

[54] **ELECTROGRAPHIC PRINTER WITH PLURAL OSCILLATING PRINT HEADS**

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[58] Field of Search 101/DIG. 13; 197/1;
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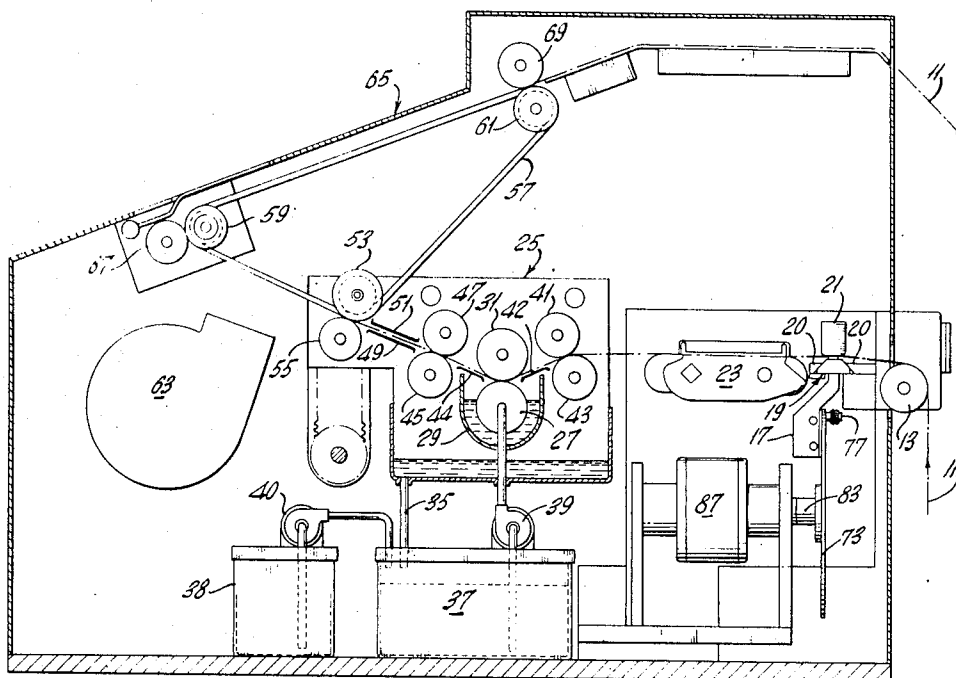
[57] ABSTRACT

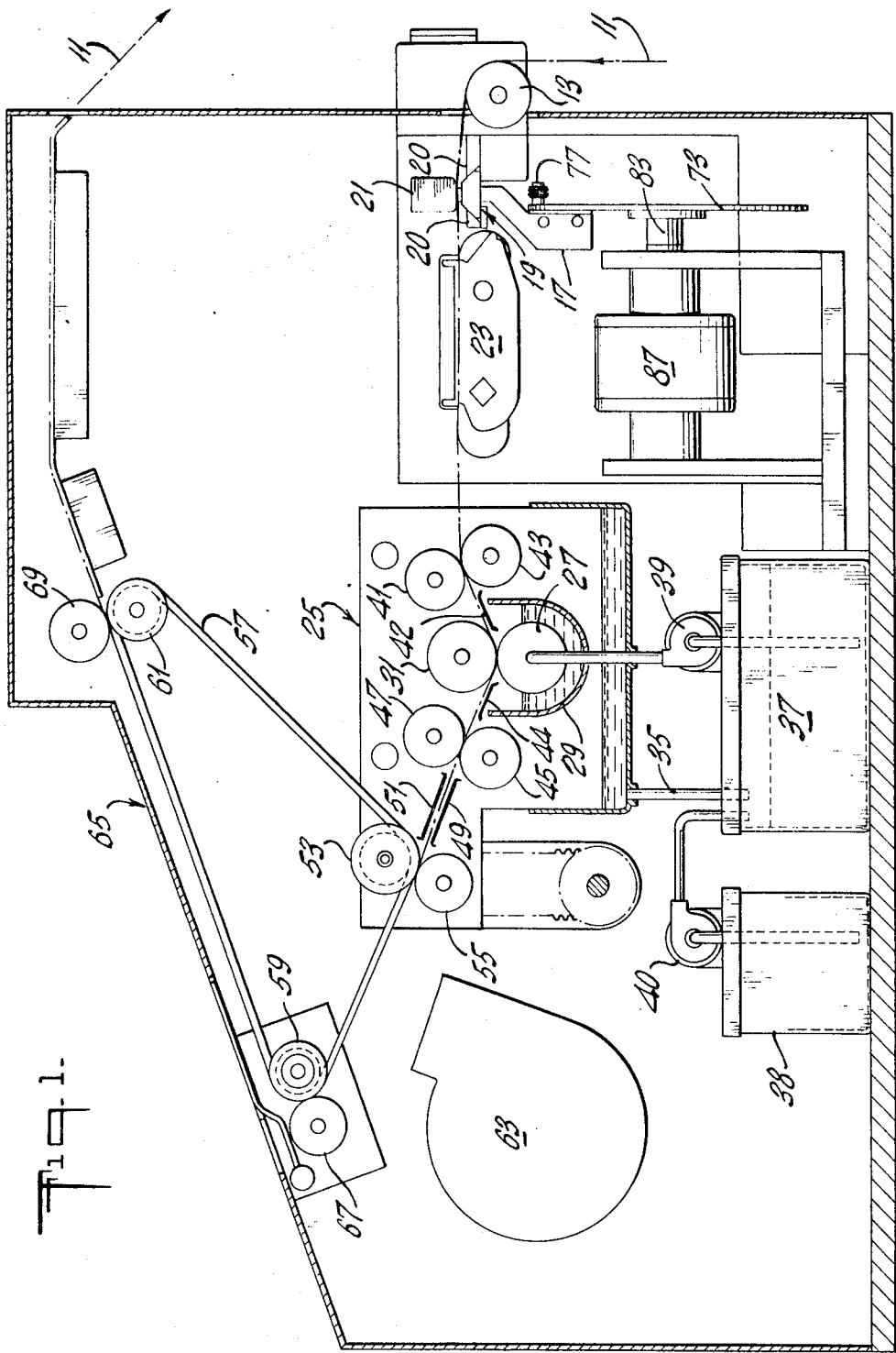
A high speed, electrographic, non-impact printer for printing matrix-type characters on the dielectric coated face of a paper web. A print head having a plurality of linearly arranged styli therein is transported in an oscillatory fashion across the dielectric coated face of the web with the styli in virtual contact therewith. Means are provided for selectively energizing the styli for depositing dots of electric charge in image configuration on the dielectric as the print head traverses the web in both directions. The position of the print head as it traverses the web in both directions is sensed for controlling the selective energizing means for depositing dots of electric charge on the dielectric only when the print head is in predetermined positions in its path across the web. The dots of electrical charge are developed by means of a toner system.

