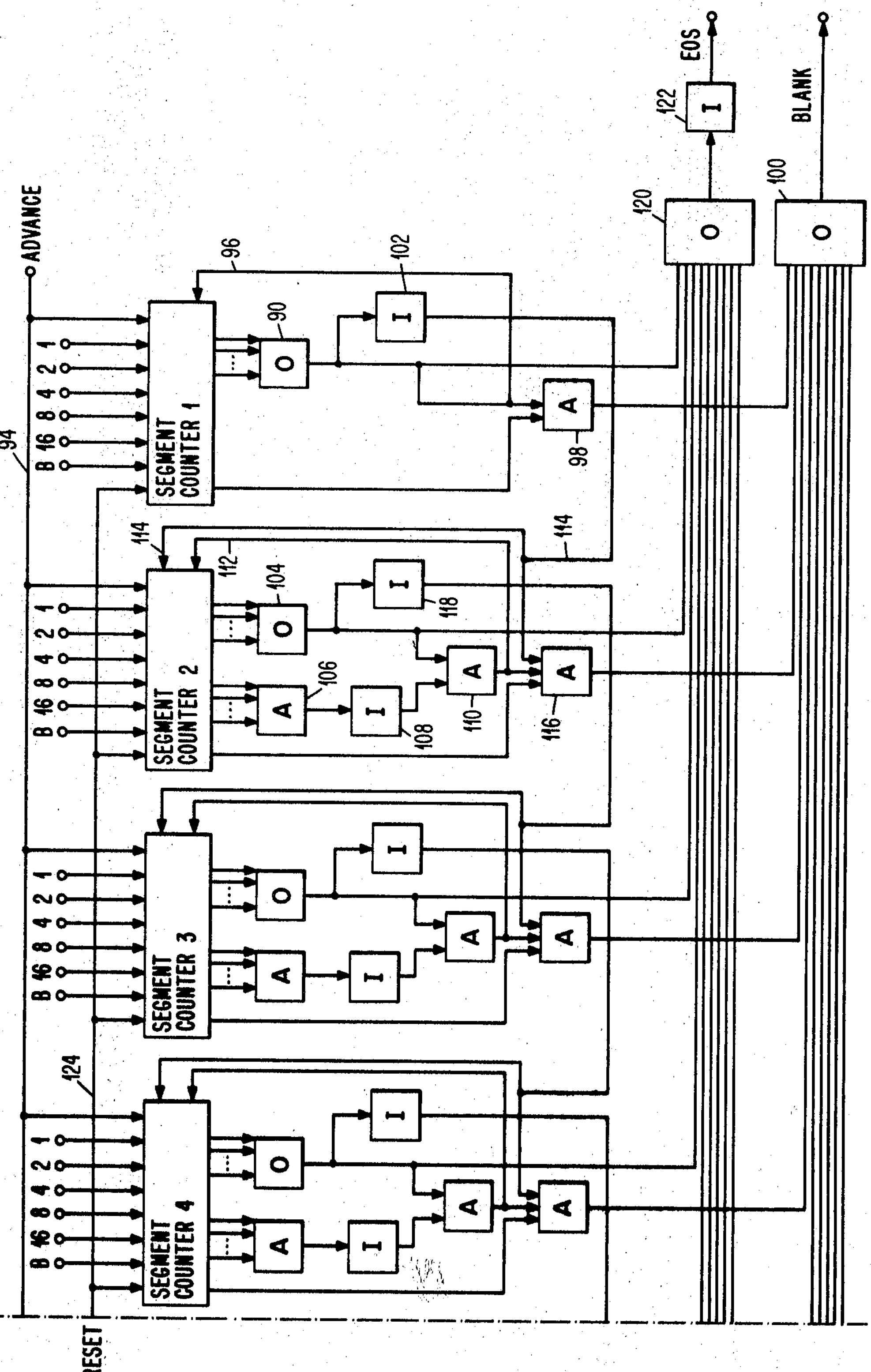
ADVANCE
RESET
EOS
BLANK
SEGMENT COUNTER 1
SEGMENT COUNTER 2
SEGMENT COUNTER 3
SEGMENT COUNTER 4
B 16 8 4 2 1
94
96
90
102
98
114
112
104
118
106
108
110
116
124
120
122
100

