

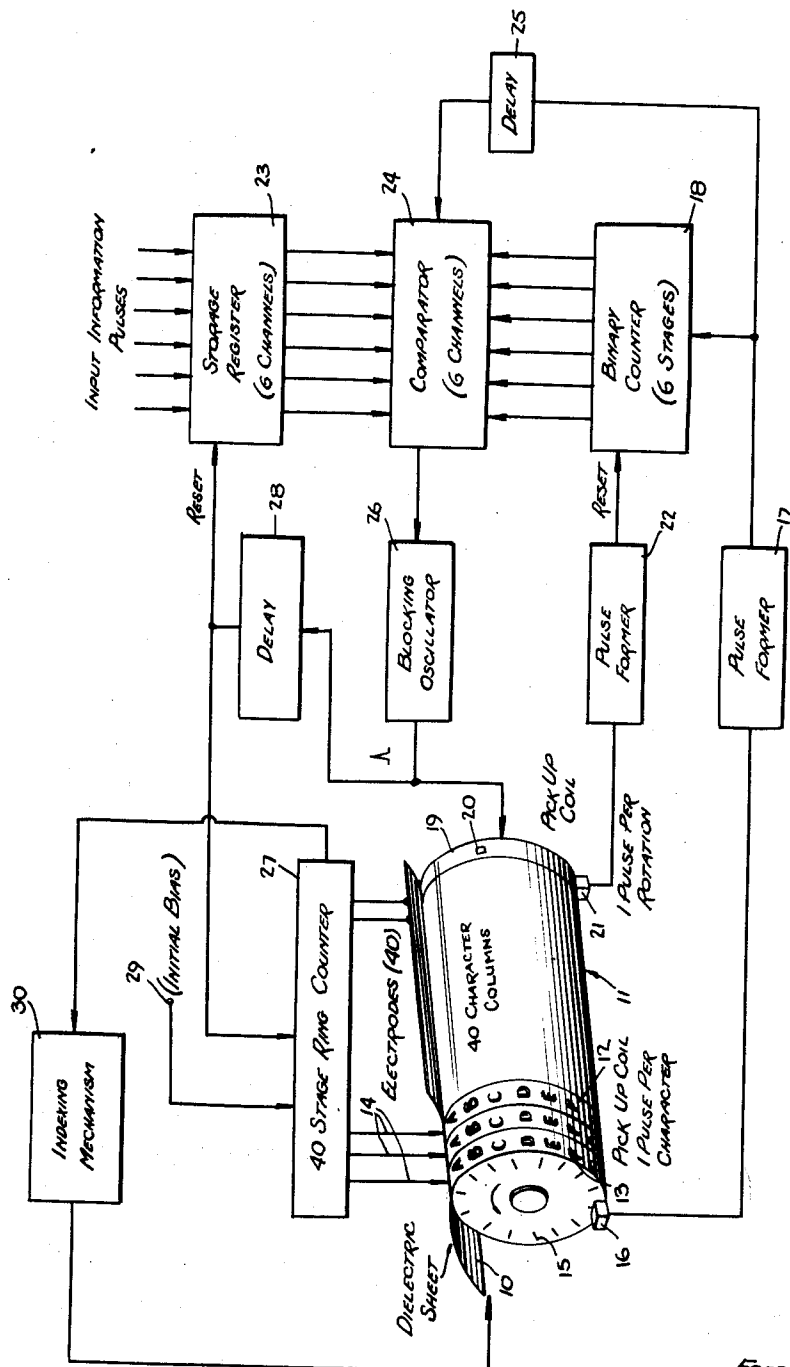
Jan. 5, 1960

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2,919,967

HIGH-SPEED ELECTROSTATIC ALPHANUMERICAL PRINTER

Filed June 6, 1957



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2,919,967

HIGH-SPEED ELECTROSTATIC ALPHA-NUMERICAL PRINTER

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Application June 6, 1957, Serial No. 664,137

7 Claims. (Cl. 346—74)

The present invention relates generally to the recording of computational data and more particularly to electrostatic apparatus for high-speed printing of alphanumerical information received on a random basis.

Analog and digital computer machines, however complex in structure, are constituted by three basic components; namely, an input system by means of which a problem is introduced into the machine, an operations system including arithmetic and storage elements for carrying out the mathematical functions entailed in solving the problem, and an output system for printing or recording the results.

