The scanning of the character generation apparatus is improved by the generation of horizontal and coarse vertical automatic position control signals subsequent to the initial accessing of a character and prior to the actual scanning of a character image whereby the speed of accessing a selected character is increased and the logic and electronic control circuitry for operating the system is simplified. Two different rate scanning rasters are used with a fast scanning raster used to correct the position of the character generator beam and a slower scanning raster is used to actually scan the character.

Provision is made for ensuring the correct storage of width values in a memory. The width values appear in coded format and are associated with at least one of the indexing bars forming each of the character fields on a character font.

Increased speed and improved operation of the output reproduction apparatus is obtained by jump scanning non-character spaces which may include interword and intercharacter spaces used for justification of a composed text.

13 Claims, 21 Drawing Figures
FIG. 5B

NOTE:
1. EXAMPLE USED: 5 UNIT CHARACTER; 5 PT, SET TO YIELD 25 CAN STROKES.
2. SHADED AREA INDICATES SIGNAL ACTIVE
3. AAC PERIOD 37 \( \mu \)S FOR 5PT, 5 SET
4. AAC PERIOD DURING VAPCG IS 87 \( \mu \)S FOR 15 PT.

FIG. 6

SPACE COUNTER 170
MULTIPLEXER 168
CONTROL
LINE POSITION COUNTER
STROKE COUNTER
DAC 122
CRT. DEFL. AMP.

CHARACTER WIDTH
OUTPUT COUNTER 160
STROKE COUNT
LPC 120
172
BUFFER
FIG. 7A

PRIME

RESET

SCAN FONT

READ & STORE WIDTH CODES DURING SCAN

SCAN FONT SECOND TIME

READ WIDTH AND COMPARE

TEST FOR ERROR

ERROR

NO ERRORS (PRIME COMPLETED)

FIG. 7B

WIDTH RNG.

CHAR. SAG.

HP 1

HP 2

HP 4

HP 8

184 ROM

OR 0

OR 1

OR 2

OR 3

OR 4

OR 5

OR 6

CASE

DIGITAL

FIG. 7E

FONT GRID

TO SELECT e:

I1c = +0.625V

I1z = -0.625V

(BEAM IS DIRECTED TO THE UPPER LEFT OF THE CHARACTER)

- 6.875V

RIGHT +5.625V

DOWN +5.625V

- 5.625V
**Fig. 9A**

VOLTAGE AT PIN 26 IS INVERSELY PROPORTIONAL TO POINT SIZE (-10V MAX)

**Fig. 9B**

AAC WIDTH ADJ.
CHARACTER IMAGE GENERATION APPARATUS
AND CRT PHOTOTYPESETTING

BACKGROUND OF THE INVENTION

This invention relates to apparatus for improving certain functions and operations of the character image generation apparatus and CRT phototypesetting system as set forth in co-pending application Ser. No. 467,536, filed May 6, 1974, and assigned to the same Assignee as the present application. In particular, the present apparatus provides an improved automatic position control for controlling the electronic scanning of the selected character images over that which is disclosed in the aforementioned co-pending application. Additionally, this invention increases the speed of the cathode ray tube by apparatus which causes the CRT beam to jump the actual white spaces between the characters rather than scanning such white spaces as does the CRT beam in the aforementioned co-pending application. Finally, the present invention provides structure for a read width cycle during which the width codes associated with each of the respective characters on a font matrix are read and compared to determine valid width values which are stored in a memory for use during the printing of a character by the CRT beam.

The improved image dissector and CRT phototypesetting system of the present invention uses essentially the same basic apparatus as is used in the aforementioned co-pending application and the disclosure of that application is incorporated herein by reference.

The character generation system of the present invention overcomes certain difficulties of prior art systems by utilization of character signal generation apparatus such as the basic image dissector tube as conceived by Farnsworth in 1923, but with state of the art improvements that provide enhanced performance. For example, improved coil and dynamic focus assembly construction has resulted in significantly higher signal resolution. Additionally, geometric distortion has been reduced and there has been an overall improvement in the signal output of such devices. Such an image dissector tube is very simply constructed, is relatively inexpensive compared to the prior art digital and analog type character generation apparatus, and produces electronic signals representative of character images with sufficient accuracy and detail to provide characters in a desired text meeting modern high-speed printing standards.

The image dissector used in the character generation apparatus of the invention does not require additional complex electrode or element structure, such as a grid structure for selecting one of a number of channels each of which is associated with a given character, for generating the necessary electron character images. An example of such a system is Columbia Broadcasting System's Inc. Linatron. One primary difficulty in using a single aperture image dissector tube of the type described above resulted from the inability to accurately locate a desired character among a group of characters on a font matrix and accurately scan the character to generate the necessary electron beam image representative of the character.

A primary feature of the present invention which enables the use of an image dissector tube for generating the character images resides in the technique for providing quick and accurate access to a selected character and for generating horizontal and vertical automatic position control signals for controlling the vertical and horizontal deflection so that the character may be scanned to produce the necessary electronic signals representative of the character.

The operation of the entire character generation and reproducing system is enhanced by the generation of horizontal and coarse vertical automatic position control signals prior to the actual scanning of the character image by means of relatively simple circuitry which senses the video. The use of such vertical and horizontal automatic position control signals further enhances the use of the basic image dissector tube, increases the speed of the system with respect to the access of a selected character, and decreases the complexity of the logic and electronic control circuitry for operating the system.

In the present invention the character scanning is enhanced over that which is disclosed in prior art systems and in particular that which is disclosed in the aforementioned U.S. patent application. The scanning is divided into a fast and a slow scan and during the fast scan the scanning deflection voltages are adjusted so that the actual character scanning begins at an optimum location adjacent a character to be scanned. The two speed scanning increases the speed and accuracy of character scanning. During the slow scan the vertical deflection voltages are finely and repetitively corrected to maintain the proper initial position of the vertical scanning strokes.

Phototypesetting systems have used character fonts in which the character widths are physically associated with the respective characters and that width information is detected and stored for proper escapement of the characters in the desired textual format. The present invention utilizes a character font in which the character widths appear in coded format adjacent the characters. However, in the present invention the character widths are read and stored in memory during a width read cycle in the prime mode of operation of the system. The character widths are read twice in sequence and compared to ensure that the character data stored in memory is error free. In some previous phototypesetting systems, the character width is read just prior to the scanning of a character, as is for example utilized in the phototypesetting description described in the aforementioned U.S. patent application. The width reading as performed by this invention enables the scanning of a selected character to be initiated more readily as the width code is not read for each character during the printing cycle.

Additionally, in the present invention the character font has been modified to increase the area to which the initial scan of a character is directed by the horizontal and vertical address deflection voltages. Thus, the present system will accommodate a larger initial deflection error than prior art systems of a similar type.

An improvement of the invention includes a "jump scanning" of the output CRT device in which the spaces between characters are not scanned. The spaces include interword and intercharacter spaces used for justification and fixed space. A technique for automatically and accurately locating a desired character among a group of characters on a font matrix is described in U.S. Pat. No. 3,497,761 entitled "Cathode-Ray Tube Apparatus" in the name of C. A. Washburn. Another improvement of the invention includes offsetting the character generation scan after correcting the position of the scan with respect to the indexing
bar. This eliminates a lateral positioning error of the first scanned edge of the reproduced character.

OBJECTS OF THE INVENTION

It is a primary object of the present invention to provide improved automatic position control circuitry for an electronic scanning character generation system for use in a cathode ray tube phototypesetting system.

It is another primary object of the present invention to provide apparatus in a character image generation and CRT phototypesetting system for reading and storing width data associated with respective characters on a character font.