FIG. 3B

CHARACTER GENERATION BY IMPROVED SCAN, STORAGE, AND DECODING APPARATUS

BACKGROUND AND OBJECTS OF THE INVENTION

The invention relates to an improved system for storing and decoding scan intensity information in a raster scan character generator. More particularly, the black and white segments, which make up each scan, are stored as segment counts. The segment counts are serially arranged so that a segment position in a scan is defined by the associated segment count's location in the sequence of segment counts making up a scan.

Raster scan character generators are well known in the art. Controlling scan intensity by coordination of counting out stored counts in synchronism with movement of the scanning beam is also well known. In the past, these scan counts which control intensity have been of two types which are overly complex.

One technique defines black and white segments in a scan as a character is generated, by using an address to specify the bottom of each unblanked character segment. The size of the unblank segment is defined by an additional count.

The second technique in the prior art is to define the address of each black/white transition and white/black transition relative to a reference line. Counts or addresses defining these transition points in a scan are then loaded into a plurality of counters with each counter being advanced or counted simultaneously with movement of the scanning beam.

The address from the bottom of the character to the top of a character may consist of as many as 400 or more points. As the photoprinting art develops and more resolution is desired, the number of points in a vertical scan will increase even more. With a large quantity of address points in a single vertical scan, very large binary words are required for the addresses or counts in the prior art techniques. Also, the hardware to work with such large binary words is complex and expensive.

The real significance of a digital controlled photoprinter is the ability to attach such a photoprinter to a computer and have rapid communication between the computer and the photoprinter. When large binary words are used, the communication between the computer and the photoprinter is more difficult. Therefore, the operation of a digital controlled photoprinter system is greatly simplified if the code for digital control of the cathode-ray beam is simplified.

It is an object of this invention to simplify the code by which black and white segments in a digital controlled photoprinter are codified for display control.

It is a further object of this invention to simplify the decoding hardware used to convert a digital signal into a black and white segment in a character generator.

SUMMARY OF THE INVENTION

In accordance with this invention the above objects are accomplished by coding the black and white segments making up a scan in a character generator into digital counts which specify the length of each segment. The positions of the segments relative to each other are defined by the sequential arrangement of the segments as they are decoded.

The hardware implementation may take several forms. Shown herein are two implementations. In the first implementation, the sequence of segment counts making up a scan are loaded into a plurality of counters. The segment counts are then serially counted out by the counters according to their sequential arrangement. As the counting proceeds, the scanning beam is moving along a scan so that the length of each segment count as it is counted out will specify the length of a blank or unblank segment in the scan.

In the second implementation, the segment counts are buffered and fed sequentially to a single counter. After the counter counts out a segment count during a scan of the cathode ray beam, the next sequential segment count is loaded into the counter. This second implementation requires only a single counter. However buffering stages are also required in order to store the sequential segment counts until the counter can be reloaded.

The great advantage of the invention is that the segment counts can be represented by smaller binary words than address positions, as used in the prior art. Further, there is no need for hardware to monitor address positions of the cathode-ray beam in this invention. Instead, the position of the segments in the display are controlled by their sequential arrangement as they arrive at the counter decoder. This latter advantage results in a considerable reduction in hardware and, in turn, in of cost in decoding a digital signal into a scan segment.

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

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1A shows a character "B" with a grid overlay defining the length of vertical segments in a scan through a character.

FIG. 1B shows the segment-count codes for a scan through the character "B" of FIG. 1A for one embodiment of the invention.

FIG. 1C shows the segment-count codes for the scan in FIG. 1A for an alternative embodiment of the invention.

