Dec. 17, 1968 F. K. STAUFFER 3,417,281

CURSIVE CHARACTER GENERATOR

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FIG. 1

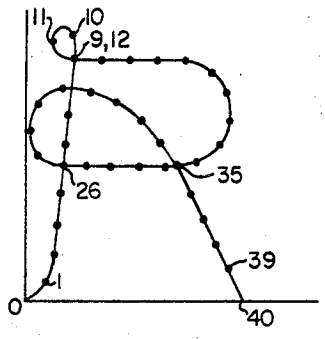


FIG. 2

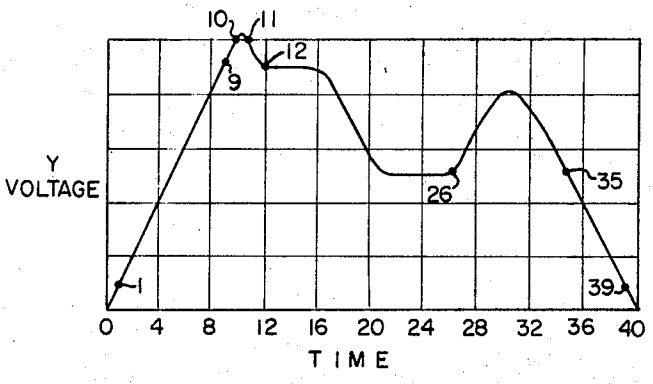


FIG. 3

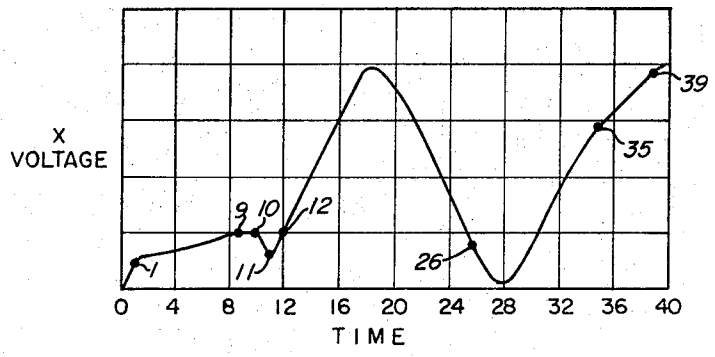
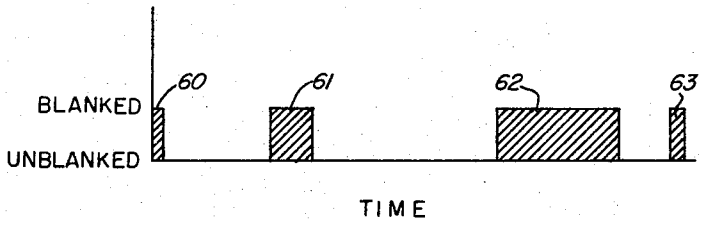


