

May 5, 1964

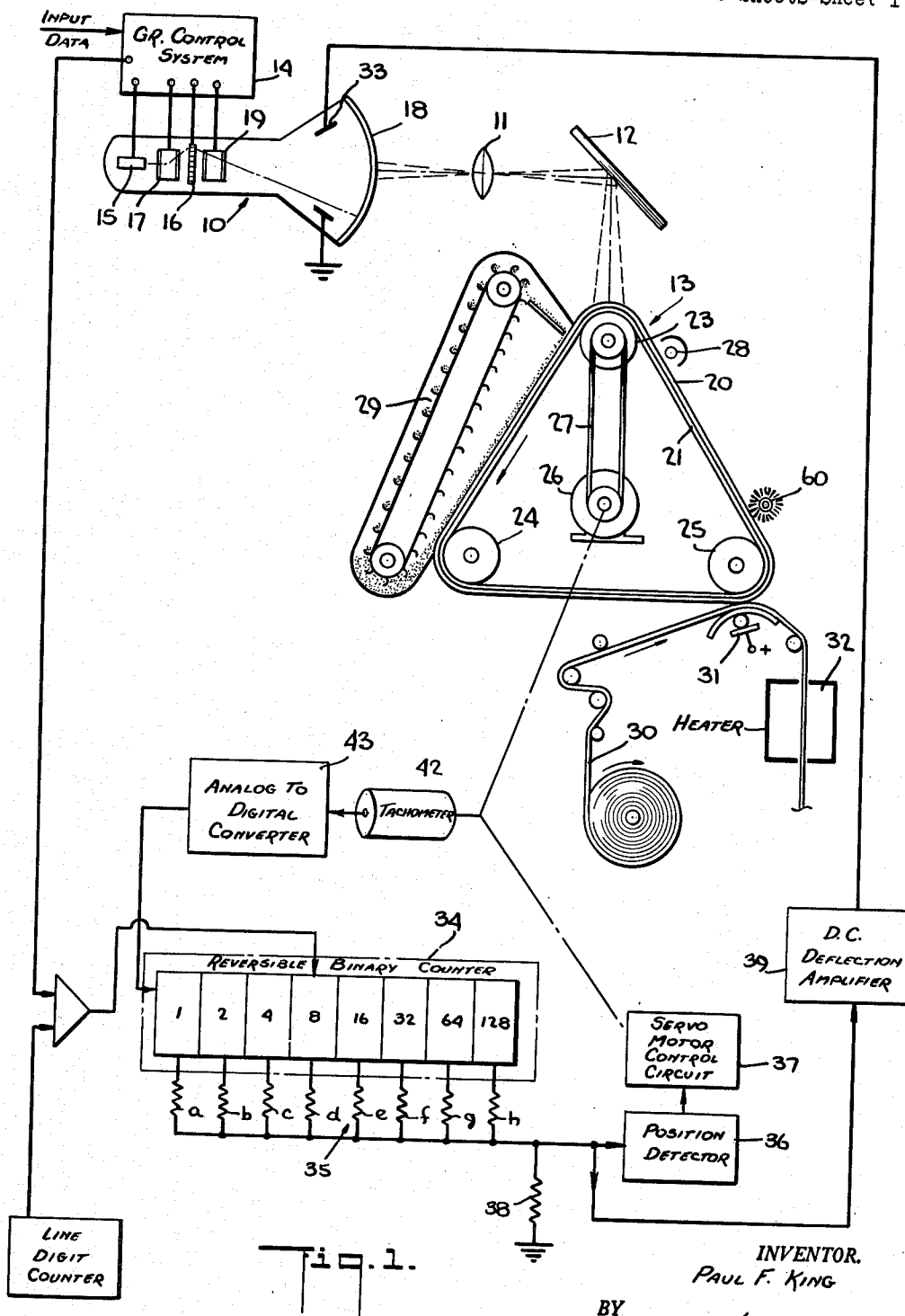
P. F. KING

3,132,206

HIGH SPEED PRINTING APPARATUS

Filed May 6, 1960

3 Sheets-Sheet 1



INVENTOR.
PAUL F. KING
BY
Kennyon & Kenny
ATTORNEYS

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P. F. KING

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3 Sheets-Sheet 2

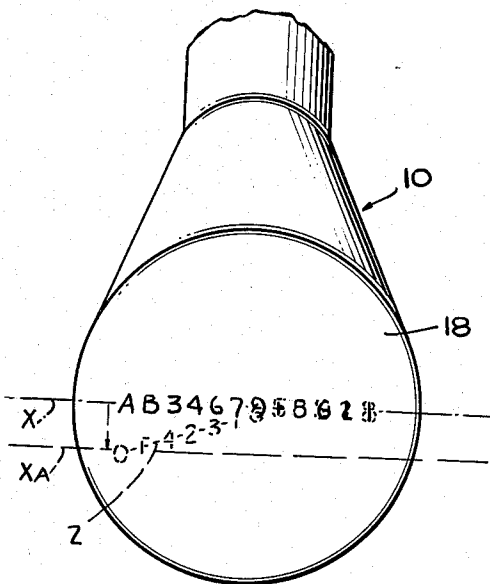


Fig. 2.