FIG. 2 shows a segment count decoder wherein sequential segment counts making up an entire scan are loaded into a plurality of counters which are sequentially counted out.

FIGS. 3A and 3B show the logic schematic of either segment counter in FIG. 2.

FIG. 4 shows a segment count decoder wherein a single counter is used, and the sequence of segment counts are buffered into the single counter.

DETAILED DESCRIPTION

In FIG. 1A the outline of a character "B" to be generated is shown with a grid overlay. Each vertical column of the grid represents a scan by a cathode-ray beam. As the cathode ray beam raster scans vertically and is indexed horizontally, it prints the character by having its beam blanked and unblanked during segments of each scan. The length of a blank or unblank segment in a given scan is defined by the number of blocks in a segment of a scan that are all black or all white.

Of course, the width of a scan and the length of each block in each scan is greatly exaggerated in FIG. 1A so as to indicate how a character may be coded. In actuality the scans are much thinner and contain many more blocks. In a final display, the resolution is such that to the naked eye the periphery of the character appears to be continuous.

In FIG. 1B, a segment-count code consists of five-count bits and one EOS (End of Scan) bit. The five-count bits in the segment code indicate the number of blocks in a segment, i.e., the length of a segment. For example, in the scan shown, starting from bottom and proceeding to the top of the scan, the block lengths are two white, three black, five white, six black, four white, and three black. This sequence of counts is represented in segment-count codes of FIG. 1B. In addition, the topmost black segment has a one bit in the end-of-scan bit position. This one bit indicates that no more meaningful information exists in the scan, and that the cathode-ray beam can flyback and proceed with the next scan used to print the character.

The segment-count codes in FIG. 1C are identical to those in FIG. 1B with two exceptions. First, an extra segment-count code is used at the top of the character to indicate the top white portion, which in this case has a length of two blocks and, thus, a segment count of two. The second difference is that, in place of the end-of-scan bit, this code has a blank bit. The blank bit indicates whether a given segment count represents a black or white segment. In the table shown, a 1 bit indicates white and a 0 bit indicates black. Of course, the code can be reversed as desired. In this code there is no need for an end-of-scan bit since the cathode-ray beam is always directed through a full scan. End-of-scan is indicated by all of the segment counts having been counted out.

The hardware for decoding segment counts of the type shown in FIG. 1C is the embodiment shown in FIG. 2. As background for the photoprinting system envisioned for using either embodiment of this invention, reference should be made to Pat. application Ser. No. 682,843, filed Nov. 14, 1967, "Reciprocating Lens Photocomposer," by Ernest P. Kollar.

In one preferred embodiment of the invention, a plurality of counters are used and sequentially operated to count out segment counts in a scan as shown in FIG. 2. There are two groups of segment counters — segment counters A and segment counters B. The purpose of having two groups is so that one group of segment counters may be counted out, while the other group is loaded with segment counts defining the next scan. The operation of segment counter group A or B will be described shortly with reference to FIGS. 3A and 3B. In FIG. 2 the control signals used to load the segment counters and count out the segment counters are shown.

In FIG. 2, the counter 32 is used to distribute the segment counts to specific counters in the groups of segment counters A or B. Counter 32 is under computer control so that it may be advanced as each segment-count code arrives on data bus 33. Counter 32 is also reset under computer control after segment counts defining a scan have been distributed.

AND gates 34 and 36 control whether segment counters A or segment counters B receive the distribution pulses from counter 32. AND gate 34 is enabled by a Load A control signal, while AND gate 36 is enabled by a Load B control signal. Segment counters A and B are reloaded as soon as possible after their counts are counted out. As soon as counters A or B are counted out (indicated by end-of-scan) the appropriate Load A or Load B signal comes up. The counters A or B are thus always loaded and ready when their turn to count out occurs.