FIG. 4



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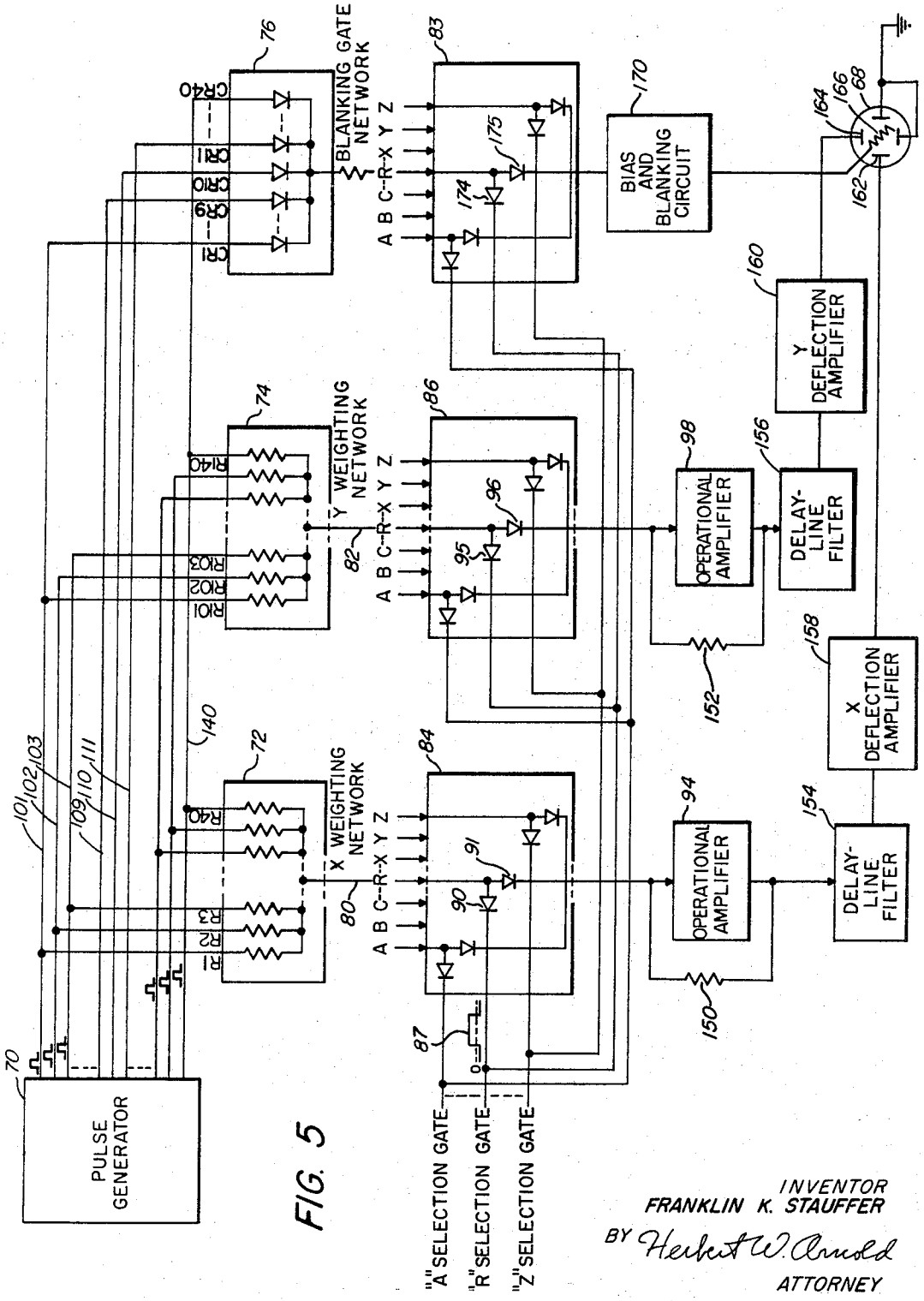


FIG. 5

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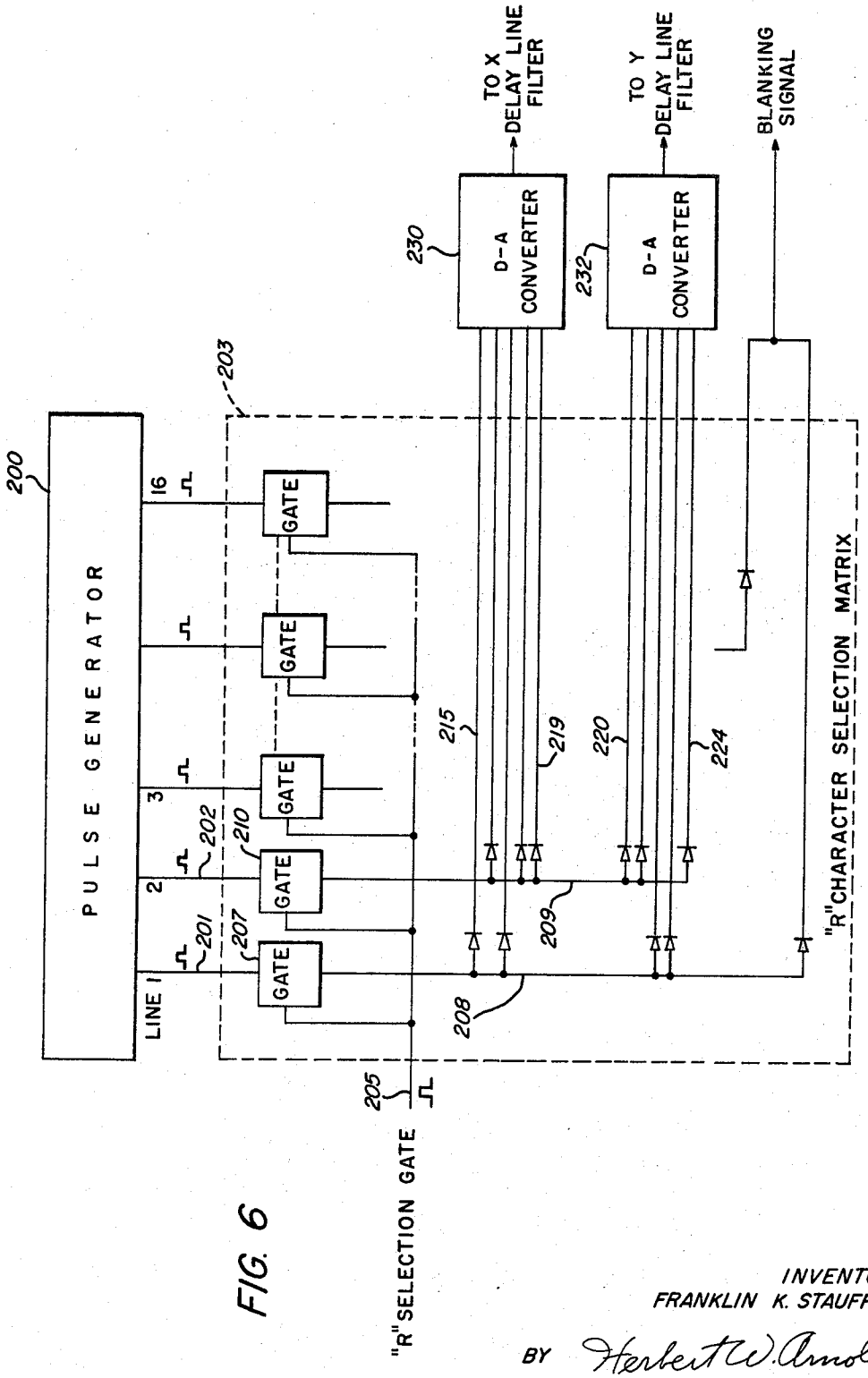