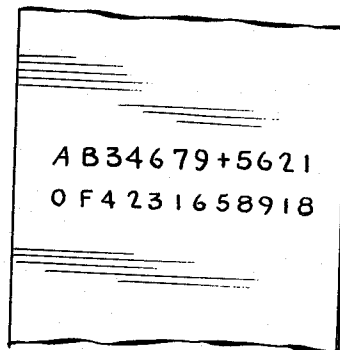


Fig. 3.

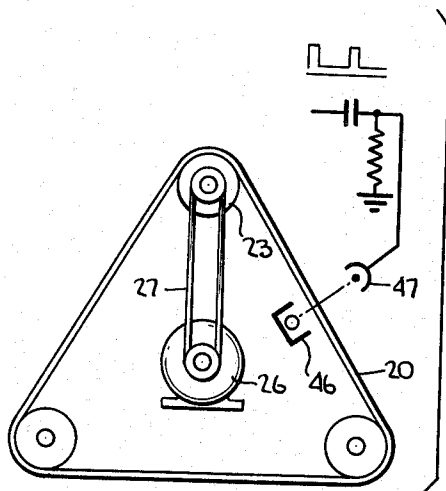
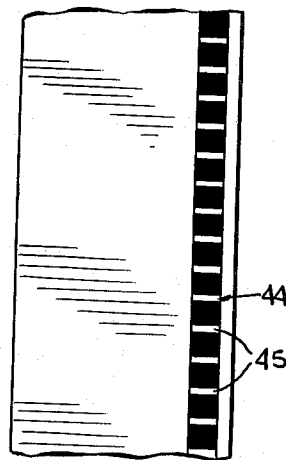


Fig. 5.

Fig. 6.