AND gates in the 40 series utilize the distribution pulses from counter 32 to distribute segment counts into segment counters A. Thus, a pulse on line 1 from counter 32, passed by AND gate 34, will enable AND gate 41 to pass the first segment count SC 1 to the first segment counter in counters A. Next, a pulse on line 2 enables AND gate 42 to pass the second segment count SC2 to the second segment counter in the segment counters A. This procedure continues until a pulse on line 9 from counter 32 enables AND gate 49 to pass segment count 9 into the ninth segment counter in segment counters A.

AND gates in the 50 series operate in the identical manner to load segment counts into segment counters B. Of course, AND gates in the 50 series will not receive distribution pulses from counter 32 until the AND gate 36 is enabled by the Load B control signal.

To control which group of segment counters A or B is counted out, the advance pulses from a scan/unblank synchronizer are gated by A and B cycle control signals via AND gates 60 and 62. A scan/unblank synchronizer is shown in FIG. 4 of copending Pat. application Ser. No. 682,843, filed Nov. 14, 1967, "Reciprocating Lens Photocomposer," by Ernest P. Kollar. During A cycle operation, the advance pulses are passed by AND gate 60 to the segment counters A. Conversely, during B cycle, the advance pulses are passed by AND gate 62 to the segment counters B.

Similarly, the monitoring of the segment counters A and B for blank/unblank signals and end-of-scan signals is controlled by AND gates in the 70 series. During A cycle operation, AND gate 74 is enabled to pass the blank/unblank signal and AND gate 78 is enabled to pass the end-of-scan signal. Likewise, during B cycle operation, AND gate 72 is enabled to pass the blank/unblank signal, and AND gate 76 is enabled to pass the end-of-scan signal.

OR gates 80 and 81 act to collect the outputs of their associated AND gates. In particular OR gate 80 monitors AND gates 72 and 74 to generate a blank/unblank signal during either A or B cycle. Similarly, OR gate 81 monitors AND gates 76 and 78 to generate an end-of-scan signal during either A or B cycle.

AND gates 82 and 83 in the left, bottom corner of FIG. 2 are alternately enabled by the A and B cycle signals to reset the groups of segment counters A or B. The reset operation occurs shortly after the end-of-scan signal is generated during a given cycle. Thus, after a group of segment counters is counted out to zero and the end-of-scan signal is generated the reset signal sets all the counters back to all 1's. Thereafter the Load A or Load B signal can reload the appropriate counts A or B when the segment counts from the next scan are available over the data bus 33.

The operation of FIG. 2 proceeds in the following sequence. Assuming the segment counters in groups A and B have been reset so that they all contain 1's, then a Load A signal enables AND gate 34 so that distribution counts are passed through the AND gates in the 40 series to load segment counts into segment counters A.

Thereafter, A cycle control signal enables AND gate 60. Advance pulses then count out segment counters A. The monitoring of the blank/unblank condition from the segment counters A is carried out by AND gate 74 which is also enabled. When all segment counts have been counted out of counters A, AND gate 78 passes the EOS signal. After the EOS signal, a reset signal is passed by AND gate 82 to reset the segment counters A. Counters A may then be loaded again by another Load A signal. In the meantime while segment counters A were being counted out, a Load B signal enabled AND gate 36. The next scan (sequence of segment counts) was then loaded into segment counters B, while segment counters A were counted out.

During the B cycle, the segment counters B are being counted out by advance pulses passed by AND gate 62. The blank/unblank information counted out of counters B is passed by AND gate 72 to OR gate 80 and on to the blank/unblank driver (not shown). When all of the segment counts in segment counters B have been counted out, the end-of-scan signal will be passed by AND gate 76 to OR gate 81. Shortly thereafter the segment counters in group B will be reset to all 1's by the reset signal passed by AND gate 83. This alternating procedure of counting out one group of segment counters while the other group of segment counters is loaded is continued as long as the photoprinting operation is desired. The photoprinting operation is under control of a computer.

Referring now to FIGS. 3A and 3B, one group of segment counters is shown. This group could be either group A or group B of FIG. 2. For simplicity of discussion it will be assumed that the group of segment counters in FIGS. 3A and B are the group A segment counters. The group B segment counters would operate in the identical manner.