FIG. 6

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3,417,281

CURSIVE CHARACTER GENERATOR

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16 Claims. (Cl. 315—18)

This invention relates to the generation and visual display of electrical signals and more particularly to improved means for tracing a desired form or character upon the face of a cathode ray device.

The generation of characters for display on a cathode ray tube has been accomplished in numerous ways. Among these is the formation of the electron beam in the cathode ray tube such that the cross-sectional view of the beam becomes the outline of the character. For example, a character may be formed by individually gating strokes or dots from a format of straight lines or dots, respectively. However, the outline of characters formed in this manner frequently only approximates the general outline of the original character and usually lacks the definition and ease of identification of a well-defined character, such as might be manually drawn. When an attempt is made to provide a character with the aforementioned definition, it generally requires numerous electrical circuits which adds to the over-all cost and complexity of the system. For example, one method is to generate x and y time functions of the desired character and then make a Fourier waveform analysis of each function in order to generate and sum the necessary sine and cosine frequency components prior to application to the appropriate x and y inputs to the cathode ray tube. For a reasonable approximation to the functions, approximately ten sine and cosine terms are required, having both positive and negative terms. This arrangement is difficult to provide, and results in extensive circuitry which increases both operational and construction costs. Another known system displays characters by dividing the characters to be displayed into a number of straight line increments which are then successively assembled in proper sequence into a complete character. The straight line increments are traced or drawn on the cathode ray tube face by sloping waveforms of measured duration. This system is described in Sheftelman, U.S. Patent 2,766,444, wherein electronic delay lines are used to provide sequential distribution of pulses to the character wave forming generators which are representative of straight line increments to be formed on the tube face. Such a system requires relatively complex and somewhat redundant equipment, as a plurality of encoding stages are required to recode the basic information to be displayed into a form suitable for use with delay line distribution. Furthermore, many amplifying stages must be used in connection with the delay line to equalize the amplitude of the pulse outputs therefrom which further increases the complexity of the required circuitry. Even with such complex circuitry, the characters provided are stroked from straight lines and lack high resolution or identification. It is, therefore, desirable to provide a relatively simplified and improved apparatus for displaying well-defined characters at high speeds and with minimum bandwidth requirements.

In accordance with the invention, a generator of characters for display, such as on the face of a cathode ray device, is provided by forming a time function voltage waveform in both horizontal and vertical for the position of all points forming a continuous trace of the outline of the symbol or character, and applying appropriate gating waveforms to remove undesirable portions of the symbol. The electron beam of the cathode ray tube or display device is, therefore, made to trace in a continuous or uninterrupted manner the point-to-point segments forming the outline of a symbol, resulting in the smooth, cursive, or continuous writing of each symbol or character. In particular, this is achieved by providing a signal line having both x and y weighting elements for each successive segment forming the symbol and combining the appropriate x and y voltage waveforms to move the electron beam cursively from point to point on the face of the tube to form the outline of the symbol. At the same time, a blanking waveform for blanking undesirable portions of each character is provided. These portions or discontinuities of the resulting character are necessarily generated by rounding off all sharp corners in the x and y functions of the trace so as to reduce bandwidth requirements. This arrangement thus permits the attainment of maximum writing rate with minimum bandwidth requirements. For smoothness of the cursively drawn character, the invention provides feeding the x and y outputs from the weighting elements into a filter element which smooths out steps present in the output of the summing network as the individual weighting elements are sequentially selected to form a character. Separate horizontal and vertical voltage waveforms for each complete symbol are fed to the appropriate x and y axis deflection circuits of the cathode ray tube. Thus, by operating directly in the time domain rather than combining by Fourier analysis groups of frequencies, a relatively simple device can provide a smooth, highly defined cursive character capable of being written at high speed.