INVENTOR.
PAUL F. KING
BY
Termyon Henyon
ATTORNEYS

May 5, 1964

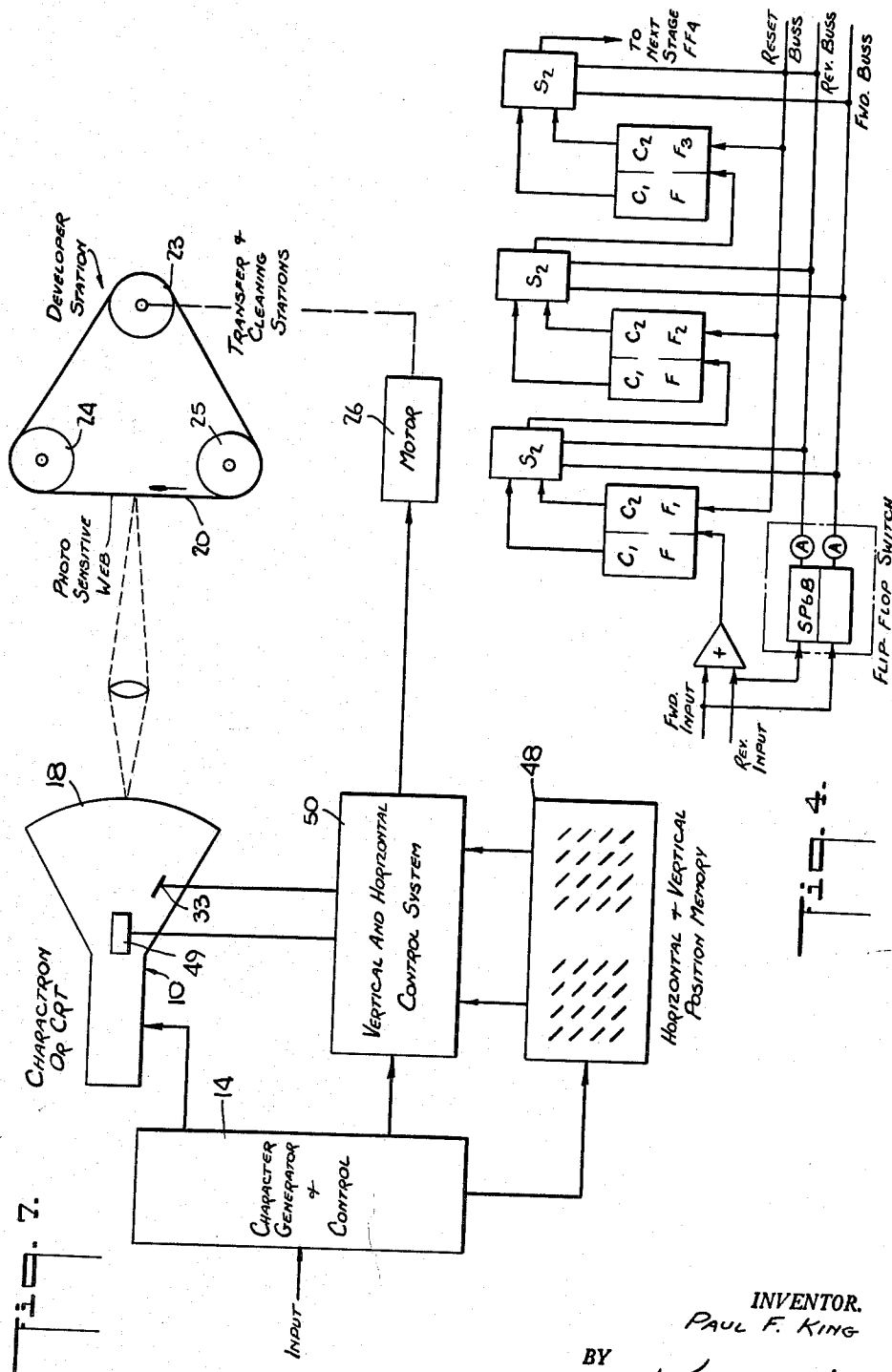
P. F. KING

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HIGH SPEED PRINTING APPARATUS

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3 Sheets-Sheet 3



INVENTOR.
PAUL F. KING
BY *Kenny & Kenny*
ATTORNEY

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3,132,206

HIGH SPEED PRINTING APPARATUS
Paul F. King, Webster, N.Y., assignor to Xerox Corporation, a corporation of New York
Filed May 6, 1960, Ser. No. 27,324
11 Claims. (Cl. 178—15)

The present invention relates generally to electronic printers wherein alpha-numeric characters presented on the face of a cathode-ray tube are xerographically recorded, and more particularly to an improved high speed printer adapted to effect a line advance or to permit printing of a partial line without interrupting the input information supplied to the tube.

For business purposes, the final output information provided by electronic computers must ordinarily be in the form of a printed record. Mechanical version of printers which have been devised vary from electrically-operated typewriters working at a maximum of 20 characters per second to line-at-a-time printers which are capable of printing 1,000 or more 120-character lines per minute. As faster computers and data processing systems have become available there has arisen a need for correspondingly faster printers having a speed capability far beyond that of mechanical printers.

In one existing form of high-speed printer, a Characteron tube acts to transform input pulse code information into light rays of predetermined configuration. The alpha-numeric characters displayed on the face of the Characteron tube are projected onto a xerographic printer and recorded on ordinary untreated paper. Thus, pulse-code data of electronic processors may be converted to printed records in the form of letters, numerals, charts and graphs.

In the Characteron tube, the electron beam is shaped to form a symbol or character by projecting the electrons from the gun through a very small aperture of the desired pattern. By placing several different apertures in a stencil-like matrix and selectively deflecting the beam relative thereto, a like number of differently shaped characters may be obtained. As the electron beam continues its passage, it is subsequently realigned and then deflected to the desired line location of the face of the tube. A display tube of this type is capable of speeds as high as one million characters per minute.

When projecting the image from the Characteron tube onto a recording web for xerographic printing, it is the usual practice to hold the web stationary during the printing of a line and then to mechanically ratchet the web forward for printing at the next line position. While this arrangement can accommodate a random printing rate within a given line, it requires a dead time of at least 20 to 50 milliseconds at the end of each line to allow for the advance of the web.

In some applications this restriction is not material, in others it impairs the efficiency of the system and in some instances it renders the system unworkable. In many data processing systems having a hard copy output printer, information is fed to the cathode-ray character forming tube from magnetic tape input or buffer storage tape units. Because of the dead time limit of conventional line advance mechanisms, it becomes necessary to bring these units to a stop during the time the receiving web is being advanced.

The delay imposed by the requirements for web advance can be avoided in certain instances by providing a continuously moving web. However, this introduces new limitations into the data processing system. A printer having a continuously moving web would require that the printing rate be constant at all times and that an equivalent dead time be provided for all printed lines which are not complete.

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In view of the foregoing, it is the principal object of this invention to provide an electronic hard copy printer of the line advance type which operates efficiently and at high speed.

More particularly, it is an object of this invention to provide an electronic hard copy printer in which data fed to a cathode-ray tube adapted to display alpha-numeric information is recorded on a xerographic web whose movement is so controlled relative to the operation of the tube as to effect a line advance or permit the printing of a partial line without interrupting the flow of input data to the tube.

Still another object of the invention is to provide a high speed printer to receive and print information at a random rate.

Also an object of the invention is to provide a pulse responsive servo system for driving a xerographic web in synchronism with the deflection of a cathode-ray beam.

Briefly stated, these and other objects of the invention are attained by the use of a character-forming cathode ray tube whose screen presentation is optically projected onto the surface of a moving xerographic web. The tube character display is produced by deflection of the electron beam across the screen thereof. When an instruction is received for a line advance, the beam is deflected downwardly one line width from its normal printing position and printing is continued on the new line. At the instant the beam is downwardly deflected, the drive motor for the xerographic web is energized to advance the web, and as the web moves upwardly the cathode ray beam moves in the same direction in synchronism therewith. Both motions are arrested when the beam is returned to its normal position. Thus, printing operations are uninterrupted during the advance of the web and the system is free of dead time delay.

For a better understanding of the invention as well as other objects and further features thereof, reference is made to the following detailed description to be read in conjunction with the accompanying drawing, wherein like components in the several views are identified by like reference numerals.