It is yet another primary object of the present invention to improve the printing speed of a character image generation and CRT phototypesetting system by causing the CRT beam to jump non-character spaces between the characters of the text.

Still another object of the present invention is to provide an improved automatic position control for the generation of characters from an electronic scanning character generation system by using a two-speed scan control.

Another object of the present invention is to provide an improved automatic position control for scanning selected characters in a system of the type specified herein wherein indexing bars and logic circuitry are utilized to improve the accuracy of positioning the character scanning and the allowable initial character deflection error.

It is still yet another object of the present invention to minimize errors in the reading of the width code from a character font.

A still further object of the invention is to increase the printing speed of the cathode ray tube in a phototypesetting system of the type specified herein by the employment of logic circuitry which causes the CRT beam to jump for non-character spaces.

Yet another object of the invention is to eliminate lateral positioning error of the reproduced character.

SUMMARY OF THE INVENTION

A font matrix of characters in a two-dimensional pattern is irradiated by a lamp to provide simultaneous character light images on the photocathode of an image dissector tube. The characters to be reproduced are determined from a tape reader and stored in a memory buffer thereby enabling the character generation system to be independent of the source input as well as to enable the justification of the text if that is desired. A selected character is addressed by the application of major vertical and horizontal deflection control signals to the image dissector tube, which are representative of X and Y addresses of the characters on the font matrix. Position correction circuitry utilizes the video output of the image dissector tube to correct the position of the scan of the character with respect to indexing bars which define individual character areas. At least one of the indexing bars includes encoded width data for each character. The scan of a character begins with a fast scan of the indexing bars during which time the necessary minor corrections are applied to the scanning deflection signals in preparation for the actual scanning of the character.

The improved automatic position control utilizes a two-speed scanning technique wherein a high-speed scanning is employed for the first seven vertical strokes of the character image scanning during which time the indexing bars are utilized to position the stroke at a position immediately adjacent the upper left portion of a selected character. Prior to scanning the character, the scanning strokes are offset to position the first active stroke at the edge of the character field. During the subsequent character scanning strokes the vertical position is sensed using automatic position control bars associated with the selected character on the character font to control and finely adjust the vertical position of the scanning.

The coded character widths are detected and stored in memory during a read width cycle in a prime mode of operation of the phototypesetting system in which each width code on the character font matrix is read, stored, re-read, and compared to minimize width error. Any comparison errors will generate a new read width cycle. The width code on the character font is contained within and in close proximity to automatic position control bars where the beam position is most accurate. Additionally, the code reading stroke video signal is highly filtered to minimize noise errors.

The speed of the output reproducing system is increased by causing the CRT beam to jump non-character space such as spacebands, letterspaces, etc. in a given line of text. Such non-character space is added to a line position counter by means of logical adder circuitry. The horizontal position of the CRT beam is directly controlled by the line position counter through a thirteen-bit I/A converter and a deflection amplifier.

Normally, each character is formed by a great number of strokes, each of which advances the actual beam one eighteenth point (0.00076 inches). In the aforementioned co-pending application all fixed spaces (thin, EM and EN) plus spacebands are also stroked as normal characters. The improved apparatus and technique of the present invention result in a speed improvement of the CRT phototypesetting system of approximately two hundred lines per minute (from 300 to 470 LPM) in six point, eleven pica stock market output which contain a significant amount of non-character space.

The characters are produced on a film which is positioned in proper alignment and in contact with a fiber-optic face-plate on the viewing surface of a cathode ray tube. During character reproduction, the electron beam of the cathode ray tube is slaved to the scanning pattern of the image dissector tube, with the exception that the electron beam current of the cathode ray tube is maintained constant (except during blanked intervals and for producing pseudo-bold output) as is the velocity of the electron beam.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram illustration of the phototypesetting apparatus;
FIG. 2 is a simplified representation of the character generator;
FIGS. 3A and B are block diagram representations of the image dissector control circuitry;
FIG. 4 is a block diagram of the CRT control circuitry;
FIG. 5A is a block diagram of the control logic for the phototypesetting apparatus;
FIG. 5B illustrates digital control signals for character generation timing;
FIG. 6 is a block diagram representation of the CRT output jump ahead circuitry;
FIG. 7A is a flow chart representing the sequence of operations for width code reading;
FIG. 7B is a block diagram representation of the X and Y character select circuitry; FIG. 7C is a block diagram representation of the width decoder circuitry; FIG. 7D illustrates a portion of the character font showing an example of the width code beside the character and the manner in which the beam is positioned during the initial portions of the character scan; FIG. 7E illustrates the manner in which the deflection voltages are assigned to the font grid; FIG. 7F shows the digital control signals used for width read timing; FIG. 8 is a block diagram representation of the video processor circuitry; FIGS. 9A and 9B are block diagrams illustrating the vertical stroke generation circuitry; FIG. 10A is a block diagram representation of the vertical automatic position control circuitry; FIG. 10B illustrates the relationship of the character generator beam to the indexing bar on the character font during the initial strokes of the fast automatic position control sequence; FIG. 11A is a block diagram illustrating the horizontal automatic position control and stroke advance circuitry, and FIG. 11B illustrates the advance of the strokes during horizontal automatic position control; FIG. 12 shows an embodiment of a character font matrix illustrating the relationship of the character fields, the indexing bars and the width code data.

GENERAL DESCRIPTION

The input to the phototypesetting system comprises a six-level perforated tape containing justified text with line-ending codes. FIG. 1 is a block diagram representation of the basic system wherein control panel 20 provides the necessary data input to the system such as the line measure, point size, set size, leading value, and controls for letter spacing. The characters and width data are contained on font grid 22 which is illuminated by lamp 24 and projected through the font grid to projection lens 26 and onto the photocathode of image dissector 28. Initially the width value on font 22 of a selected character is read by image dissector 28 and stored in a width memory. Paper tape 30, containing the justified text, is read by reader 32 and provided to decoders in memory 34. Calculation logic within memory 34 may be provided to determine the spacing values to justify the copy to fit the selected measure. Such logic circuitry is well known to those skilled in the art and circuitry is well known to those skilled in the art and forms no part of the present invention. Output control logic 36 provides data and command signals to analog circuits 38, which drive image dissector 28 and Cathode Ray Tube (CRT) 40 to produce output copy on film 42 which is transported past fiberoptics 44 from film supply 46 to film cassette 48, which transport is controlled by film motor 50.

Image dissector 28 receives the light pattern from the font and produces video (black and white) signals for controlling the CRT beam by scanning the character image. The output copy on film 42 is generated by vertical strokes of light transmitted through the fiberoptics from the face of CRT onto film 42.

The input to the system may comprise, for example, a justified six-level TTS coded, paper tape. The phototypesetting CRT system preferably includes twelve type sizes, namely 5, 6, 7, 8, 9, 10, 12, 14, 18, 24, 30 and 36 point. The set size output is preferably from 5 point to 36 point. In the preferred embodiment there may be any line length of type up to 27 Picas, and leading is provided in one-half point increments up to 63% points. Font 22 consists preferably of one hundred six characters plus the special functions em, en and thin. Film 42 preferably comprises either three or 6 inch width paper.

The phototypesetting CRT system may be interfaced with a general purpose computer which has the capability of operating a TTS perforator. Additionally, tapes may be prepared on any TTS keyboard perforator which has a measure-counting capability. The system may also operate in conjunction with AP, UPI, or CPA transmitted paper tape wire services.