12 Claims, 18 Drawing Figures

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Fig. 2.

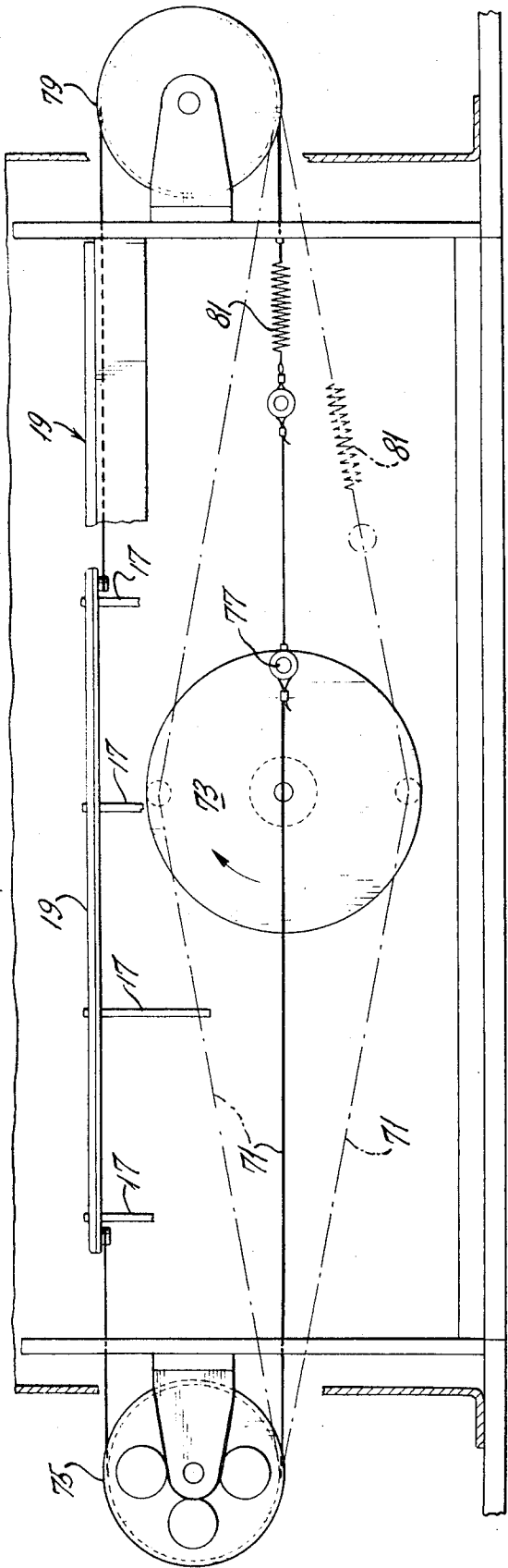


Fig. 12.