The written or printed values yielded by the output system may assume any one of several forms depending on the nature of the data and its eventual use. With the recent development of high-speed computer machines and other mechanical and electronic devices which produce data at high rates of speed, there has arisen a concomitant need for high-speed recording devices, for otherwise the printer or other recording mechanism may act to retard the operation of the entire machine. Where the production rate of output data exceeds the capacity of the output printer, the usual practice is to store the output information as rapidly as it is produced and to feed it from storage to the printer as rapidly as the printer will accept the information.

In the co-pending application entitled "Electrostatic Recording of Information," Serial No. 623,327, filed November 20, 1956, there is described a novel electrostatic image-forming technique for recording alphanumerical information, which technique overcomes many of the drawbacks characteristic of known mechanical and optical printers. The electrostatic image-forming process as disclosed in said co-pending application makes possible the transfer of electrostatic images to a recording medium at extremely high speeds, these images being subsequently rendered visual by methods conventional in the xerographic art. The digital computer switching circuits coacting with the electrostatic image-forming apparatus permit the logical spacial ordering of electrostatic images which owe their origin to information pulses received serially in time.

In the art of xerography in its electrophotographic aspects, an electrostatic charge applied to the surface of a photoconductive insulating layer is selectively dissipated by exposure to a pattern of light and shadow to be recorded, thereby forming on the surface of the insulating layer an electrostatic latent image corresponding to said pattern. An image formed in this fashion may be developed by the deposition of finely divided material in conformity with the charge pattern and thereafter fixed by fusing the powder on the surface of a print to which the powder pattern has been transferred. A detailed description of the electrophotographic technique and of the apparatus involved in developing and fixing pictures may be found in the U.S. patent to Carlson, No. 2,297,691.

In the apparatus disclosed in the co-pending applica-

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tion as distinguished from xerography in its electrophotographic aspects, physical symbols or characters rather than light patterns are recorded as electrostatic images. The images are then developed by depositing a finely divided powder or an ink mist, the resulting visible images being made permanent by fusing or drying. The electrostatic images are produced by character faces or symbol-shaped electrode elements which are brought in close proximity to an insulating surface, such as a web of dielectric material. The web is electrostatically pre-charged by an intense electric field to a point somewhat below critical stress value. Alternatively, a static bias voltage may be applied to bring the applied field to the point of incipient breakdown.

Transfer of the configuration of the symbol or character from the shaped electrode to the insulating web is effected by the use of a relatively low potential triggering pulse which raises the electric field above the critical stress value to produce a field discharge in the space between the insulating web and the electrode. The discharge action gives rise to the formation of an electrostatic pattern of the symbol on the insulating surface. Electronic switching circuits are associated with the electrostatic apparatus to supply trigger pulses thereto in accordance with information received electrically from a digital computer or other signal source. This process is now known as Tesiprinting (Transfer Electro Static Image).

In one species of the invention illustrated in the co-pending application, alphanumerical characters are formed with the aid of raised character-metal elements disposed about the circumference of a cylindrical drum, one column of characters being provided for each column of the printed page. The characters are caused to pass in the vicinity of a paper web by rotating the character drum at a constant angular velocity. Disposed above the paper is an array of electrodes, one for each column to be printed. When the selected character passes beneath a chosen electrode, the electrode is subjected to a high-voltage pulse.

The logical circuitry associated with the character drum, as disclosed in said co-pending application, requires a synchronous serial input at a specified printing rate. Where the computer is of the type producing output information on an intermittent or random basis, this circuit cannot be used.

Accordingly, it is the principal object of the invention to provide an electronic system coordinated with an electrostatic apparatus for printing alphanumerical information which permits asynchronous operation.

More particularly, it is an object of the invention to provide logical circuitry for a high-speed non-optical electrostatic printer whereby alphanumerical information may be printed as received.

Briefly stated, in a high-speed electrostatic apparatus in accordance with the invention for recording information received at random, there is provided a rotary character drum having a bank of like character rings thereon. Each ring contains a series of character-shaped raised elements in a circumferential arrangement, the characters in the series being representative of different values of incoming information. A movable web of insulating material is disposed tangentially relative to the drum which revolves at a constant angular velocity. An array of fixed electrodes is disposed above the web at positions corresponding to those of the rings therebelow. An electronic circuit is provided to control the operation of the character drum, the circuit being responsive to the value of incoming information to apply a triggering pulse to the drum when the ring elements representative of the incoming value are aligned with the electrodes. The electrodes are activated in sequence whereby

only one electrode at a time carries a bias having a magnitude conducive to field discharge between the web and the related ring character when the pulse is applied to the drum, thereby producing a latent electrostatic image of the selected character on the web. Means are also provided responsive to the applied pulse for transferring the bias to the next electrode.