Other objects and advantages of this invention will become apparent as the description thereof progresses, reference being had to the accompanying drawings, wherein:

FIG. 1 shows an exemplary symbol developed by the invention;

FIG. 2 is a plot of the y deflection voltage waveform for the cursively drawn character "R" of FIG. 1;

FIG. 3 is a plot of the x deflection voltage waveform for the cursively drawn character "R" of FIG. 1;

FIG. 4 is a blanking waveform adapted to remove undesired portions from the character "R" of FIG. 1;

FIG. 5 is a block diagram of the cursive character generator according to the invention; and

FIG. 6 is a block diagram of another embodiment of a cursive character generator according to the invention.

Referring to FIGS. 1 to 4, there is shown a character representing the letter R which is chosen for purposes of illustration and which appears on the face of a cathode ray tube when the y voltage waveform of FIG. 2 and the x voltage waveform of FIG. 3 are applied to the deflection circuitry of a cathode ray tube. The appropriate blanking waveform of FIG. 4 is used to blank out the undesired portions of the letter R due to the uninterrupted travel of the electron beam. For example, the beam of a cathode ray tube, such as the electrostatic cathode ray tube shown in FIG. 5, starts its travel at the beginning of the first increment starting from point **0** and going to point **1** of the character R. This motion of the beam was the result of the vector addition of the y and x voltage waveforms of FIGS. 2 and 3, respectively, at the y and x plates of the cathode ray tube. The production of this waveform will be described in connection with the circuitry of FIG. 5. While the spot has travelled from point **0** to **1** of FIG. 1, it does not, however, appear on the face of the cathode ray tube due to an appropriately timed blanking wave **60** which is applied to the control grid of the cathode ray tube to blank out the beam from point zero to point one, although the appropriate deflection voltages are applied. At point one, the blanking wave ceases, and the visual portion of the character R appears from point one to point nine. At point nine, the beam,

instead of being moved sharply to the right to commence the first horizontal leg of the character which due to the square corner would require a wide bandwith for the *x* and *y* waveforms, is permitted to continue in a vertical direction with relatively no interruption through points **10**, **11** to point **12**. While this produces a portion which is undesirable to display, it permits the generation of relatively smooth, *x* and *y* waveforms, as seen in FIGS. 2 and 3, in which the corresponding points show the corresponding slope of these waves. To blank out the undesirable portion of the character from points **9** to **12**, a corresponding blanking wave **61** is provided which blanks out the beam during this portion of the *x* and *y* deflection voltages. The beam is then turned on to continue through points **12** to **26**, as seen in FIGS. 2 and 3. At this point, blanking voltage **62** is applied to the control grid of the cathode ray tube and blanks out the excursion of the beam between points **26** to **35**, as seen in FIGS. 1 to 3. Thus, the undesirable overshoot, such as between points **9** and **12**, is also blanked out. The leg of the character "R" is then traced on the face of the cathode ray tube by unblanking the beam from points **35** to **39**. A relatively smooth character has thus been traced on the face of the cathode ray tube and a further blanking wave **63** is used to blank out the lower portion of the final leg.

It should be understood that the same *x* and *y* deflection waveforms may be used in connection with cursively writing the letter "P" except that the blanking voltage waveform is made to continue from point **26** to point **40**, thus blanking out the second leg of the letter R. By generating a character in this manner, high speeds can be obtained with minimum deflection bandwidth requirements. Further, the beam tracing out the character produces uniform writing intensity, since the character has been broken up into equal length segments during the time the character is unblanked.