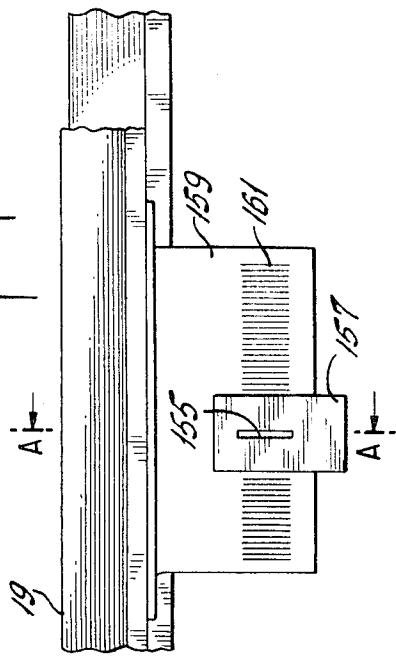
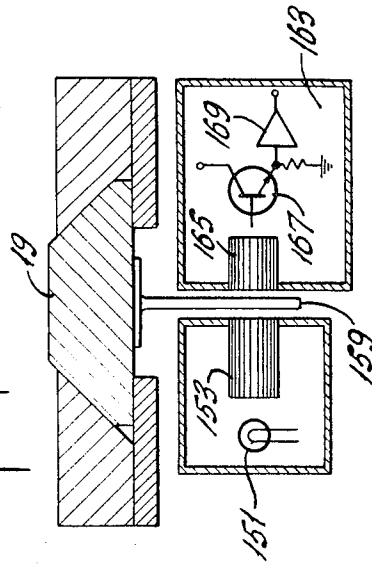
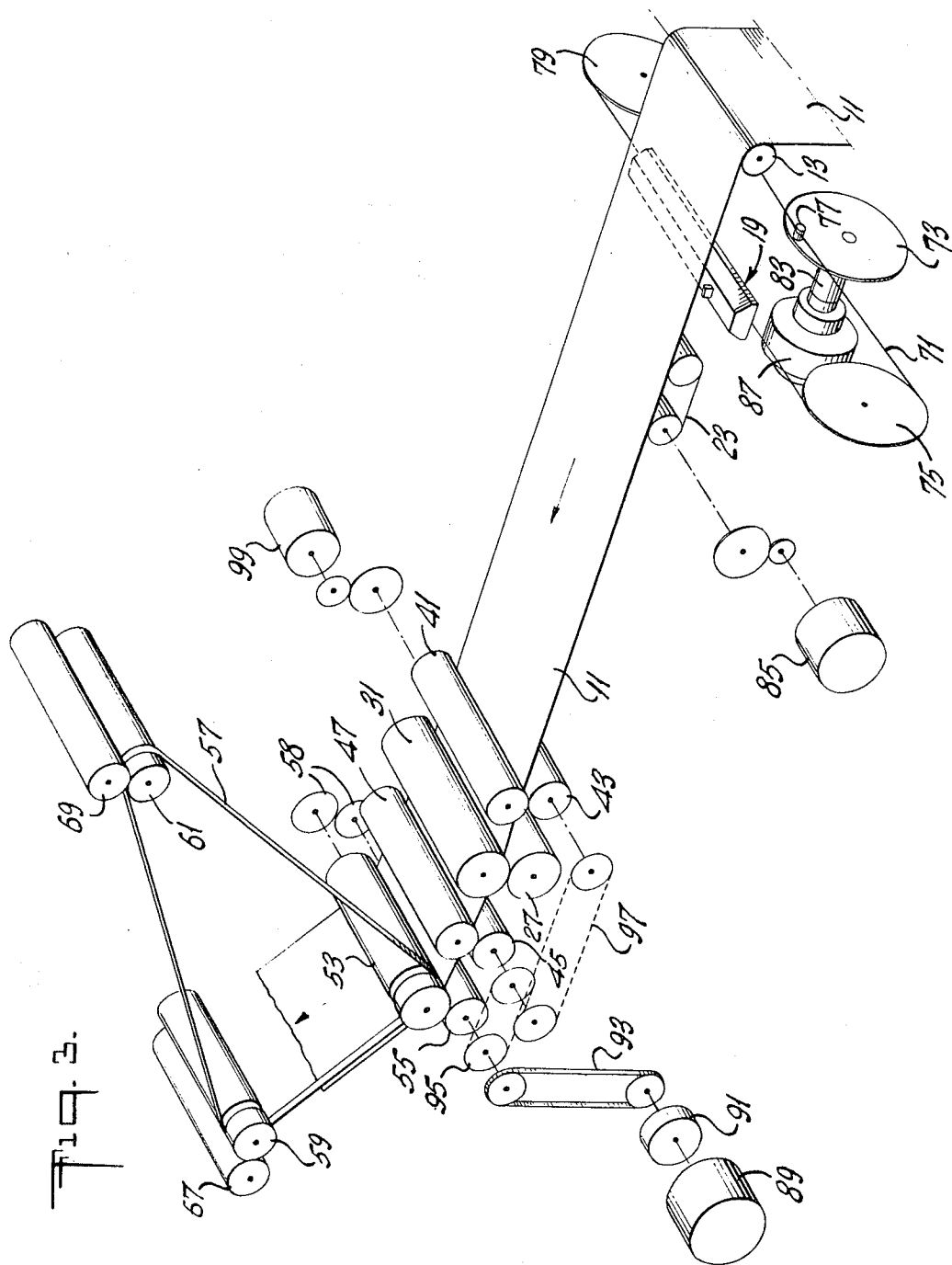