In the drawing:

FIG. 1 is a schematic diagram of one preferred embodiment of a high speed electronic printing system in accordance with the invention.

FIG. 2 shows the face of the character forming cathode ray tube incorporated in the system.

FIG. 3 illustrates the formation of characters on the xerographic web derived from the face of the tube.

FIG. 4 shows in block diagram form the reversible binary counter included in the electronic printing system.

FIG. 5 illustrates schematically a modification of the servo system.

FIG. 6 is a section of the xerographic web employed in conjunction with the servo system shown in FIG. 5.

FIG. 7 shows in block form a high speed electronic printing system adapted to print business forms.

Referring now to the drawings and more particularly to FIG. 1, there is shown a high speed electronic printing system in accordance with the invention including a character-forming cathode ray tube 10. The alpha-numeric presentation on the fluorescent face of the tube is optically projected by means of a lens system 11 and a reflector 12 onto the surface of a xerographic recording device, generally designated by numeral 13.

Cathode ray tube 10 may be of the general type known by the name "Characteron" and disclosed for example in U.S. Patents 2,275,017 and 2,283,383. The invention is not limited to character-forming tubes of this type and can make use of any known form of cathode ray tube capable of generating and displaying alpha-numeric characters and symbols such as the Cathode-Ray Read-Out

tubes described in the article by Perry and Alco on pages 72 et seq. in the January 3, 1958, edition of "Electronics" magazine. These tubes trace out characters by the Fourier Synthesis technique. For purposes of illustration, the character-forming tube described hereinafter will be of the Charactron type.

The input data applied to the cathode-ray tube may be derived from a variety of information sources, such as electronic computers, automatic data processors, magnetic storage units, central filing systems and telecommunication networks. The input data is supplied to the electronic control circuits 14 for the tube. These circuits are of the type disclosed in the Charactron patents identified above and include means for control of the electron beam and logic circuits which select characters and produce deflection inputs for the tube control circuits.

In the Charactron tube, a cathode-ray beam from a gun 15 is projected through a matrix 16 having apertures therein shaped like letters, numerals or other characters to be printed. The diameter of the beam is sufficient to overlay only one of the apertures in the matrix 16. Selective voltages applied to the deflection plates 17 will cause the electron beam tube to be directed to the desired area on the matrix 16 so as to overlay a particular shaped aperture. The electron beam emanating from matrix 16 has a cross-sectional configuration which matches the shape of the selected aperture. The shaped beam is then directed at the fluorescent screen 18 to a location thereon controlled by voltages applied to deflection elements 19 and 33, the light image formed on the screen having the configuration of the selected character.

Successive code signals from a computer or other data processing device establish appropriate selection voltages which are serially applied to the deflection plates 17, and the electrostatic fields produced thereby successively deflect the beam to the different areas of the matrix to generate the variously shaped electron-streams which serve to make up the total message. Positioning of the successive characters along a line upon the display screen is accomplished by the fields established by deflection plates 19.

The image displayed on the face 18 of the cathode-ray tube is optically projected onto the surface of a flexible xerographic plate in the form of a continuous belt which may be constituted by an outer layer of photoconductive insulating material 20, overlying a backing member of conductive material 21. The photoconductive layer may be the usual material for this purpose such as anthracene and sulfur, as disclosed in the Carlson patent, U.S. 2,297,691, or materials such as a pigment in an insulating binder as disclosed in the patent to Simmons et al. U.S. 2,791,949. One preferred photoconductor is amorphous or vitreous selenium as disclosed in U.S. Patent 2,753,278.

The continuous belt is positioned about three drum rollers 23, 24 and 25 which move the belt through its path of travel and are so arranged that the belt in effect becomes a three-sided or triangular xerographic plate. The upper roller 23 is driven by motor 26 coupled thereto by a suitable belt 27. The endless plate is electrostatically sensitized by a corona discharge electrode 28, such as disclosed in the Carlson Patent 2,588,699 or in the Walkup patent, U.S. 2,774,921. Preferably the charging means is constituted by screen-controlled corona discharge apparatus of the type disclosed in the Walkup patent, U.S. 2,277,987 which affords a substantially uniform charge under varying speeds of operation.

The sensitized endless plate is shifted to the exposure zone where the projected image of the cathode-ray tube face results in the formation of an electrostatic latent image on the surface of the plate. The xerographic plate then moves through a cascade-developing apparatus 29 wherein the latent electrostatic image sustained on the surface of the plate is developed through the deposition thereon of fine powder particles. This development may be accomplished in accordance with the teachings of the

patent to Wise, U.S. 2,618,552 or by any other technique known in the art of xerography.

The developed image formed of electroscopic powder is then conveyed to a transfer zone where it is transferred to the surface of untreated paper 30 taken from a roll, the paper being moved in synchronism with the endless plate. An electrode 31, which is connected to a high-voltage source, serves to apply an electrostatic charge to the paper. The charge is of opposite polarity to that of the powder on the image areas and is of sufficient intensity to attract the powder and thereby transfer the image to the paper.