Tape reader 32 reads six-level TTS coded paper or Mylar tape at a rate of approximately five hundred characters per second and presents a six-level TTS code input to decoder circuitry within memory 34, which in turn controls the start/stop of reader 32. The memory and logic within memory 34 comprises plug-in IC chips. Analog circuit 38 processes video signals from image dissector 28, provides the logic within memory 34 with an analog active clock (AAC) control signal and raw unit widths from font grid 22. Analog circuits 38 include the CRT horizontal and vertical deflection amplifiers, CRT waveform generator, video processor, image dissector horizontal and vertical deflection amplifiers, image dissector video preamplifier, and other necessary control circuitry to be more fully described below.

The character generator comprises font grid 22, lamp 24, projection lens 26 and image dissector assembly 28, which preferably consists of an image dissector tube and associated deflection and focus coils. The character generation circuitry generates video information by scanning font 22 with vertical strokes of an electron beam.

The printer of the CRT phototypesetting system comprises cathode ray tube CRT 40 having fiberoptics face-plate 44, film supply 46 and film cassette 48. Photocopy output is generated by exposing film 42 with light transmitted from the CRT phosphor through a fiberoptic face-plate contacting the film surface.

SEQUENCE OF OPERATION

Font grid 22 is installed within the machine and control panel 20 is formatted as desired. The prime button on control panel 20 is depressed, thereby initializing logic circuits 34 within memory. The system is placed in a “prime mode” during which the width values on the font are read twice, and a comparison made to detect any errors in the sensed widths. If an error is detected the width read cycle is repeated. If no errors are detected the width values are placed in memory for future reference and the operational sequence proceeds as follows. The line measure inserted into the system from control panel 20 is stored in a width counter within memory 34. Justified paper tape 30 is placed within tape reader 32 and a start button on control panel 20 is depressed. Reader 32 runs forward, the codes thereon are read and stored in memory 34 until an end of line (return) code is sensed. The line may be processed by the logic within memory 34 to determine spaceband and letter-space values for justification. The line is then released to the character generator and printer (CRT 40) for printing. The logic within memory 34 provides the necessary controls and data to analog circuits 38 for point size, italicizing,
bolding, condensing or expanding of the output copy produced on film 42.

**IMAGE DISSECTOR**

With reference to FIG. 2, the image of an entire font is projected through the iris of lens 50, which has a two to one reduction ratio and onto photocathode 52 of the image dissector tube. Photocathode 52 is coated with a material that emits electrons from the areas that are struck by light. The electrons are attracted through an accelerating mesh 54 into a drift tube area 56. Focus coil 64 focuses the electron stream to a fine electron beam image of the font at the plane of aperture 62. Under the influence of horizontal and vertical deflection coils 58 and 60, the electrons are precisely allowed to pass through aperture 62 which has a diameter of 0.001 inches.

The electrons emitted from other areas of the font image are attracted to the plate portion of the aperture anode and are separated from the signal stream. A multiplier section 66 includes 68, 70 . . . 78, first dyode 68 is struck by the signal electrons to release secondary electrons which are greater in number than the original stream of electrons. Each succeeding dyode is more positive, thereby accelerating the stream of electrons and generating additional secondary electrons. The multiplied signal consisting of an electron stream is finally attracted to anode 80 and passes through a load resistor 82 thereby generating a video signal that corresponds in time with the sequence of scanning the character area of the font.

A character on the font is reproduced in video signal form as follows. The area on the font containing the desired character is coarsely located by selected horizontal and vertical deflection currents generated by digital/analog converters actuated from the tape input and connected to horizontal and vertical deflection coils 58 and 60. The black and white areas of the character are then scanned in linear vertical strokes from top to bottom, thereby causing output signal electrons corresponding to white portions of the scanned character to be directed through photocathode 52 and no output signal electrons corresponding to the black portions of the scanned character area. Each succeeding vertical stroke is directed slightly to the right of the last, allowing a new portion of the character to be scanned. Such stroking continues until the relative width portion of the area containing the character has been scanned. The variation in the number of electrons passing through anode load resistor 82 produces a voltage which is input to a preamplifier to provide a character generator output signal representative of the selected character.

As will be apparent from the following description, the CRT phototypesetting system is not limited to an image dissector tube for generating the required signals representative of the characters. Other devices capable of single channel operation such as flying-spot scanners, or photodiode arrays can also be used as part of the character generator apparatus.

**IMAGE DISSECTOR CONTROL CIRCUITRY**

With reference to FIG. 3A, a particular font character is accessed by digital address signals HP1 – HP8 and VP1 – VP8 (four-hits horizontal and four hits vertical) from four-bit digital analog converter 90. Converter 90 converts the four-bit digital levels into major horizontal and vertical deflection voltages. The X D/A and Y D/A output voltages are provided to horizontal deflection amplifier 92 and vertical deflection amplifier 94, which supply the image dissector horizontal and vertical deflection coils 58, 60 with a current that directs the beam of image dissector 28 to the approximate desired location on font 22. Digital/analog converter 90 also provides a focus-correcting waveform to focus regulator/modulator 96, which supplies a focus correction current while also regulating the basic focus current of the image dissector focus coil 98.

Point size register 100 provides a ten-bit output to vertical stroke generator 102 to generate the appropriate vertical strokes for directing the beam down through the character. It is noted that the amplitude of the character generator strokes has been made constant for all point sizes, but the velocity of the beam is greatest for small point sizes, in other words, the velocity of the beam is point size dependent. The constant amplitude is necessary because the same font character image area and therefore height is stroked for all point sizes of output copy. As previously noted, the point size control has been established to provide a stroke time interval proportional to point size. This interval controls the timing of both the character generator and output CRT strokes. The output CRT stroke generator is provided with a constant rise time and therefore its stroke amplitude will be lower for short intervals and greater for long intervals. Since the interval has been made proportional to point size, the amplitude of the CRT strokes and hence the characters generated will be proportional to the selected point size. However, the beam velocity remains constant and therefore, the rate of film exposure is constant and uniform exposure results for a constant beam current.

The master stroke-timing signal SD (stroke drive) from vertical stroke generator 102 synchronizes image dissector strokes and CRT strokes. The blanking signal from vertical stroke generator 102 deactivates the video signal of the video processor circuit during retrace of the image dissector beam. The video output of image dissector 28 is premade with preamplifier 104. AACK signals are generated by vertical stroke generator 102 for synchronizing the operation of the analog and digital circuitry.

Signal RWG displaces the stroke horizontally to properly read the width codes as described hereinafter. The signal SAG displaces the stroke horizontally to move from the indexing bar to the adjacent character field prior to character scanning as described more fully hereinafter.

With reference to FIG. 3B, set size register 110 provides ten-bit data to horizontal stroke advance circuit 112 to generate stroke advance signals. Horizontal stroke advance circuit 112 provides a slightly greater horizontal deflection voltage after each stroke of the image dissector beam, thereby enabling the beam to advance slightly to the right for each new stroke so that a given character on font 22 can be scanned. This stroke advance signal is applied to horizontal deflection amplifier 92 (FIG. 3A). As the beam passes through the black and white areas on font 22, the image dissector 28 generates a video signal which is amplified by video preamplifier 104 (FIG. 3A) and forwarded to video processor 114 along with a blanking control signal from vertical stroke generator 102 (FIG. 3A) and a control signal (PREN). The output of video processor 114 comprises a video (black or white) signal which is input to the CRT printer and vertical automatic posi-
tioning control and skew circuit 116, which is also controlled by signal VAPCG generated by circuitry described below. The output of VAPC and skew circuit 116 is a vertical automatic positioning control signal and a skew signal, which are respectively provided to vertical deflection amplifier 94 and to horizontal deflection amplifier 92 (Fig. 3A).