Fig. 13.



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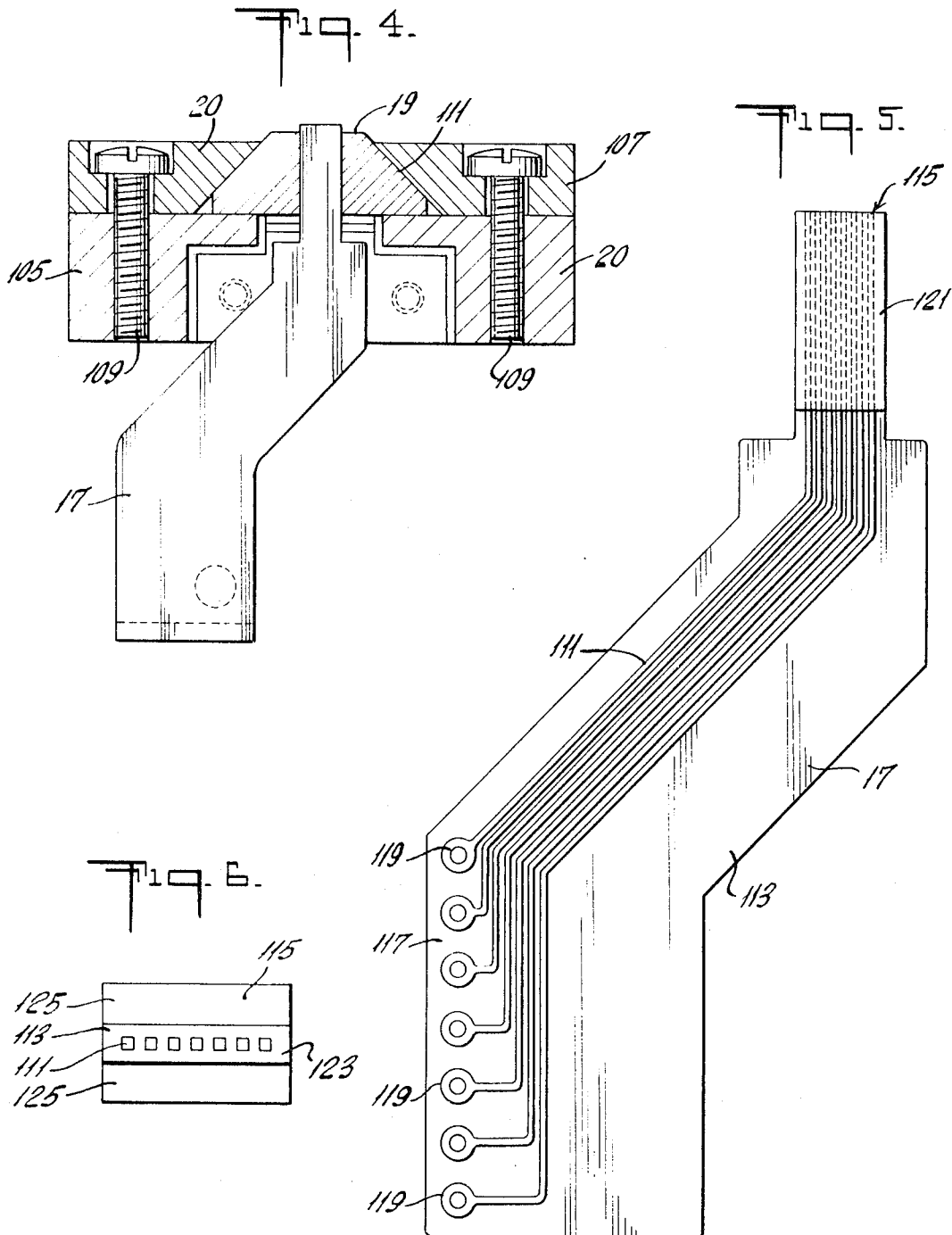