The electroscopic powder is fusible or thermo-adhesive and a suitable heater 32 is provided to cause the powder images to be affixed to the paper and thus form a permanent printed record of the images. Alternatively, the paper may be provided with a thermo-adhesive coating which when heated will cause powder to adhere thereto. A cleaning brush 60 is provided in engagement with the endless belt for removing surplus powder therefrom subsequent to the transfer operation.

In the character-forming tube 10 shown in FIG. 1, the normal vertical position of the electron beam is in alignment with an axis X extending horizontally through the center of the tube. Thus, the beam is ordinarily deflected along axis X to produce a succession of characters, as shown in FIG. 2, in accordance with the information supplied to the tube.

In the conventional character-forming cathode-ray tube arrangement, the next line of output information is also displayed along the same axis X. Hence when copying, as by xerography, it is the usual practice, at the completion of a line, to ratchet or advance the xerographic web one line width in preparation for the next line presentation. In order to prevent a display on the cathode-ray tube during the advance of the web, it is essential to halt the supply of data to the cathode-ray tube until the web occupies its next line position. Thus, in a conventional recording arrangement, the web is stationary while the recording is being made and is advanced one step upon completion of the line recording, the advance period constituting dead time during which no cathode-ray presentation is permitted.

In accordance with the present invention, when an instruction is received for a line advance, the electron beam in cathode-ray tube 10 at the starting point is deflected downwardly one line width to the off-center axis XA, as shown in FIG. 2, and the beam then proceeds by horizontal deflection across the tube to produce the succession of characters constituting the next line of output information. Downward deflection of the beam is effected by a voltage applied to the deflection element 33 in the cathode-ray tube. This element may take the form of a deflection plate or a magnetic deflection coil.

At the same time that the beam is deflected downwardly, the drive motor 26 for the xerographic web is energized by a servo control system to be later described, and the web is advanced. As the web 20 is advanced upwardly, the cathode-ray beam, which initially was displaced downwardly one line width from the central axis X, also is deflected upwardly in synchronism with the web.

Since the beam concurrently is being deflected horizontally across the tube to produce the succession of characters thereacross, the vector resultant of the simultaneous horizontal and vertical deflections of the beam is the slope Z in FIG. 2. But since the display of characters along the skew line Z occurs in synchronism with the upward movement of the recording web, these characters are formed on the web along a transverse line, as shown in FIG. 3, which is exactly parallel with the preceding printed line. Both the vertical deflection of the beam and the motion of the web are halted simultaneously when the beam reaches the center axis X, at which point printing continues therealong until the line is completed,

It will be seen therefore that no dead time occurs during the advance of the web and that printing continues without interruption, the characters on the tube being so deflected vertically from their normal center position as to assume their proper line position on the moving web.

If a number of short lines are to be printed in sequence, the beam may be several line widths below the center of the tube face. Under such circumstances a large amount of power would be applied to the motor, giving the receiving web a high acceleration in an effort to bring the beam back to its normal position. The receiving web speed would be quite steady when the character input rate is constant and the lines are of uniform length. Should the information input stop abruptly the motor power would be reduced to zero. The inertia of the mechanical system will of course move the printing area above the normal position before the web comes to rest. The control system will however raise the beam corresponding and hold the printing position.

Vertical spaces in the hard copy output can be provided by transmitting a series of line advance instructions to the printer. A space of several inches can be made without deflecting the beam beyond the face of the tube. The vertical spacing capability can be used to advance the printing from one page to the next with very little loss in time. If it is desired, a special instruction can be provided to advance the printing position a desired number of spaces within the limits of the tube face.

We shall now consider the structure and function of the servo control system which acts to synchronize the movement of the xerographic web with the operation of the character-forming cathode-ray tube, in the manner described above, to obviate waiting time.

As shown in FIG. 1, the servo system for controlling the operation of motor 26, which drives the xerographic web, includes a reversible binary counter 34 and a resistive de-coding network 35 coupled to the counter to produce an error signal. This signal is applied to a position detector 36, the output of detector 36 being fed to the servo motor control circuit 37.

The reversible binary counter includes a set of bi-stable storage elements in cascade relation, each of which is adapted to transfer back and forth between its two stable states upon the reception of pulses. The pulses to be counted are applied to one of the bi-stable elements. Each time that this element changes from the state representing binary 0, a pulse is caused to be sent to the second element in the set. When the second element transfers to 0, a pulse is transmitted to the third element in the cascade, and so on for all of the bi-stable elements in the set. The bi-stable elements may, for example, be in the form of flip-flop circuits, magnetic core devices or any other known devices. In FIG. 1, the set of bi-stable elements is constituted by eight stages providing, in succession, the counts 1, 2, 4, 8, 16, 32, 64 and 128.

The counter must be of the reversible type whereby by supplying subtractive or reverse pulses thereto, the count is reversed. An example of a reversible counter is shown in FIG. 4, the counter containing a set of complementary flip-flops C_1 — C_2 which have two complete sets of interstage transfer circuitry S_2 . It will add or subtract depending upon which side of the complementing flip-flop stages the interstage transfer pulse is derived from. Two gating busses are provided which disable one or the other sets of the transfer circuitry, and they are controlled by a fast flip-flop switch SP6B. The switch flip-flop SP6B operates faster than the counter flip-flops and completes the change of state of the gating busses before the first counter changes state.