CRT PRINTER DESCRIPTION

With reference to Fig. 4, CRT 40 generates output copy by projecting vertical strokes of light through fiber-optics face-plate 44 which is in contact with film 42. The basic horizontal position of the CRT beam is determined by a thirteen-bit output from line counter 120 which is converted into an analog voltage by horizontal digital/analog converter 122, the output of which is in turn provided to horizontal deflection amplifier 124.

The basic vertical position of the CRT beam begins at the top-align location of the character. The beam is driven downward by the CRT stroke from waveform generator 128 by means of vertical deflection amplifier 130. Signal SD input to waveform generator 128 synchronizes the CRT stroke with the image dissector stroke. The digitized video output of video processor 114 is amplified by CRT driver 126 and is used to modulate the beam in synchronism with the font pattern (White on font equals beam On).

GENERAL DESCRIPTION OF LOGIC CIRCUITRY

The logic circuitry is illustrated in block diagram format in Fig. 6A. The phototypesetting apparatus has three basic sequences during normal operation:

1. Input/storage cycle-read tape and store codes until return is read.
2. Justification calculation cycle-calculate for the unused space to justify the preset line measure.
3. Print cycle reads the line from memory and print.

INPUT STORAGE CYCLE

With reference to Fig. 5A, when the prime switch on control panel 20 is actuated, the line measure from the control panel switches in picas, points, is converted to line measure converter 138 to machine units and stored in a width counter used during a calculation cycle. With the depression of the start button on control panel 20, reader 32 runs at a 500 cpm rate and applies a six-bit TTS code to reader control 140. Reader control 140 buffers the reader 32 output to character decoder 142 which determines if the six-bits are character or function codes, letterspaceable, space codes or supershift functions. Character decoder 142 outputs are input to data control and line store 144 for storage, and simultaneously, address width control circuits 146 so that the character width may be subtracted from the preset line measure. Simultaneously with width handling, the other outputs of character decoder 142 are input to space calculation control circuit 148 for maintaining track of letterspaceable characters and the number of spacebands or insert space codes in the line. Supershift outputs of character decoder 142 enable automatic control of point size, set, leading, and the setting of new line measures.

The phototypesetting system logic determines which codes are to be stored and writes them sequentially into line storage 144 for use during the print cycle of the system. The character code addresses the width control circuit 146 and the character width is provided to line ending calculation circuitry 150. The width, at this time, is multiplied by the set size selected and the result is subtracted from the remaining line measure. Space control and calculation circuitry 148 is utilized at this time for counting the number of spacebands and letterspaceable characters in the line as this information is necessary during the justification calculation. Reader 32 continues to run until a return code is sensed at the end of the line and at that time reader 32 stops and the system logic circuitry enters a justification calculation mode.

JUSTIFICATION CALCULATION MODE

The function of the calculation performed in the justification calculation mode is to assign the remaining widths in the line to spaceband and/or letterspace. In the space control and calculation circuitry 148, the spaceband count is used to calculate how much width is to be assigned to each spaceband. In the phototypesetting system, the spaceband begins with no assigned width which is expanded by the logic circuitry within the space control and calculation circuitry 148. Such calculations continue until all the width has been assigned and at that time, the print mode begins.

PRINT MODE

The functions of the print mode are to enable selection of each character to be printed, control the height and width of each character, and control the number of horizontal steps to be used by the cathode ray tube of the output reproduction unit. Subsequent to the printing of a line, the print mode controls the paper advance system (leading).

Data control and line store circuitry 144 provides the location of each character to be printed from the image dissector tube 28 (Fig. 1), and character code to character decoder 142 and width control 146. Print and output control circuitry 152 counts the strokes for each character, directs the CRT when to print, and informs the CRT how many horizontal steps to move the beam.

Point/set control circuitry 154 is used during both the calculation mode and the print mode and during the print mode it controls the length of the vertical stroke on the CRT and each step of the horizontal advance of image dissector tube 28. Subsequent to the handling of all the character and space information for a given line, the return code at the end of the line informs print and output control circuitry 152 to allow leading to take place under control of leading control 156.

DETAILED DESCRIPTION OF THE LOGIC CIRCUITRY

CHARACTER DECODER CIRCUITRY

Character decoder circuitry 142 determines which codes are EM precedent or non-letter spaceable. Those codes which are not letterspaceable inhibit a letter-space counter in space control and calculation circuitry 148 from incrementing for those codes. Those codes which are part of an EM precedent sequence increment a letterspace counter in space control and calculation circuitry 148 and are written into line storage 144.

Character decoder 142 interprets the various supershift formats to make changes from the fixed format of control panel 20. To select a new line measure, via tape control, a supershift code followed by SM and four decimal digits is read. Character decoder 142 senses the sequence S followed by M, converts the TTS code
for the decimal quantity to BCD and ensures that it is placed in line measure converter 138 according to pica and point representation.

In order to select a new point size via tape input, a supershift code followed by a T and two decimal digits is read. The function of character decoder 142 is to recognize that sequence and decode the two decimal digits for use as the point size in point/set control circuit 154.

In order to select a new line-space quantity for leading, a supershift code followed by S, L and three digits is used. It is the function of character decoder 142 to determine the proper sequence and convert the BCD configuration of the line-space quantity to standard binary representation. This input is to leading control 156.

DATA CONTROL AND LINE STORAGE CIRCUITRY

As codes are read from paper tape by tape reader 32, they must be stored in sequential order for use by the print cycle after all calculations are completed for each line. Data control and line store circuitry 144 determines which codes are to be stored, provides information to the analog circuits to locate the codes on font grid 22, and provides addresses for a width memory for each code’s width so that calculations can be performed.

WIDTH CONTROL CIRCUITRY

Width control circuit 146 stores all widths from font grid 22 in locations that are addressable from the TTS code of each character and provides each width as it is addressed to line ending and calculation circuitry 150. Width control circuit 146 stores the width of each code on font grid 22 which is installed in the phototypesetter system. These widths are written from the font into a width memory on lines RUI 1-8 during the prime sequence (as previously described), and are capable of being read out of memory at any other time.

POINT/SET CONTROL CIRCUITRY

The functions of point/set control circuit 154 are to provide:

1. A set size multiplication factor for line ending calculation circuit 150.
2. The point digital/analog value to the analog circuits for controlling the frequency of the vertical stroke of image dissector 28.
3. Set digital/analog values to the analog circuits for controlling the horizontal advance of each image dissector stroke.

These digital/analog values depend upon settings of control panel 20 or control sequences input through reader 32 to character decoder 142.

LINE MEASURE CONVERTER CIRCUITRY

Line measure converter circuitry 138 changes the BCD configuration of the line measure to binary representation to produce total machine units required for that measure. This resultant value is provided to a width counter in line ending calculation circuitry 150 for use during line end calculation and space calculation.

Line measure converter circuitry gates either control panel switch values or tape control line measure values to a line length converter (not shown) the output of which is the machine unit value of line measure in a complement form. For an example, using eleven picas, the output of converter 138 is the one’s complement of 2376 machine units.

LINE ENDING CALCULATION CIRCUITRY

The function of line ending calculation circuitry 150 is to subtract the machine unit width of each character in a line from the remaining line measure in a width counter until the return code at the end of the line is sensed. At that time, line-ending calculation circuitry 150 aids space control and calculation 148 in assigning remaining width to spacebands, into inter-character space, or insert space in order to justify the line. The width counter (not shown) is initially set to a value determined by line measure converter 138. The value of width to be subtracted is determined by a multiplier (not shown) the inputs to which are determined by point/set control 154 and width control 146.