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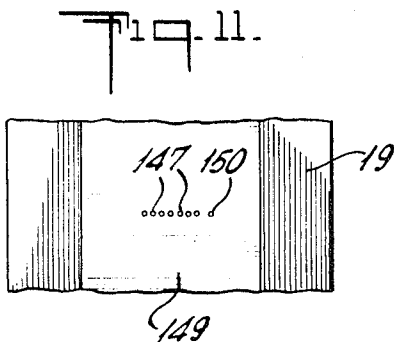
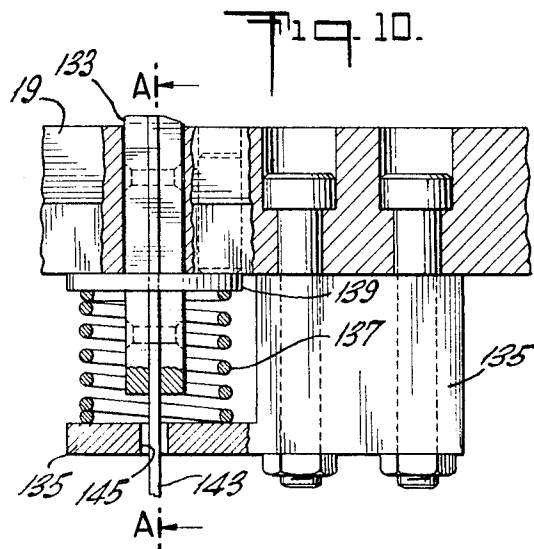
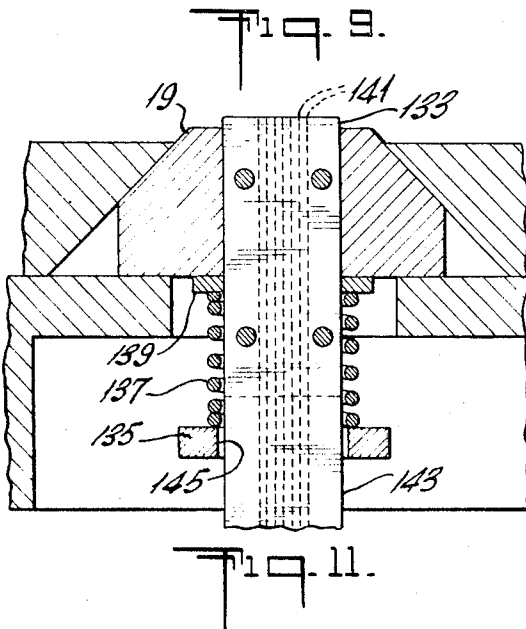
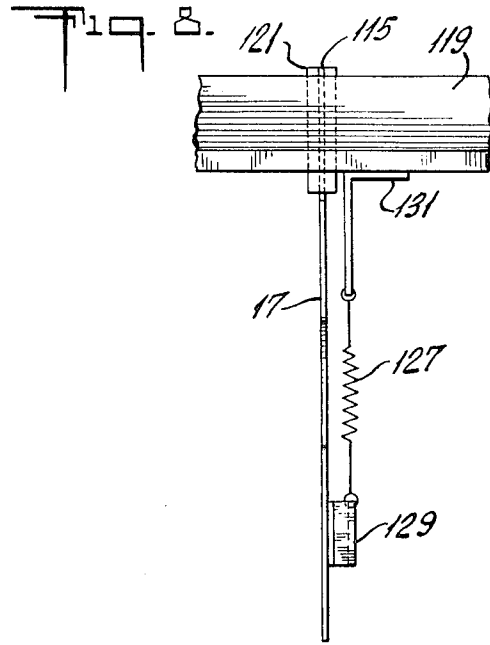
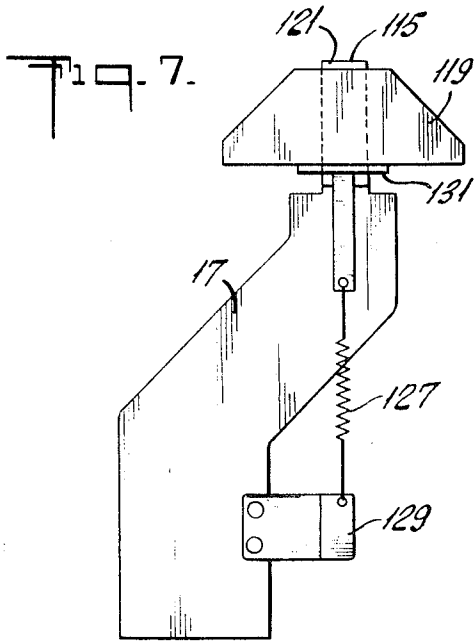