For a better understanding of the invention, as well as other objects and further features thereof, reference is had to the following detailed description to be read in connection with the accompanying drawing which shows in block diagram an electrostatic printer and an electronic control circuit therefor in accordance with the invention.

Referring now to the drawing, there is disclosed an electrostatic printer capable of reproducing all of the alphabetical symbols, as well as the decimal digits and other mathematical characters such as +, -, Ω , Z, α , etc. The printer is arranged selectively to print line by line any one of 64 characters in 40 character columns. The computer output takes the form of a six bit binary code having 64 permutations, each representative of a different character. It is to be understood that this arrangement is merely illustrative of the invention, and that a greater or smaller number of characters and columns may be used, as desired.

Electrostatic images are formed on a dielectric sheet 10, such as a Mylar web or any other dielectric substance having a sufficiently high resistance to hold an electrostatic image for a period which permits subsequent utilization of the image by transfer to another surface or by development.

The dielectric web is arranged to pass tangentially over a rotating character drum, generally designated by numeral 11. Drum 11 is rotatably mounted and driven at a constant angular velocity. Supported across the drum is a bank of forty identical rings 12, each containing a circumferential arrangement of raised character metal elements 13. One ring of characters is provided for each column to be printed on the page. The characters in each ring thereof are composed of alphabetical letters, numbers and other symbols as above described, each representative of a different value of applied information.

Above the dielectric web there is transversely disposed an array of stationary electrodes 14, one for each ring of characters. The electrodes are sequentially activated by a bias voltage relative to the character drum such that during each drum revolution only one electrode is active. In operation, when a selected character passes under a chosen electrode, the drum is subjected to a triggering pulse. The web is pre-stressed below the critical value and the triggering pulse acts to raise the stress above critical value to produce a field discharge between the character and the web and thereby form a charge pattern having the shape of the selected character. The technique for pre-stressing the web and the nature of the field discharge is fully treated in said co-pending application.

The manner of sequentially selecting the proper character ring and the particular character therein involves the use of digital computer techniques. For this purpose radial magnetic marks 15 are embedded in the left end of the drum 11. The marks are aligned with the angular positions of the various characters on the rings, there being one mark for each character. These marks are sensed by a magnetic head 16 to produce voltage surges which are shaped into pulses by pulse former 17 and applied to a six stage binary counter 18.

Thus in operation, as the drum undergoes one full revolution, 64 marks traverse the pick-up head, one pulse being counted per character. These pulses cause the binary counter successively to produce values in a six bit code representative of the 64 angular positions of the drum and hence of the characters thereon.

At the right side of the drum and rotating therewith is a disc 19 containing a single magnetic mark 20. A magnetic reading head 21 disposed below the disc picks up a voltage surge for each full revolution of the drum.

This surge is shaped into a pulse in pulse former 22 and fed to the binary counter 18 to reset same. Thus in the course of a single revolution, the six stages in the binary counter are successively set up to represent the 64 character positions, and the counter is then re-set automatically for the next cycle of operation.

Input information from the computer takes the form of values in a six binary code and is applied to a six channel storage register 23, the information being presented in parallel by the register. Since 64 code permutations exist for any given binary value of input information presented by the register, this value will match one of the 64 binary values developed in binary counter 18 in the course of a single drum revolution.

The value held in the storage register 23 is compared with the values successively established in the binary counter 18 into a comparator 24. When the values coincide, a pulse derived from the pulse former 17 through a suitable delay circuit 25 is fed through the comparator 24 to a blocking or one shot oscillator 25. The delay is sufficient to allow for operation of the comparator.

For example, let us assume that stored in register 22 is a six bit binary value 000011 representative of the decimal 3. When the decimal 3 on the character rings 12 are angularly aligned in recording position with the dielectric web 10, binary counter 18 will at that instant contain the binary values 000011 as a result of the counting of magnetic marks 15 by the pick-up coil 16. Since the values applied thereto are matched, comparator 24 will be activated to apply a triggering pulse to the blocking oscillator 26. The time position of this triggering pulse relative to a revolution of the character drum will of course depend on the binary value stored in the register and will be different for each value.

All of the ring characters 13 on the character drum are electrically connected in common to the body of the drum 11. The pulse from the blocking oscillator 25 is applied to the drum 11, the amplitude of the pulse being such as to produce an electrical stress causing a field discharge in the region between that portion of the web 10 lying beneath an activated electrode and the related raised character on the drum. For example, if the third electrode 14 in the series thereof is activated, and the pulse is applied to the drum at the instant the letter "B" is aligned with the web, then an electrostatic image of this letter will be formed in the third column on the web.