SPACE CONTROL-CALCULATION CIRCUITRY

Space control/calculation circuitry 148 counts all spacebands and letterspaceable characters (minus one) during the input/storage cycle. If an insert space code is read, then space control/calculation circuitry 148 counts the number of insert space codes instead of letterspaceable characters. During justification calculation, space control/calculation circuitry 148 controls justification of the line by calculating the amount of space to be added to each spaceband and/or letterspace position in order to justify the line.

During justification calculations, space control and calculation circuitry 148 determines how much width is to be assigned to:

1. A spaceband in the line;
2. An insert space in the line, or
3. An inter-character space.

When calculation is complete, space control and calculation circuit 148 indicates the value of one of the following:

1. The number of machine units to be assigned a spaceband if the line was not letterspaced.
2. The number of machine units to be assigned to each intercharacter space if the line was letterspaced.
3. The number of machine units to be assigned to each insert space code if the line contained insert space codes.

If the number of machine units remaining in the line could not be divided equally, then at the end of calculation a deficit value would remain in space control and calculation circuit 148. If that value represented spacebands, a count pulse for every spaceband is generated during the print cycle. When the deficit is filled, the value increments and all remaining spacebands in the line receive one more unit. If the deficit represents letter-spaceable characters, an increment during the print cycle is provided. If the deficit represents insert space codes, an increment is provided during the print cycle of each insert space.

PRINT OUTPUT CONTROL CIRCUITRY

Print output control circuitry 152 is used to interface the digital signals developed by the results of calculation with the analog components used to locate and scan a character on image dissector 28, and position and expose characters through CRT 40 on photographic paper or film 42.

During the prime sequence print output control 152, in conjunction with point/set control 154 and data
control 144, counts the number of image dissector vertical strokes to correctly position the scan beam for reading each width bar on font 22. Data control 144 provides horizontal and vertical information for approximate ID beam position, point/set control 154 provides information to control the stroke rate of the beam, and output control 152 counts fifteen strokes before allowing width to be read on the 16th stroke. During the fifteen strokes, the analog components of the apparatus prepare the beam to be positioned on the center of the width bar during the sixteenth stroke ensuring accurate width reading.

During normal operation, print output control 152 functions ONLY after the calculation cycle of each line is finished. Reader 32 is stopped during the entire calculation cycle and it is also stopped for an entire print cycle if either an end-of-line (EL) function is processed or a supershift code is read during a print cycle.

During the print cycle, print output control 152, in conjunction with point/set control 154 and data control 144, counts the number of vertical strokes to correctly position the ID beam, unblanks the CRT beam, and controls the CRT beam horizontal deflection as indicated in FIG. 5A. Again, during the print cycle, data control 144 provides horizontal and vertical information to ID 28 to locate each character of a line. Point/set control 154 affects the scan stroke of the ID beam which has a direct bearing on CRT stroke length. Print output control 152 counts eight strokes before unblanking the CRT beam. During the first seven of these strokes, the ID beam position is being horizontally and vertically corrected to create accurate beam position before scanning of a character takes place. Once actual character scanning takes place, print output control 152 counts the number of strokes for each character which, in turn, horizontally deflects the CRT beam. If any space is encountered, or letterspace, insert space, spacebands, thin, etc., instead of stroking for the width of each space, print output control 152 immediately deflects the beam by the amount of space indicated which will be more fully described hereinafter.

Output control circuitry 152 is used to interface logic timing with analog timing and at the completion of the justifying cycle, the first character in a line is ready to be stroked onto the CRT. Output control 152 provides the signals necessary to read each code of a line from line store 144 for use to locate the character on font 22, to load each code width into output counter 160 for control of CRT horizontal deflection, and to vertically and horizontally correct the image dissector 28 beam position in preparation for character scanning.

To read any code out of line store 144 for use during printing, the proper location of the code must be addressed. The code's width is addressed in width control 146 while the code's position on font grid 22 is being located by data control 144. The code's width is multiplied by set-size in line ending calculation 150 to obtain total machine width and then is loaded into output counter 160 as a deficit. When the code's position on font grid 22 has been located, the image dissector beam must be vertically and horizontally corrected before enabling character scanning. After loading output counter 160 with the code's width times set size, beam position correction takes place, after the completion of which actual printing of the character begins.

An AAC pulse is developed by vertical stroke generator 102 (FIG. 3A) for every vertical ID stroke and the frequency of these pulses is point size dependent. However, during the beam position correction the frequency of the AAC pulses is always based on fifteen point (the same as during width reading).

Output control counter 162 is enabled to count AAC pulses. Each count is immediately decoded to produce the OCC signals indicated on FIG. 5B. For the first seven strokes of the image dissector beam, high speed automatic vertical position correction takes place under control of signal VAPCG (Ref. FIG. 5B). Signal VAPCG is provided directly to VAPC and skew control 116 (FIG. 3B) controlling vertical position of the image dissector beam. For the fifth, sixth and seventh strokes, the image dissector beam is corrected horizontally during signals HAPC1 and HAPC2 (FIG. 5B). Signal SAG is generated during beam correction and is used to advance the final ID beam position just prior to character scan. The eighth stroke ensures correct beam position before printing of a character by off-setting the ID beam to the edge of the character field.

During print control signal PREN (FIG. 5B) enables the image dissector beam of the CRT. Once the image dissector beam is positioned to begin a character scan, print control circuitry 152 (FIG. 5A) enables the video of the image dissector to control the CRT beam until the proper number of strokes have been counted which equal the width of the character. If a spacing operation is performed, the print control will not enable the image dissector control of the CRT. Instead print control circuit 152 will directly deflect the CRT beam the required amount of machine units. One machine unit is equal to a CRT beam deflection of 0.000765 inch. Once actual character scanning takes place, print output control 152 counts the number of strokes for each character which, in turn, horizontally deflects the CRT beam. If any space is encountered, or letterspace, insert space, spacebands, thin, etc., instead of stroking for the width of each space, print output control 152 immediately deflects the beam by the amount of space indicated which will be more fully described hereinafter.

Output control circuitry 152 is used to interface logic timing with analog timing and at the completion of the justifying cycle, the first character in a line is ready to be stroked onto the CRT. Output control 152 provides the signals necessary to read each code of a line from line store 144 for use to locate the character on font 22, to load each code width into output counter 160 for control of CRT horizontal deflection, and to vertically and horizontally correct the image dissector 28 beam position in preparation for character scanning.

To read any code out of line store 144 for use during printing, the proper location of the code must be addressed. The code's width is addressed in width control 146 while the code's position on font grid 22 is being located by data control 144. The code's width is multiplied by set-size in line ending calculation 150 to obtain total machine width and then is loaded into output counter 160 as a deficit. When the code's position on font grid 22 has been located, the image dissector beam must be vertically and horizontally corrected before enabling character scanning. After loading output counter 160 with the code's width times set size, beam position correction takes place, after the completion of which actual printing of the character begins.

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Signal PREN is generated to enable the ID video to control the CRT beam. Signal OCOVF indicates an overflow of output counter 160. Output counter 160 is loaded with the complement of the character width.

Signal OCOVF occurs when the exact number of AAC pulses have been generated during signal PREN. The occurrence of signal OCOVF indicates that one character has been completely scanned on font grid 22 and one character has been exposed by the CRT onto film or paper 42. Signal OCOVF immediately removes signal PREN. Had the code indicated a space code, signal PREN would not have been generated. The output of output counter 160 would be sent in parallel to line counter 120.