Referring to FIG. 5, there is shown a block diagram of a character generating system for providing the *x* and *y* deflection waveforms and the gating waveform to be applied to the *x* and *y* plates and control electrode of a cathode ray device **68** of the electrostatic deflection type. However, it should be understood that it is not necessary to use this type of tube, inasmuch as a magnetic deflection cathode ray tube or combination magnetic deflection-type tube for positioning the character, and electrostatic deflection could be used for providing the display of a character. To generate a given character, for example, the letter "R," a source of sequential square waves are generated on individual output lines by a pulse generator **70** which in this embodiment may comprise a well-known shift register, such as a series of bistable multivibrators in which a single pulse is propagated through the register to produce an output from each stage. It may be understood a delay line or a pulse generator providing sequential pulses over successive output lines may be used. In the present embodiment, there are forty output lines **101** through **140** corresponding to the forty segments of the letter "R" of FIG. 1. These forty lines are fed in parallel to *x* weighting network **72** and *y* weighting network **74**. The signals are further fed to a blanking or gating network **76**, which gates out unwanted portions of the character. In the example shown, resistor **R1** in network **72** is weighted, that is, its resistance is selected at a value which, along with the weighting of resistor **R101** in network **74**, provides the appropriate *x* and *y* waveform to move the beam from point zero to point one of the character "R" in FIG. 1. In like manner, line **102** is fed to *x* resistor **R2** and *y* resistor **R102** to move the beam from position one to position two. This process continues until the entire character has been traced and an output from resistors **R40** and **R140** has occurred. Each *x* and *y* output is combined by being connected in parallel and appears on output lines **80** and **82**, respectively. The currents in the individual weighting resistors are applied through an *x*-diode switching circuit **84** and a *y*-diode switching circuit **86**, which are used to select one of the, for example, twenty-six characters of the alphabet. An "R" switching signal **87** of approximately four volts is applied to isolation diode **90** to gate this diode into nonconduction and permit conduction of diode **91**. This selection signal is also applied to the *y* selection circuit **86**. All other gate lines are held negative by appropriate bias, not shown. Conduction of diode **90** causes diode **91** to conduct and the *x* waveform for the "R" character to be applied to a D-C operational amplifier **94**. In like manner, the "R" switching signal is applied to isolation diode **95** to cause conduction of "R" diode **96** and to connect the sequential outputs of the *y* weighting network **74** to *y* operational amplifier **98**. It should be understood that the "R" selection gate signal is applied continuously for the entire duration of the letter "R" and may be provided by a source of direct current actuated by a mechanical or well-known electrical switching arrangement, not shown. For example, the output signal of a Teletype writer or computer could be used to actuate each of the twenty-six character lines. While no values of the weighting resistors are given for matrix **72** or **74**, the weighted values are generally selected to be inversely proportional to the amplitude of the particular segment to be displayed. For example, when weighting resistor **R1** is of a value, say 10,000 ohms, to produce an *x* component voltage for deflection from zero to one on FIG. 1, the value of a resistor, which would deflect the beam to point **10** in the *y* direction, would be approximately 1,000 ohms. Thus, a complete set of *x* and *y* weighting resistors for each character together with appropriate diode gating is provided. Each weighted resistor for the *x* and *y* waveforms is applied to the appropriate *x* and *y* operational amplifiers **94** and **98**, respectively, which preferably are well-known D-C amplifiers which produce an output proportional to the value of the amplifier feedback resistors **150** and **152**, respectively, and inversely proportional to the value of the selected weighting resistors, according to well-known operational amplifier techniques.

It should be understood that the weighting of each resistor is selected such that the beam deflects at a uniform writing rate. This is achieved by breaking the character into substantially equal segments in the region which is to be displayed. This means the beam travels substantially the same distance in each of the segments and, therefore, writes at a constant speed. This arrangement achieves uniform intensity even in non-straight portions of the trace and avoids the necessity for providing complex intensity modulation to the cathode ray tube grid in addition to the usual blanking wave to be described. The *x* and *y* weighting resistors are then selected at values to match the *x* and *y* voltage waveforms, shown in FIGS. 2 and 3, which, as previously described, were derived from *x* and *y* plots of the letter "R" of FIG. 1.

The operational amplifiers **94** and **95**, including the feedback circuit resistors **150** and **152**, may be of a type commercially available, such as a model P45 operational amplifier of Philbrick Researches, Incorporated, Boston, Mass. Such amplifiers preferably provide a closed-loop bandwidth in excess of two megacycles. For example, the amplifier referenced has a bandwidth capable of operation at a character rate in excess of twenty microseconds. This bandwidth could be approximately two megacycles, while if instead of forty segments, twenty segments and a less smooth character are desired, a writing speed of ten microseconds per character may be obtained from the same amplifier. Thus, the invention is not to be limited to a specific bandwidth or writing speed, since individual techniques can provide higher or lower writing speeds, although the invention contemplates high-speed operation.

It should be understood a conventional operational amplifier may be used which has a sufficient bandwidth to pass the *x* and *y* deflection waveforms. The output of the operational amplifier **94** is fed to a delay-line-type filter for smoothing out the minute steps inherent in gen-

erating the individual segments making up a character. The output of operational amplifiers **94** and **98** are each connected to a delay line filter **154** and **156**, respectively, which smooth the waveforms obtained at the output of each operational amplifier by removing the tendency of the waveforms to be stepped due to their segmentation. These *x* and *y* delay lines are of a conventional tapped type and, for example, herein consist of a plurality of serially connected LC delay sections with a tap at an appropriate number of sections to provide the desired delay-to-rise time ratio of, for example, ten-to-one. The delay line further preferably has a number of sections which provide a total delay time substantially equal to the time taken to trace a segment on the face of the cathode ray device less one tap width. For example, a total of ten taps may be used in order to divide a given step to be smoothed into ten equal segments, each tap being connected to the output of, for example, the third series-connected LC section and to a weighting resistor. The individual weighting resistors which are connected to each tap are made substantially equal in resistance and all are connected to a common output line and fed to the input of its corresponding *x* and *y* deflection amplifier. The delay line which may be commercially available is, for example, a nine-tap delay line of approximately .04 microsecond per tap and a total delay of .45 microsecond, and has a typical delay-to-rise time ratio in excess of ten-to-one. However, while the above delay line provides maximum smoothness of character, it may be omitted when a less smooth character can be tolerated, as cost or simplicity dictates.