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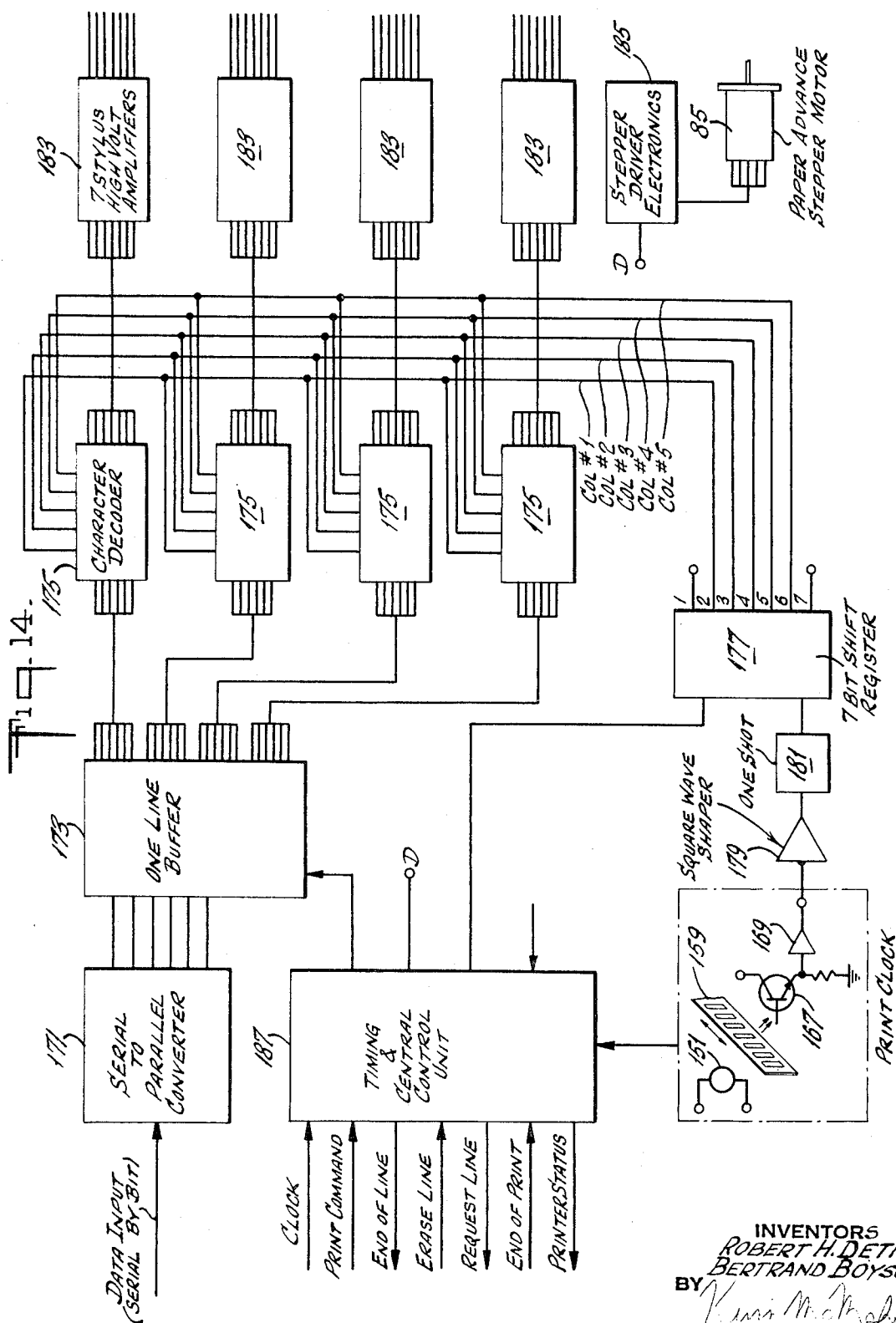
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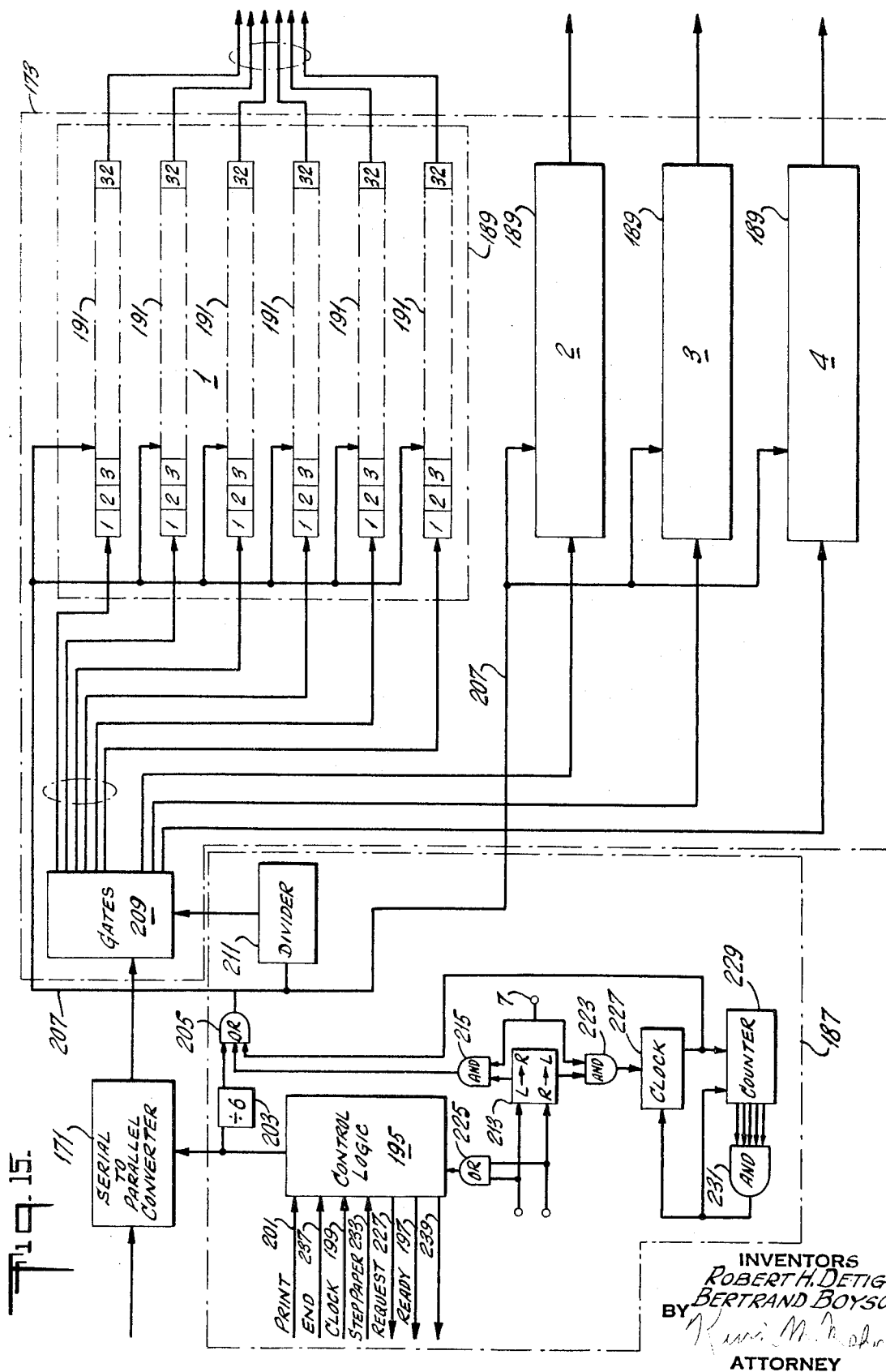