LINE POSITION COUNTER CONTROL CIRCUITRY

The line position counter 120 provides a thirteen-bit output to the horizontal control of the CRT for purposes of deflecting the beam one machine unit for each count. The normal function of line position counter 120 is to count each stroke of the image dissector beam which, in turn, deflects the CRT beam for each machine unit of character width. Output counter 160 will inhibit line counter 120 by signal OCOVF after the image dissector beam character strokes are completed.

For spacing a different method of changing line position counter 120 is used. Instead of blank-stroking for space by counting the width into line position counter 120, a space value from either space control 148 or output counter 160 is selected by SC/OC MUX 166 and immediately added by ADD circuit 168 to the present line position count and parallel-loaded into line position counter 120. This provides an instantaneous beam deflection equal in value to the number of ma-
chine units of space.

With line counter 120 at zero, the CRT beam is caused to be deflected to the left margin of the film 42. Line counter 120 is incremented by AAC pulses for each vertical stroke of the image dissector beam. Corresponding values from counter 120 are provided to the analog circuitry for CRT beam deflection. Whenever a space code is sensed, a parallel enable signal is generated to line counter 120 to allow immediate deflection of the CRT beam the amount of space necessary. The input to adder 168 is via space counter/output counter MUX circuit 166. The input from space control 148 is used for CRT beam deflection for insert space, normal spacebands or letter-spacing, while the input from output counter 160 is used for fixed space (TH, EM, EN, etc.).

CRT OUTPUT JUMP AHEAD

The present invention includes circuitry for increasing the CRT system speed by not stroking the “white space” in each line, i.e., spacebands, letterspaces, etc. The circuitry for jumping the white spaces is illustrated in FIG. 6 and operates such that the actual non-character space between characters is jumped by the CRT by adding the space to line position counter 120 by logical thirteen-bit adder 168. Line position counter 120 is a thirteen-bit counter which directly controls the horizontal position of the CRT beam through thirteen-bit digital/analog converter 122 and the corresponding CRT deflection amplifier. The output of line position counter 168 is buffered by buffer 172. As has been previously described, each character is formed by many strokes each of which advances the actual beam one unit of one set (0.000765 inch). In the phototype-setting apparatus described in co-pending application Ser. No. 467,536, filed May 6, 1974, all fixed spaces, i.e., thin, EM and EN, plus the spacebands, are also stroked as though they were normal characters. It is noted that there is no letterspace or insert space capability in the phototype-setting apparatus described in the aforementioned co-pending application. The calculation of fixed spaces from either output counter 160 or the calculation from space counter 170 (a component of space control and calculation 148, FIG. 5A) is selected by multiplexer 166 and added directly to line position counter 120 by means of thirteen-bit adder 168. The detailed description of the operation of space control 148, output counter 160, multiplexer 166, adder 168 and line position counter 120 has been previously described.

The above described technique results in a net speed improvement of approximately two hundred lines per minute (from 300 to 475 LPM) in six point eleven Pica stock market output which contain a significant amount of non-character space.

WIDTH CODE READING

The width code in binary notation is located on font 22 (FIG. 12) to the left of each character. The width code represents the actual relative unit width minus three in an 8-4-2-1 binary code. During the prime cycle the program sequence illustrated in FIG. 7A is executed. That sequence of events comprises a read width cycle which is completed only when each width code is read exactly the same in two successive scans of the width codes on the font. The double read cycle minimizes width errors.

After the apparatus is reset by the prime control, data control 144 (FIG. 5A) addresses every character on font 22 in sequence under control of print control 152. Each character is addressed and the width read as described hereinafter. The width values are stored in width control 146. Subsequently the beam generating of widths for all of the characters, each character is again addressed by data control 144 and the width codes re-read. The re-read width values are compared to those stored in width control 146 and tested for error. In case of error, data control 144 repeats the aforementioned cycle until two successive width read and compare cycles produce the same data. If there are no errors, the cycle is completed at the end of the second read-compare sequence. Methods and apparatus for data storage and comparison are well known to those skilled in the art and are not therefore described in detail herein.

The circuitry illustrated in FIGS. 7B and 7C is utilized to read each character width value on the font. A character is accessed via horizontal and vertical digital/analog converters 180, 182 which receive coded data from character select ROM 184 within data control 144 (FIG. 5A) and operate in the same manner as for normal character exposure which will be described more fully hereinafter. The vertical and horizontal automatic position control signals function normally for the first seven strokes (OCC1- OCC7, FIG. 7F). Eight additional strokes (OC8, FIG. 7F) are added thereby enabling vertical APC to bring the beam to a more accurate position on the bottom edge of the indexing bar above the selected character. This is illustrated in FIG. 7D. Characters on font 22 are accessed by deflection voltages as shown in FIG. 7E. Read width gate signal RWG (FIG. 7F) moves the beam to the left so that it is centered on the width code bars during the sixteenth stroke.

The above width code reading strokes are performed at the same stroke frequency as the APC strokes (the frequency used for a fifteen point character). However, in actual practice the slower frequency as compared to the frequency of smaller point sizes such as five or six point, enables a greater amount of signal integration thereby improving signal detection accuracy. The video output from video preamplifier 104 (FIG. 3A) is provided to filter 186 through amplifier 188. The vertical ID stroke from vertical stroke generator 102 (FIG. 3A) is input into a clock generator which comprises IC comparator 190, flip-flops 192, 194, resistor ladder 196 and one-shot multivibrator 198. Resistor ladder 196 utilizes transistor switches 200, 202, 204, which are driven by the indicated logic outputs from flip-flops 192, 104 to generate four trigger points for IC comparator 190. Each trigger point corresponds to the center sampling point of a width code. The width codes are in an 8-4-2-1 sequence to minimize errors as the stroke amplitude/deflection is most accurate at the start of a sweep. Therefore, the largest binary value is placed nearest to the initiation of deflection.

The transistor switch/comparator approach illustrated in FIG. 7C is only one manner of implementing the generation of four trigger pulses. Clock generators based on time (rather than amplitude) may be used just as effectively. For example, timing generators used to convert data from serial-to-parallel in data communication networks could also be used instead of the transistor switch/comparator circuitry illustrated in FIG. 76. The features of the width code reading are:
1. The width code is contained within and in close proximity to the indexing bars where the beam position is most accurate;
2. The high degree of filtering of the code reading video minimizes errors; and
3. The double reading and error control minimizes errors.

**ANALOG CIRCUITRY**

The video processor circuitry is illustrated in FIG. 8 and receives the raw video signals from video preamplifier 194 (FIG. 3A) and provides two basic functions, namely, the decoding of the width value during the prime mode and the generation of the CRT beam ON/OFF levels which are synchronous with the video during the print mode (black on font equals CRT beam Off). The circuitry includes width filter 210 having a long-time constant, video filter 212 having a short-time constant, and an auto threshold control (ATC) 214, which ensures a constant percentage threshold level into the reference inputs of comparator amplifiers 216, 218. ATC circuit 214 compensates for any variation of font illumination. The raw video output from video preamplifier 194 is provided to the high input of amplifier 220 which has a gain of approximately three. The output of amplifier 220 is input to width filter 210, the output of which is provided to the low input of comparator amplifier 216. The reference input of comparator amplifier 216 is connected to the output of ATC circuit 214 and the output of that amplifier comprises the width data during the prime mode of operation. The output of amplifier 220 is provided both to ATC 214 and video filter 212. The output of video filter 212 is input to the low input of comparator amplifier 218 and the reference input of amplifier 218 is the automatic threshold signal. The output of comparator amplifier 218 comprises one input to AND gate 222, the other inputs of which are a print enable signal (PREN) and a blanking signal from vertical stroke generator 102 (FIG. 3A). The output of AND gate 222 is a digitized video signal. The output of comparator amplifier 218 is inverted by inverter 224 and provides a signal to the automatic position control circuitry which will be described hereinafter.