Examining FIGS. 3A and B, it is clear that each segment counter is loaded with six bits in parallel. These six bits come in over a cable from the associated AND gate. For example, segment counter 1 is loaded when AND gate 41 (FIG. 2) is enabled. Segment counter 2 is loaded with six bits in parallel when AND gate 42 (FIG. 2) is enabled. The remaining segment counters 3 through 9 are loaded in the same manner under control of the hardware shown in FIG. 2.

The six bits constitute the segment-count code shown in FIG. 1C. The left-hand most bit defines whether the segment count indicates a blank or unblank segment. The remaining five bits indicate the count and thus the length of the segment.

Each segment counter is made up of six trigger circuits with five of the trigger circuits being connected together in a counter configuration as is well known. The sixth trigger circuit stores the B bit or the blank bit.

The operation of the logic tied onto the segment counters will be described with regard to segment counters 1 and segment counters 2 only. All other segment counters operate in the same manner as segment counter 2. Initially, it is assumed that a sequence of segment counts defining a scan have been loaded into the segment counters 1 through 9. As the cathode-ray beam begins its scan, advance pulses from a scan/unblank synchronizer appear on line **94**. The advance pulses **94** operate initially on segment counter **1** only. When segment counter **1** is counted out to zero, the advance pulses will then be applied to segment counter **2**.

Referring to segment counter **1** and its associated logic, OR gate **90** monitors all of the count triggers in the counter. If any trigger has a **1** (there is some count in the counter), OR gate **90** will have an output signal. This output is fed back via line **96** and used to gate advance pulses into segment counter **1**. The output also enables AND gate **98**, which passes the blank/unblank condition stored in the sixth trigger through to OR gate **100**. If the segment counter has stored a blank condition, then this blank condition is passed by OR gate **100** to blank the cathode-ray intensity. This blank condition will continue so long as OR gate **90** has an output which conditions AND gate **98**. OR gate **90** will cease to have an output when the segment counter **1** has been counted out to zero. When this occurs, AND gate **98** is inhibited. Also, line **96** no longer has a signal, so the advance pulses are no longer gated into segment counter **1**. Since the signal level out of OR gate **90** has dropped, inverter **102** will now have an up level as an output.

Segment counter **2** is next counted out. OR gate **104**, monitoring segment counter **2**, will have an output since counter **2** has not yet been counted out. AND gate **106** will normally not have an output so that the inverter **108** will normally have an output which will enable AND gate **110**. With AND gate **110** enabled, the output from OR gate **104** is passed by line **112** back to segment counter **2**. The output from inverter **102** from the previous segment counter is also passed to the segment count **2** via line **114**. When lines **112** and **114** are both up, segment counter **2** is gated to receive the advance pulses from line **94**.

The function of AND gate **106** and inverter **108** is to disenable the monitoring information of OR gate **104** in the event all of the count positions loaded into segment counter **2** are 1's. An all **1** segment-count code is a code word not used by the segment counters for controlling beam unblanking. The code word has another purpose in the photoprinting machine which is not relevant to the segment-count scan control. It is only necessary that the segment count scan control ignore the code word. AND gate **106** accomplishes this by monitoring the segment-count code for all 1's and inhibiting AND gate **110** in the event all 1's are present.

Assuming that the count is other than all 1's, the OR gate **104** output is passed by AND gate **110** to AND gate **116**. Thus, AND gate **116** is conditioned by the output from AND gate **110**; it is also conditioned by the output from inverter **102** associated with the previous segment counter. AND gate **112** passes the blank or unblank information stored in the sixth trigger of segment counter **2** to the OR gate **100**.

When the count in segment counter **2** is counted out to zero, the output from OR gate **104** will drop. This will inhibit AND gate **116** and also inhibit further advance pulses from being applied to segment counter **2**. Inverter **118** will have an output which is then passed to segment counter **3** stage to enable its operation. The remaining segment counters **3** through **9** operate in exactly the same manner as segment counter **2**.