One commercially available reversible counter suitable for this purpose is Navcor or model 111B, manufactured by Navigation Computer Corp. of Philadelphia, Pa., this model being described in "Pulse Techniques," volume IX, No. 3, published by this company.

The resistive decoding network 35 is constituted by a bank of resistors a to h , one end of each resistor being

connected to a respective stage in the binary counter 34, the other ends thereof being commonly connected to ground through a totalizing resistor 38. Resistors a to h constitute weighting resistors which supply current in proportion to the values of the associated binary stages. The combined current passing through resistor 38 is therefore an analog function of the digital value held in the counter at any given time.

The analog output voltage from the network 35 is applied through a suitable direct-current amplifier 39 to the deflection plates 33 of the character-forming cathode ray tube 10. The arrangement is such that when the value held in counter 34 is one-half of the maximum count, the resultant analog voltage which is developed at resistor 38 and applied to the deflection plate 33 is at a level maintaining the electron beam at its normal printing position at the center of the tube (axis X in FIG. 2).

When the beam has completed its printing operation at the end of a line, it is reset by its control system 14 to its initial position at the start of the line along central axis X. At this starting point, the control system supplies an advance pulse through an amplifier 40 to the counter 34, which increases the count therein above the held value, which as indicated previously is one-half the total count. Preferably, the value is increased by a large increment, such as 8 or 16, hence the advance pulse is applied not to the first stage of the counter but to a higher stage providing the large increment.

Assuming therefore that the counter holds 64 counts, representing one-half the maximum value, and that the advance pulse adds 8 counts thereto, the presence of 72 counts will produce an analog voltage causing deflection of the cathode-ray beam downwardly from the center axis X to an off-center axis X_a (FIG. 2) spaced one line width therebelow.

To ensure that the advance pulse is applied after completion of a line, a check pulse may be applied to amplifier 40 from a line digit counter 41 which provides a pulse only after the prescribed number of digits constituting a printing line has been counted. Amplifier 40 is adjusted so that a pulse is applied to the binary counter 34 in the event that an advance pulse is received from control system 14 or a check pulse is received from counter 41.

The analog voltage from decoding network 35 is also applied through the position detector 36 to the servo control circuit 37 for the motor 26 driving the xerographic web. The position detector provides a control voltage as a function of the applied analog voltage and includes a threshold circuit with the mid-count analog value as a reference. Hence, no output is developed by the detector until the input analog exceeds the mid-count value, the output being thereafter proportional to the extent of change above mid-count. Thus, when the beam is deflected downwardly one line width, a torque is developed in the motor 26 causing the xerographic web to advance, the degree of torque depending on the incremental value introduced into the counter.

As the web moves, subtract or reverse pulses are fed back to the binary counter 34 and the value held therein is gradually reduced from the incremental value above mid-count (normal beam position) to the mid-count value. The manner in which this reduction is effected is as follows:

Motor 26 is mechanically coupled to the shaft of a tachometer 42 which produces a voltage output proportional to the speed of the motor. This voltage is converted into pulses by an analog-to-digital converter 43, the number of pulses yielded thereby being proportional to the magnitude of the analog voltage. These pulses are fed subtractively into the first stage of the binary counter.

Thus, as the flow of reverse pulses act to reduce the count held in the counter from its incremental value above mid-count the analog voltage developed at the output of network 35 is reduced proportionately. Con-

current with the reduction in analog voltage, the deflection voltage on the cathode-ray tube decreases and the speed of the motor is also reduced until the juncture is reached at which the count held in the counter is again at half maximum value, at which point the motor comes to a halt and the cathode-ray beam is again at the central axis X.

The servo system responds to the count of additive pulses in the counter to develop a torque in the servo motor which in turn produces subtractive pulses, these being fed back into the counter so as to reduce the count therein to the level at which a null is established. The extent of motor movement and the concomitant excursion of the cathode-ray beam can be controlled by the incremental value introduced into the counter.

Obviously had 32 pulses been fed into the counter, rather than 8, the deflection of the beam and the advance of the web would have been far greater. In any event, printing continues during the advance of the web, the characters being displaced from the central axis of the cathode-ray tube along a slope until such time as the beam is returned to tube center. From there on printing continues along the normal center line until the line is completed. When the line is completed, an advance pulse is again generated and the line advance printing process is repeated.

In the servo system shown in FIG. 1, the subtractive pulses which reflect the advance movement of the web are generated by means of a tachometer 42 operating in conjunction with an analog to digital converter 43. Another technique by which these pulses may be developed is shown in FIGS. 5 and 6, wherein the xerographic endless web is provided marginally with a variable density light track 44 providing a continuous series of equi-spaced light-permeable areas 45, very much in the manner of a sound track on film. A light source 46 is positioned behind the marginal track on the web and as the web advances, light pulses are projected through the track which are intercepted by a suitable photocell 47 to produce electrical pulses serving as the subtractive pulses for the counter.