At video filter 212, the noisy video signal is smoothed into a sharper square wave which is input to comparator 218. When the image disector beam is scanning a white area on the font, the resulting positive video level causes the output of comparator 218 to switch positive. This switching video signal is sent through AND gate 222 to CRT drive 126 (FIG. 4) where the cathode of the CRT is turned on and off according to the video level.

**WIDTH DECODING**

The width code to the left of each character on font 22 is scanned during the prime mode and the black on the font is the active width value. One single scanning stroke (the sixteenth stroke) generates the four-bit width values which is based on fifteen units. Automatic horizontal and vertical beam positioning occurs prior to the sixteenth stroke.

The width decoder circuitry is illustrated in FIG. 7C. During the prime mode read width gate signal (RWG) FIG. 7F) which is enabled for the sixteenth stroke, is produced by pulse signal OCC 15 to prepare shift register 226 to receive the four-bits of width code during the sixteenth stroke. Flip-flops 192, 104 are both reset so that switch 200 is closed, placing a step “one” voltage to the positive input of comparator amplifier 190. When the stroke ramp voltage is equal to step one, the output of comparator 190 goes negative thereby triggering clock 198 and at this time the image disector beam is sampling the topmost width code (8) which in FIG. 7D is black or “one.” Clock 198 shifts the 8 bit into shift register 226 and toggles A and B flip-flops 192, 194. Thereby switch 200 opens and switch 202 closes, presenting a step 2 voltage to comparator 109. When the stroke equals step two, clock 198 shifts the second width code (4) into register 226, thereby shifting the eight-bit to the second stage thereof. The aforementioned sequence continues until the four bits are shifted into shift register 226. The four-bit width code (1001) equals nine units. The “raw unit” width value (4 bits) is stored in width control 146 (FIG. 5A) at the location that corresponds to the TTS code of the character h.

**X AND Y CHARACTER SELECT CIRCUITRY**

The X and Y character select circuit is illustrated in FIG. 7B. The position of a font character as viewed by the image disector is located by its TTS code which generates a deflection voltage in the x and y planes. For example, the lower case e is located at the center of the font, so no significant deflection voltage is required in either the X or Y planes for that character. The TTS code on lines OR0 to OR6 at the input of character select ROM 184 generates four positional bits for the horizontal (HP1 to HP8) and vertical (VP1 to VP8). These digital codes are input to digital/analog converters 180, 182, each of which provides an output voltage somewhere between minus 7 and plus 6 volts DC. The maximum deflection voltages are shown in FIG. 7E. This positional voltage is used to deflect the image disector beam onto the approximate target area of the font. Automatic positioning control then occurs. During the prime mode, signal RWG offsets the beam to the left so that the sixteenth stroke will pass through the middle of the width code (FIG. 7D). When preparing to stroke a character, signal SAG (FIG. 5B) offsets the beam to the right of the indexing bar, to the left edge of the character field. The output voltages from converters 180, 182 are provided to horizontal deflection amplifier 92 and vertical deflection amplifier 94 (FIG. 3A) where they are combined with the signals HAPC, VAPC and skew correction signals.

**VERTICAL STROKE GENERATION**

Vertical stroke generation circuit 102 (FIG. 3A) is more fully described in FIGS. 9A, 9B and generates the wave shapes and timing pulses that influence or control the majority of the analog circuits throughout the phototypesetting system. Point size register 100 provides a ten bit output that is converted by D/A converter 230 to a signal supplied to all circuits that are point size dependent. Signals STK and SD control both the image disector and CRT stroke timing. Signal AAC occurs at the top of the image disector stroke and is used as the clock in all analog circuits and generates the signal OCCO-15 in the digital circuits.

With reference to FIG. 9A, the vertical stroke (STK) for the image disector is generated as follows. The ten-bit code to D/A 230 results in a negative voltage which is greatest (minus ten V) for five point, and least (minus 1.5 V) for thirty-six point. This voltage is provided to integrator 232 which charges capacitor 234 at
W. the rate of five microseconds/PT towards plus seven volts. Comparator 236 monitors the level of the vertical stroke output of integrator 232 and when it reaches plus seven volts, the output of the comparator goes negative. The negative output triggers one-shot MV 238 to produce the signals SD and RD, and one-shot MV 240 produces signals RD (retrace delay) and RD. Stroke drive signal SD activates field effect transistor switch 242, which discharges capacitor 234. This is a significant time, as both the image dissector stroke and cathode ray tube stroke voltages are driven to zero, thereby creating the retrace or return of the beam. Signal SD is a constant 12 microseconds width as illustrated in FIG. 9A.

With reference to FIG. 9B, comparator 244 also monitors signal STK but is adjusted to approximately plus 6.8 volts. When the level of signal STK reaches that voltage, comparator 244 goes negative thereby generating the analog active clock (AAC) signal (Ref. FIGS. 5B and 7F). The duration of signal AAC is about two percent of signal STK and is point-size dependent because of the slope of STK at the negative input of comparator 244. Blanking is a signal that turns off the CRT beam during its retrace and is generated at the output of NOR gate 246. The duration of blanking is from the lead edge of an AAC signal to the fall of signal SD, plus 3 microseconds. Retrace delay signal RD is used by VAPC and skew circuit 116 (FIG. 3B) to establish the time for VAPC. The other inputs to NOR gate 246 are signals SD and the output of one-shot MV 248.

**VAPC AND SKEW CIRCUITRY**

Signal VAPC is the automatic positioning of the image dissector beam on the font in the vertical plane and occurs at two different rates; fast VAPC (for the second through seventh strokes) and slow VAPC (for the remainder of the strokes of a character.) VAPC and skew circuit 116 (FIG. 3B) are illustrated schematically in FIG. 10A where the video signal from video processor circuit 114 (FIG. 3B) is monitored at time SD·RD. If the positioning voltage directs the beam to the white area above the width code frame (as illustrated in FIG. 10B) white is monitored by AND gate 250. Signal 252 is thereby lost, applying plus fifteen volts through resistor 254 to capacitor 256. Capacitor 256 is charged positive which acts to lower the beam toward the desired target (the black and white border). A signal corresponding to the stroke from the digital circuitry previously described has discharged capacitor 256 through switch 258 at time OCCO (FIGS. 5B, 7F) to establish zero during the first stroke. Capacitor 256 is now charged positive and the voltage thereof is applied to voltage follower 260 and to vertical deflection amplifier circuit 94 (FIG. 3A) to drive the beam slightly downward toward the black area. After the next stroke at time SD·RD, the font position is again monitored for black or white, and charges capacitor 256 accordingly positively or negatively. If black is sensed then switch 262 is closed by AND gate 264 to apply minus 15 volts to capacitor 256 through resistor 266. During the second through seventh strokes, signal VAPCG from the digital circuitry, closes switches 268, 270 to provide fast VAPC by placing resistors 272 and 274 into the charge circuit, thereby charging capacitor 256 at a faster rate.

**HAPC AND STROKE ADVANCE CIRCUIT**

Stroke advance refers to the displacement of the image dissector beam to the right after each stroke. The amount displaced is set-sized dependent. Signal HAPC is the analog automatic positioning voltage for the image dissector beam in the horizontal plane and is generated during the fifth, sixth and seventh strokes. The purpose of signal HAPC is to locate the right side (black-white border) of the indexing bar containing the width code as illustrated in FIG. 11B. The horizontal stroke advance and HAPC circuitry is illustrated in detail in FIG. 11A. Set-size register 110 provides a ten bit output of set-size data to digital/analog converter 280, which develops a negative output voltage that is greatest for the small set sizes. The first signal from the digital circuitry previously described discharges capacitor 282 during the first stroke by closing switch 284. Signal SAG inhibits signal SD at gate 286 for the second through seventh strokes to enable signal HAPC to be generated.