Referring again to FIG. 5, delay line filter **154** is connected to a conventional *x* deflection amplifier **158** and delay line filter **156** is connected to *y* deflection amplifier **160** and thence to *x* plates **162** and *y* plates **164**, respectively, of cathode ray device **68**. The *x* and *y* deflection amplifiers are of a conventional type, capable of passing the required bandwidth of several megacycles.

Referring now to blanking gate network **76**, which is used to blank out the undesired portions of the character "R," a diode matrix is used in place of the *x* and *y* weighting resistors. For example, a blanking wave is generated at the cathode ray tube control electrode **166** in connection with a conventional bias and blanking circuit **170**. A blanking voltage, as seen in FIG. 4, is derived from connecting diodes in network **76** to appropriate lines **101** through **140** to receive the sequential output of pulse generator **70**. For example, a diode CR1 is connected to line **101** to provide a blanking pulse **60**, as shown in FIG. 4, which blanks out the writing beam between point **0** and **1**. In like manner, diodes CR9, CR10 and CR11 are connected to lines **109**, **110**, and **111**, respectively, to produce blanking waveform **61** of FIG. 4, which blanks out the writing beam segments **9** to **12** of FIGS. 1, 2, and 3. In like manner, the additional blanking waveforms, shown in FIG. 4, are generated to blank out the remaining undesirable portions of the letter "R." Each blanking diode in blanking network **76**, upon conduction, transmits a blanking pulse through blanking diode switching circuit **83**. This circuit is similar to circuits **84** and **86** in that an "R" gating waveform developed for the entire character is applied to isolation diode **174** and to cause conduction of diode **175** to connect the appropriate blanking pulse into bias and blanking circuit **170**. Other characters of the alphabet are shown feeding blanking circuit **83** and are energized when the corresponding character selection line for the *x* and *y* diode switching circuits **84** and **86** are energized.

It should be understood that the present embodiment describes only alphabetical characters for the sake of simplicity. However, any character or symbol desired may be generated by application of the same weighting and blanking techniques following segmentation of the portion of the character to be displayed into substantially equal segments. It should be further understood that pulse generator **70** may be triggered at the start of each character writing sequence or may run continuously with the character selection gate providing a gating pulse of forty pulse periods in duration which is applied, respectively, to the character selection and blanking circuits **83**, **84**, and **86**. While the present embodiment describes only alphabetical characters for the sake of simplicity, any character desired may be generated by application of the same weighting and blanking technique, following segmentation of the portion of the character to be diplayed into substantially equal segments. Also, while separate segments of a character are shown connected to separate weighting resistors for each segment, it is also possible to provide a total, for example, of six weighting resistors for each *x* and *y* network in place of forty, as shown, with a diode selection matrix for each character. The six resistors are then connected to a common output lead. Each of the resistors, however, is then weighted in a binary fashion with values which represents the appropriate binary code for the forty possible levels corresponding to the individual segments. For example, the value of six binary resistors represent binary values 1, 2, 4, 8, 16, and 32. Thus, in order to actuate point **35** of FIG. 1, resistors representing the value of *x* or *y* can be incremented into sixty-four discrete steps. The binary representation of the voltage value of *y* at point **35** of FIG. 2 is generated by the appropriate selection of the correct combination of binary-weighted resistors by the diode selection matrix, to be described, for example, in connection with FIG. 6. For example, if point **35** has a *y* value of 33 volts, lines one and six of the binary resistor network, not shown, would be actuated by way of line **135**, not shown, from generator **70**. Line **135** could then be connected to two "OR" gate diodes representing the value 1 and 32 of the six binary resistors. This provides the correct *y* deflection waveform value at this particular time. The blanking waveform, however, is produced in the same manner as described in connection with the forty lines shown in FIG. 5, since diodes are not weighted in the same manner as resistors.