The same result may be accomplished by magnetic marks printed along a track on the xerographic belt, the marks being detected by a magnetic pick-up head to produce a series of pulses in the course of web advance. In either case the subtractive pulses are applied to the counter to reverse the count therein until the null condition is reached. Null may be established at mid-count or at any other predetermined value.

In some data processing systems, printing on business forms may be the only purpose for which the electronic printer is intended. In such cases it is inefficient to require the computer to supply formal instructions to the printer and moreover it entails an added programming burden. This is particularly true when thousands of documents are to be printed with the same format. In data processing systems with this specialized requirement it is preferable for the printer to provide its own format control.

This can best be accomplished, as shown in simplified form in FIG. 7, by adding a horizontal and vertical position memory unit 48 to the servo-controlled flexible plate printer. The memory unit actuates a control system so coupled to the deflection plates of the cathode-ray tube to effect not only line spacing but also to control the starting point on a given line.

To this end, the cathode-ray tube 10, in addition to the vertical deflection plates 33, is provided with a set of horizontal deflection plates 49. Thus, a voltage applied from a control system 50 to the vertical deflection plates 33 will cause the cathode-ray beam to shift downwardly from its center line position, in the manner previously described, to produce an advance of the web 20 and a concurrent printing operation. On the other hand, a voltage applied from control system 50 to the horizon-

tal deflection plates 49 will shift the beam from its normal starting position on the central axis X to an intermediate position thereof in accordance with business form requirements.

The position memory unit may consist merely of manually set switches that designate where an entry is to be made in the business form. For example, if the entry is four spaces down, the appropriate switch will be connected to a particular stage binary counter included in control system 50 so as to provide an incremental increase above the mid-count value (normal center on the screen) sufficient to cause the beam to shift four spaces down. Thus, in printing checks, the first position which is set in the position memory unit 48 may designate the starting point for printing the date, the second position may designate the starting point for the name of the individual, etc.

In such a printing system the only format instruction transmitted by the computer would be a single instruction which directs the printer to consult the position memory unit for the starting point of the next entry into the business form. The position memory unit 48 transmits the new printing position to the vertical and horizontal control circuits 50 in the same length of time as would be required to print a character. In this manner many entries can be printed into thousands of business forms at random, irregular printing rate chosen by the computer without the undue burden of formal instructions.

The electronic printer disclosed above in connection with recording alpha-numeric information is also useful in analog read-out applications. Most cathode-ray character generators are capable of imaging a small spot on the sensitive surface of an xerographic web and deflecting the beam perpendicularly to the web motion to an extent proportional in the instantaneous analog value.

An analog function may then be plotted by advancing the beam downwardly or the recording web upwardly. The servo control system described hereinabove can carry out this function with a micro-advance instruction. The vertical advance produced with this instruction can be made a small fraction of a normal line advance. An advance equal to the spot diameter is a preferred choice, thus giving a solid line plot. A printer plotter using this control system is capable of recording graphs of any length. If multiple plots are desired on the same graph, several points could be recorded between each web advance instruction.

The printer described herein is capable of printing at high density rates, as in the case of a high speed teletype system, or it can operate at low density rates, as in the case of printing into business forms. In all instances a horizontal or vertical advance in the printing position requires that such information be transmitted to the printer from some unit of the data handling system. This may be in the form of separate leads connected to the printer control circuits or it may be in the form of coded information transmitted over the same sets of leads which carry the alpha-numeric instructions. Several instructions can be reserved from the code system for providing a selection of advances of various lengths.

While there has been shown what are considered to be preferred embodiments of the invention, it will be manifest that many changes and modifications may be made therein without departing from the essential spirit of the invention. For example, it is recognized that recording on photosensitive materials other than xerographic members may be desirable for buffer storage or, in some instances, for final recording. Specifically, it is understood that recording on silver halide microfilm, diazo or similar materials may be desired for temporary buffer storage for off-line operation or for permanent storage of computer output data. It is intended, therefore, in the annexed claims to cover all such changes and modifications as fall within the true scope of the invention.

What is claimed is:

1. A high speed electronic printing system comprising a read-out device including a cathode-ray tube for displaying light images on a screen and provided with deflection means to vary the vertical orientation of said beam on said screen from a normal location thereon to a displaced location; a recorder including a movable web disposed to receive the light images from said screen and a motor therefor; and apparatus to coordinate the operation of said device and said recorder including a reversible binary counter, means coupled to said counter to derive an analog voltage therefrom as a function of the count held therein, means actuated by an advance signal and coupled to said deflection means and to said motor to deflect said beam in accordance with said analog voltage to said displaced location and simultaneously to energize said motor to advance said web, means responsive to movement of said web to produce pulses whose number depends on the displacement thereof and means to apply said pulses subtractively to said counter whereby as said web advances the count held in said counter is reduced and said analog voltage is reduced accordingly.