By activated electrode 14 is meant one having an operative bias thereon relative to the drum of such magnitude that when a pulse is applied to the drum, a field discharge occurs. The series of electrodes 14 are connected to respective stages of a forty stage ring counter 27. Ring counter 27 is actuated by a triggering pulse obtained from blocking oscillator 26 through a delay circuit 28. The various stages carry an initial bias through terminal 29 and only the actuated stage produces an operative bias on the associated electrode 14 to activate same. Each time an actuating pulse is applied to the ring counter, the operative bias is transferred to the next stage, and when the last stage is reached the bias is transferred to the first stage.

Thus in operation, as the drum goes through a revolution, a given electrode 14 is activated to cause printing in the related column when a triggering pulse is applied to the drum, the character selected depending on the time position of the pulse. Shortly thereafter, as determined by the time constant of delay circuit 28, the next electrode is activated in preparation for printing in the next column, this process being repeated until all forty columns are printed, thereby completing the line.

In the course of printing a full line, the paper 10 is held stationary. It will be appreciated that the time

consumed in printing a line depends on the time taken to receive forty binary values and since the values appear at random, the total time may be different for each line. The stepping action from column to column is aperiodic since the next electrode is not activated until a value is received and a triggering pulse produced.

Upon completion of a line, the paper is advanced for printing on the succeeding line. This is accomplished by an indexing mechanism 30 for advancing the paper when the last column of the line is printed. Thus the indexing mechanism 30 may be caused to operate by coupling it to the last stage of the ring counter 27, such that when the operative bias is transferred therefrom to the first stage the paper is shifted to the next line.

During the time interval in which the recording paper is advanced from one line position to the next provision must be made to handle incoming information. This may be accomplished by means of a buffer storage which will accept information serially and feed it automatically to the system as required. The maximum capacity of the buffer storage will depend on the assumed duty cycle of the system. Clearly if the information were to be received at a steady rate equal to the maximum printing rate, the information received during the paper shift intervals would accumulate indefinitely. Hence intermittent arrival of information must be assumed to take place in such a way that the storage is not overloaded. If, for example, the time required to print a complete line at the maximum printing rate and the time required to advance the paper from one line to the next are equal the data must arrive at a rate which averages half the printing rate.

In the event the rings on the drum contain less than 64 characters, the circuit may be arranged not to recognize a given number of values, depending on the omissions. It will be noted that the operation of the system is asynchronous and is controlled by the information itself. The images recorded on the web 10 are latent images and require development and fixing to provide a printed record.

When the web is withdrawn from the electrostatic apparatus, it passes through a development mechanism wherein the invisible electrostatic images are rendered visible by depositing thereon a finely divided material, such as an ink mist or an electroscopic pigmented resin powder which adheres to the negatively charged image areas. To promote development, the particles are preferably charged positively by tribo-electric or other means.

If a uniform positive charge has been applied to the web by a pre-stressing stage, the particles are repelled from all areas of the web except the negatively charged image areas. A suitable powder development mechanism is fully disclosed, for example, in the Carlson Patent No. 2,357,809 and in the Walkup and Fauser Patent No. 2,573,881, and a mechanism for developing electrostatic images with an ink mist is disclosed in Carlson Patent No. 2,551,582.

After leaving the development mechanism and entering a fuser, the resin powder images are heated in a suitable oven to a temperature sufficient to fuse the resin. If liquid ink development is used, the fuser may serve merely as a heated drier for the ink. With webs formed of plastic materials which tend to distort when heated, it is preferred that the fuser shall consist of a chamber filled with air saturated with vapor or solvent for the resin images and not for the web material. Solvent is absorbed by the powder until it becomes tacky or semi-fluid and as the web leaves the fuser, the solvent evaporates, leaving a fixed resin image on the web. With coated paper a solvent for the plastic may be used, in which case it is possible to use infusible electroscopic powders, for they become embedded in the plastic or wax coating which is softened by heat or solvent as it passes through the fuser. A suitable vapor fuser is dis-

closed in the Carlson application, Ser. No. 299,673, filed July 18, 1952.

Instead of fixing the powder images on the original web, it is possible to transfer the images to another sheet or surface by an electrostatic transfer method, such as is shown in Schaffert Patent No. 2,576,047, or by rolling against an adhesive coated surface. Thus the resin images can be transferred and affixed to paper offset mats for use in offset printing or multiple copies. It is to be understood that means for development and printing of electrostatic images forms no part of the present invention, and any known means may be used for this purpose.