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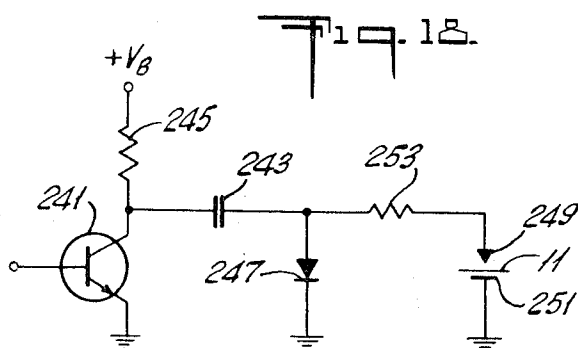
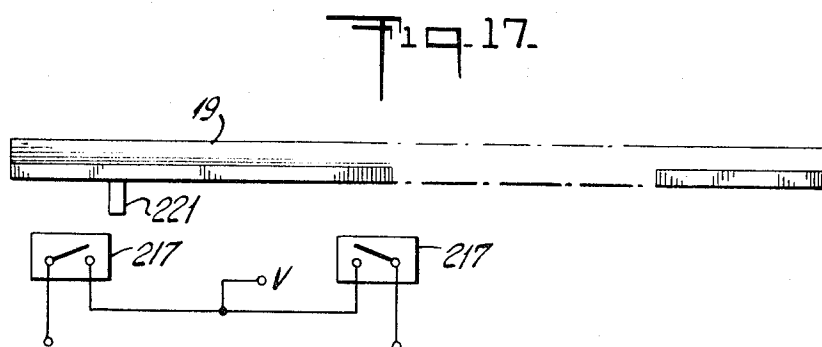
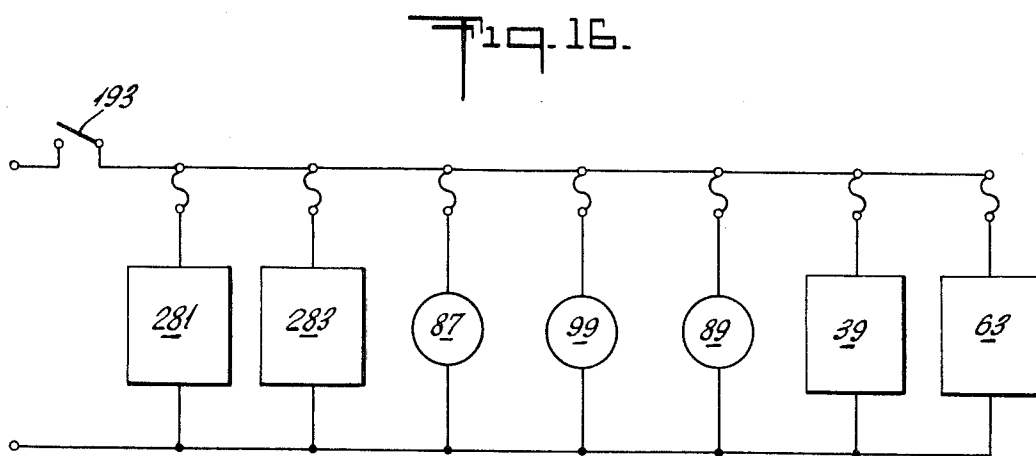
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ELECTROGRAPHIC PRINTER WITH PLURAL OSCILLATING PRINT HEADS