Referring to FIG. 6, there is shown a further embodiment for generating *x* and *y* voltage waveforms, together with a blanking signal for cursively writing a character on the face of a cathode ray tube. In particular, a pulse generator **200** provides a sequence of signals on sixteen lines corresponding to a sixteen segment character. Lines **201** and **202** show, for example, two of these sixteen lines being fed to the character selection matrix **203**. The character selection matrix for each character contains sixteen "And" gates corresponding to the sixteen lines from pulse generator **200**. A selection gate signal corresponding, for example, to the letter "R" on line **205** is fed to "And" gates **207** and **210**. When the selection signal is applied to "And" gates **207** and **210**, output signals are sequentially developed on lines **208** and **209** of the character selection matrix. The signal on lone **205** is also applied to the remaining sixteen "And" gates corresponding to the sixteen pulse lines from pulse generator **200**. As shown, an output from line **202** into gate **210** is provided on line **209**. Appropriate coded signals are then provided over binary lines **215** to **219** to provide a binary coded signal representing the binary value of each segment of the appropriate *x* waveform to move the beam of the cathode ray tube, for example, through two segments from point zero to point two of the character "R" in FIG. 1. In like manner, the appropriate diodes are connected in the network to provide a coded binary signal on lines **220** to **224**, representing the binary value of each segment of the *y* waveform to move the electron beam from point zero to point two of the character "R" of FIG. 1. Other diodes are connected in the character selection matrix to provide the remaining segments for both *x* and *y* waveforms, as well as an appropriate blanking signal to be applied to the grid of the cathode ray tube of FIG. 1. The output of the *x* waveform lines is

fed to a D/A converter 230 of the conventional type capable of converting the binary signal to an analogue signal output. The y selection waveform, lines 220 to 224, are connected to the y waveform D/A converter 232, which is also of a conventional type, for appropriate generation of a y waveform. The output of the D/A converters 230 and 232 are connected, respectively, to x and y delay line filters prior to being coupled to the x and y deflection amplifiers, such as shown in FIG. 5. In this manner, the character selection matrix is shown for generating an individual character "R" without providing a separate weighting resistor for each segment. In effect, the weighting is performed by applying the D/A converter with proper binary code corresponding to the desired signal level for each segment of the character. It is to be understood that additional lines corresponding to more segments than sixteen could be added to this embodiment. Also, any portion of the character may be blanked out by adding a diode line at the desired time interval which corresponds to the occurrence of a particular gate output line.

What is claimed is:

1. A generator of characters for display on the face of a cathode ray tube comprising means for forming a time function waveform in both horizontal and vertical coordinates of segments forming a continuous trace of the outline of the character on the face of said cathode ray tube including a weighting element for each segment, means for applying pulses sequentially to said weighting elements, means for combining the outputs of said weighting elements to provide x and y waveforms which move the electron beam cursively on the face of said tube to form the outline of said character, and means for blanking undesirable portions of said character.

2. A character generator for display of characters on the face of a cathode ray tube comprising means for forming a time function waveform in both horizontal and vertical coordinates of segments forming a continuous trace of the outline of a character on said tube including a weighting element for each segment, means for sequentially energizing each weighting element for each segment of the character, means for combining the outputs of said weighting elements to provide x and y waveforms which deflect the electron beam cursively on the face of said tube to form the outline of said character, and means for blanking undesirable portions of said character.

3. In combination, means for forming a time function waveform in both horizontal and vertical for the position of all segments forming a continuous trace of the outline of a character on the face of a cathode ray tube, said means including resistance means having a particular weighted value corresponding to each segment, means for combining the outputs of said weighted values to provide x and y waveforms to move the electron beam cursively on the face of said tube to form the outline of said character, and means for sharing the same waveform between different characters.

4. Apparatus for generating signals to deflect an electron beam to form in a cursive manner the outline of a character on a cathode ray tube, said apparatus comprising a weighting element for the values of the x and y coordinates corresponding to each segment forming the outline of said character, means for sequentially applying a signal to each of said weighting elements, and means for combining the output of said x and y weighting elements to form x and y waveforms for moving the electron beam of said tube in a cursive manner.

5. Deflection apparatus including a cathode ray tube for generating signals to deflect an electron beam through selected segments of a continuous character to be displayed upon said tube, said apparatus comprising means for generating an x and y waveform corresponding to the coordinates for each of said segments forming said character, said means including a plurality of gating elements for providing a coded output signal corresponding to the coordinates of each of said segments, and means for combining said output signals to provide x and y waveforms, means for filtering said waveforms, means for applying the output of each filter to said cathode ray tube, and means for blanking out undesirable portions of said waveforms to produce sharp corners in said character.

6. A generator of characters for display on the face of a cathode ray tube comprising means for selecting x and y coordinates along the outline of said character corresponding to segments forming a continuous trace of the outline of the character on the face of the cathode ray tube, a plurality of resistance elements, means for assigning a weighted value to said resistance element corresponding to each of said coordinates, means for applying signals sequentially to said weighted elements to provide x and y waveforms corresponding to the weighted values assigned, means for combining said weighted values of said coordinates to provide x and y waveforms which move the electron beam cursively on the face of said tube to form the outline of said character, means for individually filtering said x and y waveforms, means for applying the filtered waveform output to said cathode ray tube, and means for blanking undesirable portions of said character.