What is claimed is:

1. A high-speed electrostatic tesiprinting apparatus for recording incoming information received at random, said apparatus comprising a rotary character drum having a bank of like character rings thereon, each ring containing a series of character-shaped raised elements in a circumferential arrangement, the respective characters in the series being representative of different values of incoming information, means to rotate said drum at a constant angular velocity, a movable web of insulating material disposed tangentially relative to said drum, an array of fixed electrodes disposed above the web at positions corresponding to those of the ring therebelow, means responsive to the value of incoming information to apply a triggering pulse to the drum when the ring elements representative of said value are in angular alignment with said electrodes, and means to apply a bias to one of said electrodes having a magnitude conducive to field discharge between the web and the selected ring character when the pulse is applied to the drum, whereby a latent electrostatic image of the selected character is produced on the web.

2. A high-speed electrostatic tesiprinting apparatus for recording incoming information received at random, said apparatus comprising a rotary character drum having a bank of like character rings thereon, each ring containing a series of character-shaped raised elements in a circumferential arrangement, the respective characters in the series being representative of different values of incoming information, means to rotate said drum at a constant angular velocity, a movable web of insulating material disposed tangentially relative to said drum, an array of fixed electrodes disposed above the web at positions corresponding to those of the ring therebelow, means responsive to the value of incoming information to apply a triggering pulse to the drum when the ring elements representative of said value are in angular alignment with said electrodes, means sequentially to apply a bias to said electrodes having a magnitude conducive to field discharge between the web and the selected ring character when the pulse is applied to the drum, whereby a latent electrostatic image of the selected character is recorded on the web, and means to control said sequential means to shift said bias to the next electrode after each recording operation.

3. A high-speed electrostatic tesiprinting apparatus for recording incoming information received at random, said apparatus comprising a rotary character drum having a bank of like character rings thereon, each ring containing a series of character-shaped raised elements in a circumferential arrangement, the respective characters in the series being representative of different values of incoming information, means to rotate said drum at a constant angular velocity, a movable web of insulating material disposed tangentially relative to said drum, an indexing mechanism for advancing said web a line at a time, an array of fixed electrodes disposed above the web at positions corresponding to those of the ring therebelow, means responsive to the value of incoming information to apply a triggering pulse to the drum when the ring elements representative of said value are in angular alignment with said electrodes, means sequentially to apply a bias to said electrodes having a magnitude conducive to field dis-

charge between the web and the selected ring character when the pulse is applied to the drum, whereby a latent electrostatic image of the selected character is recorded on the web, means to control said sequential means to shift said bias to the next electrode after each recording operation, and means coupled to said indexing mechanism to actuate same upon completion of a line.

4. A high-speed electrostatic tesiprinting apparatus for recording incoming information received at random, said apparatus comprising a rotary character drum having a bank of like character rings thereon, each ring containing a series of character-shaped raised elements in a circumferential arrangement, the respective characters in the series being representative of different values of incoming information, means to rotate said drum at a constant angular velocity, a movable web of insulating material disposed tangentially relative to said drum, an array of fixed electrodes disposed above the web at positions corresponding to those of the ring therebelow, and means responsive to the value of incoming information to effect a field discharge when the ring elements representative of said value are in angular alignment with said electrodes, said field discharge occurring between said web and one of said rings corresponding to an activated electrode, said electrodes being activated in sequence as said information is received.

5. A high-speed electrostatic tesiprinting apparatus for recording binary information received at random, said apparatus comprising a rotary character drum having a bank of like character rings thereon, each ring containing a series of character-shaped raised elements in a circumferential arrangement, the respective characters in the series being representative of different values of incoming information, means to rotate said drum at a constant

angular velocity, a movable web of insulating material disposed tangentially relative to said drum, an array of fixed electrodes disposed above the web at positions corresponding to those of the ring therebelow, means responsive to the value of incoming information to apply a triggering pulse to the drum when the ring elements representative of said value are in alignment with said electrodes, and means to apply a bias to one of said electrodes having a magnitude conducive to field discharge between the web and the selected ring character when the pulse is applied to the drum whereby a latent electrostatic image of the selected character is produced on the web, said triggering pulse means including a storage register responsive to said incoming information pulses, a binary counter responsive to the successive presence of characters on said drum in the course of a rotation thereof to produce said triggering pulse when said information pulse and said indication of a corresponding character are coincident.

6. Apparatus, as set forth in claim 5, further including means to advance said web to a next line position upon completion on a line recording.

7. Apparatus, as set forth in claim 6, further including buffer storage means to hold incoming information during said advance of said web.

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