After segment counter **9** has been counted out to zero, all of the OR gates, which monitor the segment counters, no longer have an output. This lack of output will mean that OR gate **120** will no longer have an output. The drop in output from OR gate **120** is inverted by inverter **122** to produce the EOS (end-of-scan) signal. Shortly after the EOS signal, all of the segment counters are reset to contain all 1's by a signal on line **124**.

Referring now to FIG. **4**, another preferred embodiment of the invention is shown. This embodiment uses the segment-count codes of FIG. **1B**.

In FIG. **4**, it is assumed that the first segment-count code is on data bus **210**. This code is sent from the computer operating with the photoprinting system. The computer also energizes line **211** which enables the AND gates shown generally at **213** so that the first code character is transferred into register **214**. Counter **215**, which in an initial state contains all zeros, is monitored by a zero detect circuit **216**. Since the counter **215** contains all zeros, the zero detect circuit **216** will condition AND gates **237** to pass the counts from register **214** to counter **215**. Thus, the first segment count will be transferred immediately from the data bus **210** through register **214** to the counter **215**.

As soon as the count is loaded into counter **215**, the zero detect circuit **216** no longer has an output. Consequently, AND gates **217** are deconditioned and will not pass the count stored in register **214** to the counter **215**.

After the drop in signal from zero detect **216** passes through delay **218**, it is sensed by the computer at terminal **219**. The computer in response to this drop in signal places the next segment count on the data bus **210** and introduces a second load register command on line **211**. Line **211** again enables gates **213** and the second segment count is loaded into register **214**.

To utilize the segment counts now available in counter **215** and register **214**, the scan/unblank synchronizer **220** operates to coordinate the sweep of the cathode-ray tube with intensity control by the segment counts. The scan/unblank synchronizer **220** is described in FIG. **4** the aforementioned copending Pat. application Ser. No. 682,843, filed Nov. 14, 1967, "Reciprocating Lens Photocomposer," by Ernest P. Kollar.

As described in FIG. **4** of the cited patent application, the scan/unblank synchronizer puts out pulses on line **222** which advance the count in the counter **215**. These pulses occur while the scanning beam is moving upward during each scan. The time between advance pulses on line **222** is equated to vertical distance since the scanning beam is moving along a column scan as the advance pulses are generated by the synchronizer **220**. One advance pulse in effect corresponds to one block in the grid of FIG. **1A**.

As counter **215** is counted down by the advance pulses, the scanning beam is moving along a column scan. When the zero detect **216** detects that the counter **215** has counted out to zero, it generates a signal. The leading edge of this signal is used to AC-trigger flip-flop **224**. The state of Flip-flop **224** controls the unblank driver **226**. Unblank driver **226** controls whether the beam intensity is on or off.

Initially, the unblank driver controls the cathode ray beam so that it is off. Accordingly, when the first segment count is counted out indicating the end of the first white segment, the flip-flop **224** is changed in state and unblank driver **226** turns the cathode-ray beam on. The cathode-ray beam will stay on until the leading edge of the next signal from zero detect **216**.

The signal from zero detect **216** is also passed to AND gates **217** to load the count stored in register **214** into counter **215**. The zero detect signal is also delayed by delay **218** and then sent to the computer over line **219**. The computer then loads the next segment count into register **214** by enabling AND gates **213**, as previously described.

This procedure continues with counter **215** successively counting out segment counts and zero detect **216** triggering flip-flop **224** to switch the unblank driver of the cathode ray beam on and off. Finally, the last segment-count code in a scan will contain an EOS (end-of-scan) bit. When this last segment count in a scan is loaded into counter **215**, the end-of-scan bit will enable AND gate **228**. At the end of this segment count, the signal from zero detect **216** is passed by the enabled AND gate **228** back to the scan/unblank synchronizer **220**. This signal out of AND gate **228** over line **30** indicates to the synchronizer **220** that the scan has been completed. No further advance pulses are passed from the synchronizer **220** to the counter **215** until the next upward scan.