7. A generator of characters for display on the face of a cathode ray tube comprising means for selecting x and y coordinates along the outline of said character corresponding to segments forming a continuous trace of the outline of the character on the face of the cathode ray tube, a plurality of weighting elements, means for assigning a weighted value to said elements corresponding to each of said coordinates, means for applying signals sequentially to said weighted elements to provide x and y waveforms corresponding to the weighted values assigned, means for combining said signals to provide x and y waveforms which move the electron beam cursively on the face of said tube to form the outline of said character, and means for blanking undesirable portions of said character.

8. A generator of characters for display on the face of a cathode ray tube comprising means for forming a time function waveform in both horizontal and vertical coordinates of equally divided segments adapted to form a continuous trace of the outline of the character on the face of said tube having rounded off corners, a weighting element adapted to provide a signal corresponding to each segment traced by said tube, means for sequentially applying signals to each of said weighting elements, means for combining the outputs of said weighting elements to provide x and y waveforms which move the electron beam cursively on the face of said tube to form the outline of said character, means for blanking undesirable portions of said character to produce sharp corners, and means for selecting different characters.

9. A generator of characters for display on the face of a cathode ray tube comprising means for forming a time function waveform in both horizontal and vertical coordinates of equally divided segments adapted to form a continuous trace of the outline of the characfer on the face of said tube, a weighting element adapted to provide a signal corresponding to each segment traced by said tube, means for sequentially applying a signal to said weighting elements, means for combining the outputs of said weighting elements to provide x and y waveforms which move the electron beam cursively on the face of said tube to form the outline of said character, and means for blanking undesirable portions of said character, said signal means including means for generating digitally coded values of said coordinates.

10. In combination, a cathode ray tube having x and y deflection circuits, means for providing a sequence of pulses, a plurality of x and y weighting elements fed by said sequence of pulses to provide weighted output signals, means for selecting predetermined weighted output signals and applying said signals to operational amplifier

means to generate a smooth cursive x and y deflection voltage, and means for applying said deflection voltage to the x and y deflection circuits of said cathode ray tube to produce a cursive character having rounded off corners.

11. In combination, a cathode ray tube having x and y deflection circuits, means for providing a sequence of pulses, a plurality of x and y weighting elements fed by said sequence of pulses to provide weighted output signals, means for selecting predetermined weighted output signals and applying said signals to operational amplifier means to generate a smooth, cursive x and y deflection voltage, and means for blanking portions of characters on the face of said tube to produce characters having sharp corners.

12. Electron beam controlling apparatus of the type adapted to trace selected cursive characters on the face of a cathode ray tube in response to x and y deflection signals comprising a plurality of gating circuits of the logical "And" type, means for feeding a sequence of energizing pulses to one input of said gating circuits, means for applying a selection signal to the other input of said gating circuits, unidirectional signal conducting means connected to the output of predetermined gating circuits to generate coded, smooth x and y waveforms, converter means for converting said coded x and y waveforms to x and y deflection signals, means for filtering said x and y deflection signals, means for applying said filtered x and y deflection signals to said cathode ray tube, and means for blanking portions of characters on the face of said tube to produce sharp corners.

13. Apparatus as in claim **12** and including means for sharing the x and y deflection signals between different characters.

14. A symbol generator comprising a cathode ray tube, means for generating a plurality of pulsed signals corresponding to the coordinates of segments of a symbol to be displayed, a deflection circuit for said cathode ray tube, and gating means for selectively applying said pulsed signals to said deflection circuit in a predetermined pattern corresponding to the coordinates of said segments to deflect the electron beam of said tube in a cursive manner.

15. A symbol generator comprising a cathode ray tube, means for generating a plurality of pulsed signals corresponding to the coordinates of segments of a symbol to be displayed, a deflection circuit for said cathode ray tube, gating means for selectively applying said pulsed signals to said deflection circuit in a predetermined pattern corresponding to the coordinates of said segments to deflect the electron beam of said tube in a cursive manner, and means to blank out portions of said symbol from the face of said tube.

16. A generator of characters for display on the face of a cathode ray tube comprising means for forming a smooth time function waveform in both horizontal and vertical coordinates of segments forming a continuous trace of the outline of the character on the face of said cathode ray tube including a weighting element for each segment, means for applying pulses sequentially to said weighting elements, means for combining the outputs of said weighting elements to provide x and y waveforms which move the electron beam cursively on the face of said tube to form the outline of said character producing rounded off corners only, and means for blanking undesirable portions of said character to produce sharp corners.

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