Continuing with FIG. 11A, after the deflection voltage has directed the image dissector beam to the approximate target area on the font, the right side of the width code frame is located before the end of the seventh stroke as follows. Signal HAPC1 (signal OCC4 from the logic circuitry previously described, (Ref. FIG. 5B) conditions AND gate 288 to monitor the fifth stroke. As the image dissector beam is driven downward on the font, black video enables AND gate 289 and OR gate 290 to activate field effect transistor 292 which provides minus fifteen volts through resistor 294 to integrator 296. Capacitor 282 is charged while black is monitored on the fifth stroke. This drives the image dissector beam to the right which differs from general stroke advance, which occurs during stroke signal SD. On the sixth and seventh strokes, white video is monitored by AND gate 298 and signal HAPC2 activates switch 292 through OR gate 290 to charge capacitor 282, thereby directing the image dissector beam further to the right. When black has been sensed, signal HAPC becomes ineffective, allowing the image dissector beam to rest on the border as shown in FIG. 11B. Signal BLANKING ensures that gate 290 does not generate signal HAPC during beam retrace.

After the seventh stroke signal SAG goes high, allowing stroke advance. Signal SAG at the input to digital analog converter 180 (FIG. 7B) produces a small deflection of the image dissector beam just to the left of the character field to prepare for the character stroking. Video is now on at the CRT and output copy will be produced (white on the font equals CRT beam On). After signal SAG goes high, signal SD closes switch 300 for twelve microseconds, applying the output from digital/analog converter 280 to integrator 296. The resulting current through switch 300 charges capacitor 282 for twelve microseconds, thereby resulting in a step-change in voltage at the output of integrator 296. This voltage is provided to horizontal deflection amplifier 92 (FIG. 3A) to direct the image dissector beam one stroke to the right to stroke a new area of the same character on the font. This step varies with set size and is greatest for five set. This results in fewer image dissector strokes and fewer CRT strokes, which are synchronized when the video is on. Thus, the width (set) of the output copy carrier is inversely proportional to the size of the image dissector beam step. After all of the signals SD have charged capacitor 282 to about plus
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6.7 volts, the image dissector beam has stroked the entire character field and some of the black area to the right thereof. The next first stroke signal then discharges capacitor 282 to prepare for the next character.

FONT GRID

Font grid 22 is a precision optical glass plate containing the characters and spaces that are used to generate output copy. An example of a font layout is illustrated in FIG. 12 which contains 109 characters and spaces. The width values are coded and appear to the left of each character or space. The width code is arranged in four bits (vertically where black is the active bit).

What is claimed is:

1. Apparatus for printing text by converting encoded electrical signals into printed characters, comprising:
   means for generating electron images of characters to be printed from said coded input signals and including an arrangement of characters with indexing bars forming a character field for each of said characters;
   means for controlling said means for generating electron images to select characters from said arrangement of characters in accordance with a desired character format;
   said means for generating electron images further including means for deflecting said electron images in accordance with a predetermined scanning pattern in response to said means for controlling, said scanning pattern having first and second different scanning rasters wherein said first scanning raster scans at least one of said indexing bars and said second scanning raster scans said character associated with said at least one indexing bar, and means for producing output signals representative of said electron images;
   first means responsive to said output signals for correcting the position of said first scanning raster to improve the initial position of said second scanning raster for scanning a selected character, said first means including means for selectively varying the rate of said position correction during said first scanning raster; and
   second means responsive to said output signals for generating a visual image of said characters in accordance with said second scanning raster and including means for recording said visual image.

2. Apparatus as in claim 1 wherein said first means includes means for repetitively scanning another of said indexing bars during the second scanning raster and means for altering said second scanning raster to correct the position thereof.

3. Apparatus as in claim 1 further comprising means for offsetting the position of said second raster from said at least one indexing bar to an edge of a character field associated with said indexing bar.

4. Apparatus for composing printed characters from coded electrical input signals, comprising:
   means for generating electron images of selected characters from said coded electrical signals;
   means for generating output signals from said electron images;
   output reproduction means for printing characters from said output signals in accordance with a predetermined scanning pattern; and
   means for altering said predetermined scanning pattern to avoid scanning of non-character areas of said output reproduction means.

5. Apparatus as in claim 4 further comprising means for decoding said coded electrical input signals and generating non-character output signals and wherein said means for altering is responsive to said non-character output signals.

6. Apparatus as in claim 5 further comprising means for calculating justification of lines of said composed printed characters and generating inter-character spacing signals and wherein said means for altering is also responsive to said inter-character spacing signals.

7. Apparatus as in claim 4 further comprising means for displacing said scanning pattern by successive predetermined increments; and wherein said means for altering increases the magnitude of said increments.

8. Apparatus as in claim 4 wherein said output reproduction means includes an electron beam and means for deflecting said electron beam in accordance with said predetermined scanning pattern.

9. Apparatus as in claim 8 further comprising means for decoding said coded electrical input signals and generating non-character output signals and wherein said means for altering is responsive to said non-character output signals.

10. Apparatus as in claim 9 further comprising means for calculating justification of lines of said composed printed characters and generating inter-character spacing signals and wherein said means for altering is also responsive to said inter-character spacing signals.

11. Apparatus as in claim 8 wherein said means for deflecting includes means for displacing said electron beam by successive predetermined increments; and wherein said means for altering increases the magnitude of said increments.

12. Apparatus for printing characters from coded electrical input signals comprising:
   means for generating electron images of characters from said coded input signals including a character grid and indexing bars defining individual character areas, and each said character area including encoded data representative of the width of the associated character;
   and means for reading and storing all of said encoded width data, said means for reading re-reads all said encoded width data;
   means for comparing said stored width data with said read encoded width data;
   means for generating an error signal for indicating a non-comparison; and
   means responsive to said error signal for repeating operation of said reading and storage means, said means for comparing, and said means for generating an error signal.

13. Apparatus for printing text by converting encoded electrical signals into printed characters, comprising:
   means for generating electron images of characters to be printed from said coded input signals and including an arrangement of characters with indexing bars forming a character field for each of said characters;
   means for controlling said means for generating electron images to select characters from said arrangement of characters in accordance with a desired character format;
said means for generating electron images further including means for deflecting said electron images in accordance with a predetermined scanning pattern in response to said means for controlling, said scanning pattern having first and second different scanning rasters wherein said first scanning raster scans at least one of said indexing bars and said second scanning raster scans said character associated with said at least one indexing bar, and means for producing output signals representative of said electron images;

first means responsive to said output signals for correcting the position of said first scanning raster to improve the initial position of said second scanning raster for scanning a selected character, said first means including means for selectively varying the rate of said position correction during said first scanning raster;

second means responsive to said output signals for generating a visual image of said characters in accordance with said second scanning raster and including means for recording said visual image; wherein said means for producing output signals produces different output signals from said indexing bars and the areas adjacent thereto, respectively, and further comprising means for detecting said different output signals during said first raster scan and means for positioning said first scanning raster in accordance with said detected output; and wherein said first means first corrects the position of said first scanning raster only when a predetermined one of said signals is present and subsequently corrects the position of said first scanning raster only when another of said different output signals is present, whereby the useful range of position correction is increased.