Of course, the zero detect signal that is passed by AND gate **228** also operates in the normal manner to condition AND gates **217** to load the next segment count into counter **215**. This next segment count is the first segment count for the next scan. That segment count will have no end-of-scan bit, and AND gate **228** will be deconditioned as soon as counter **215** is reloaded. Counter **215** stores the first segment count of the next scan until the advance pulses again arrive over line **222** from the synchronizer **220**.

Two embodiments of the invention have been described above. Of course, there are many variations in hardware which might be used by one skilled in the art to implement either embodiment. The significant features are that the digital words used to control scan intensity are segment counts rather than addresses on the cathode ray screen, and that the position of a segment on the cathode ray screen is controlled by the sequential arrangement of the segment counts.

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

What I claim is:

1. In symbol generating apparatus for displaying entire symbols or pieces of symbols wherein a raster scanner scans an area with a series of parallel scans, and said scanner marks or does not mark during a scan depending upon whether the scanner is unblanked or blanked, respectively, and wherein the improvement comprises:

means for storing a series of segment signals, each segment signal defining the length of a blank or unblank segment in a scan without reference to other segment signals;

means for sequentially decoding each stored segment signal to determine the length of each segment in the sequence of segments making up a scan;

means for detecting whether a segment signal represents a blank or unblank segment in the scan and generating a blank/unblank signal;

means for blanking or unblanking said scanner in accordance with the blank/unblank signal during each segment of a scan for the segment length decoded by said decoding means so that each scan during symbol generation is composed by a serial sequence of decoded segment signals.

2. The symbol generating apparatus of claim **1** wherein said storing means comprises:

a serial array of counters, each counter storing a count indicative of the length of a segment.

3. The symbol generating apparatus of claim **2** wherein said decoding means comprises:

means for advancing the count in each counter so that the length of a segment is defined by counting out the count in said counter;

said advancing means operating sequentially on the counters in the serial array so that as one counter is counted out, said advancing means advances the count in the succeeding counter.

4. Photoprinting apparatus for printing symbols on radiant energy responsive medium comprising:

cathode-ray scanning means for raster scanning an area of the medium with a series of parallel scans, each scan made up of alternate blank and unblank segments;

counting means for counting segment counts where each segment count indicates the length of a blank or unblank segment;

means for loading a predetermined sequence of segment counts into said counting means where the sequence of segment counts makes up a single scan;

clocking means synchronized with said scanning means for advancing said counting means;

said counting means sequentially counting out the segment counts according to the predetermined sequence of the segment counts;

means for alternately blanking and unblanking said cathode-ray scanning means, where the length of time the scanning means is blanked or unblanked is dependent upon the time required to count out a segment count in said counting means.

5. The photoprinting apparatus of claim **4** wherein said counting means comprises a plurality of serially connected counters, each counter storing a segment count, successive segment counts in the sequence of segment counts being loaded into successive counters by said loading means.

6. The photoprinting apparatus of claim **5** further comprising gating means for gating the advance pulses from said clocking means to the counters in succession as each counter is counted out so that segment counts sequentially loaded into the serially connected counters are sequentially counted out.

7. The photoprinting apparatus of claim **5** further comprising:

means for detecting that all of the serially connected counters contain all zeros;

means for gating an end of scan signal to said scanning means when said detecting means detects all counters contain zeros.

8. The photoprinting apparatus of claim **5** further comprising:

a second plurality of serially connected counters for storing a second sequence of segment counts;

second loading means for loading alternate sequences of segment counts into said second plurality of serially connected counters whereby alternate sequences of segment counts are loaded in said second plurality of serially connected counters while the other sequences are loaded in the other plurality of serially connected counters;

said second plurality of serially connected counters being responsive to said clocking means for counting out the alternate sequences of segment counts whereby the two pluralities of serially connected counters are operating alternately on alternate sequences of segment counts.