2. A high speed electronic printing system comprising a read-out device including a cathode-ray beam tube for displaying illuminated alpha-numeric characters on a screen in response to input information and provided with voltage-sensitive deflection means to vary the vertical orientation of the beam on said screen from a normal location thereon to a displaced location; a xerographic recorder including a movable photoconductive web disposed to receive said characters from said screen and a motor to advance said web; and apparatus to coordinate the operation of said device and said recorder including a reversible binary counter, means coupled to said counter to derive an analog voltage therefrom as a function of the count held therein; a control circuit for said web advance motor, means responsive to said analog voltage and coupled to said deflection means and to said motor control circuit to deflect said beam to said displaced location and simultaneously to energize said motor, means coupled to said motor to produce pulses whose number depends on the extent of web advance, means to apply said pulses subtractively to said counter whereby as said web advances the count held in said counter is reduced and said analog voltage is reduced accordingly to cause said beam to return to its normal location, said motor being halted when said beam reaches said normal location.

3. A high speed electronic printing system comprising a read-out device including a cathode-ray tube for displaying illuminated alpha-numeric characters on a screen in response to input information and provided with voltage-sensitive deflection means to vary the vertical orientation of said beam on said screen from a normal location thereon to a displaced location; a xerographic recorder including a movable web disposed to receive the characters from said screen and a motor to advance said web; and apparatus to coordinate the operation of said recorder including a reversible binary counter, means coupled to said counter to derive analog voltage therefrom as a function of the count held therein; a servo control circuit for said web motor, means actuated by an advance signal and coupled to said deflection means and to said motor control circuit to deflect said beam in accordance with said analog voltage to said displaced location and simultaneously to energize said motor tachometer to advance said web, means coupled to said motor and an analog-to-digital converter coupled to said tachometer to produce pulses whose rate depends on the speed of said motor, and means to apply said pulses subtractively to said counter whereby as said web advances the count held in said counter is reduced and said analog voltage is reduced accordingly to cause said beam to return to its normal location, said motor being halted when said beam reaches said normal location.

4. A system, as set forth in claim 3, wherein said re-

versible counter includes a series of bi-stable stages and said means to derive an analog voltage includes a resistance network having a weighing resistor connected to each stage of said counter to produce a current proportional to the count therein.

5. A system, as set forth in claim 3, wherein said beam is caused to occupy its normal location when the count held in said counter is one half its maximum value and wherein said beam is deflected to occupy its displaced location when an incremental count above said half maximum is introduced into said counter by said advance signal.

6. A high speed electronic printing system comprising a read-out device including a cathode-ray tube for displaying light images on a screen in response to input information and provide with voltage-sensitive deflection means to vary the vertical orientation of said beam on said screen from a normal location thereon to a displaced location; a xerographic recorder including a movable web disposed to receive light images from said screen and a motor to advance said web; and apparatus to coordinate the operation of said recorder including a reversible binary counter, means coupled to said counter to derive analog voltage therefrom as a function of the count held therein, said counter normally holding a count therein equal to half the maximum count, means responsive to an advance signal to introduce an incremental count in said counter above said half value to produce a given analog value, a control circuit for said web motor, means responsive to said given analog voltage and coupled to said deflection means and to said motor control circuit to deflect said beam to said displaced location and simultaneously to energize said motor, means coupled to said web to produce pulses whose number depends on the displacement thereof, means to apply said pulses subtractively to said counter whereby as said web advances the count held in said counter is reduced and said given analog voltage is reduced accordingly to cause said beam to return to its normal location, said motor being halted when said beam reaches said normal location.

7. A system as set forth in claim 6, wherein said means to produce pulses includes an optical track on said web having a series of light marks thereon, and photoelectric means to scan said track as said web is advanced to produce said pulses.

8. A system as set forth in claim 6, wherein said means to produce pulses includes a track on said web having a series of magnetic marks thereon, and magnetic head means adjacent said track to produce said pulses as said web is advanced.

9. A system as set forth in claim 6, adapted for printing on business forms and including a switching matrix coupled to said reversible counter selectively to introduce counts therein effecting displacement of said beam to predetermined format positions on said web.

10. A high speed electronic recorder to record information represented by electrical information signals comprising:

a cathode ray tube adapted and disposed relative a sensitive member to form marks in accordance with the information signals on the sensitive member, the cathode ray tube including horizontal deflection means to deflect the marks transversely across the member and vertical deflection means to deflect the marks longitudinally along the member, advance means to longitudinally advance the sensitive member, means to receive an advance signal ordering an arbitrary longitudinal advance of the sensitive member to a new position, means to develop an error signal representative of the difference between the instantaneous longitudinal position of the sensitive member and the new position ordered by the advance signal, means solely responsive to the error signal to operate

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the vertical deflection means to deflect the marks a longitudinal distance equal to the difference between the instantaneous longitudinal position of the sensitive member and the position ordered by the advance signal,

and means responsive to the error signal to actuate the advance means in a direction to reduce the error signal whereby, to record information, marks may be instantaneously and arbitrarily positioned on the sensitive member and whereby the marks are formed in a straight line in the absence of advance signals.

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11. Apparatus according to claim 10 in which the cathode ray tube forms light images which are focused on the sensitive member and in which the sensitive member is photoconductive.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,132,206

May 5, 1964

Paul F. King

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 17, for "version" read -- versions --;
column 10, line 16, for "provide" read -- provided --.

Signed and sealed this 6th day of April 1965.

(SEAL)

Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents

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