BACKGROUND OF THE INVENTION

This invention relates generally to high-speed electrographic non-impact printers and more particularly to high-speed electrographic non-impact printers having oscillating printing heads.

Impacting mechanical high-speed printers have long been used for producing computer printout. These printers are capable of printing an entire line of type essentially in parallel and the more expensive ones are adequately fast for most present day applications.

They do, however, have several serious drawbacks. They are extremely noisy machines and must therefore be isolated, usually in a separate room, from people who are expected to work. They are also very complex and extremely expensive and are subject to a fairly high rate of mechanical breakdown.

Recently electrographic line printers have been introduced which solve some of the problems. These printers deposit electrostatic charge latent images of the information to be printed on a web of dielectric coated paper. The electrostatic image is developed by means of liquid or dry toner developing systems. These machines usually include a stationary printing head assembly having as many as 1,000 or more individual styli arranged in contact with the coated side of the web in a line normal to the direction of its movement. A common electrode is also provided, usually on the opposite side of the web and, as the web is stepped past the styli, dots of electrostatic charge are deposited on the dielectric coating by selectively pulsing the styli. Printers of this type are usually arranged to print a character by depositing charge on selected dots of a 5 × 7 dot matrix.

Line printers of this type offer a significant step forward over the earlier impacting kind. They are very quiet in operation, print at a high rate of speed, and produce quite acceptable print quality.

There are, however, many problems with these machines that still exist. Since they require an individual high voltage switch for each of the 1,000 or more styli, and also the electronics for controlling the activation of all the styli in parallel, these machines are extremely expensive and quite complex electronically. This electronic complexity also severely limits the reliability of the machine.

A further problem with these known printers is that there is a tendency to print "doughnuts," (i.e., dots having only the periphery black) unless a rather expensive grade of paper is used which has a very smooth and uniform coating. This is thought to be because the styli tend to deposit charge on the paper only around this periphery unless the paper surface is quite smooth. Dots of this type appear light and faint to the eye since the eye tends to integrate the black circle with the white interior.

OBJECTS AND SUMMARY OF THE INVENTION

It is therefore an object of the invention to improve electrographic line printers.

It is a further object of the invention to increase the reliability of and to simplify electrographic line printers by reducing the number of styli in the printer.

It is another object of the present invention to provide an electrographic printer which prints solid, dark appearing dots.

In accordance with these and other objects of the invention there is provided a high speed electrographic line printer for printing lines of information on a web having a charge retaining surface normal to the direction of its movement which includes a plurality of print heads mounted for movement across the web in contact therewith, and means for moving the print heads in an oscillatory fashion across said paper. Also provided are means mechanically coupled to the print heads for movement therewith for sensing the position thereof and means for selectively activating the styli for depositing a line of character-shaped electrostatic latent charge images on said paper for each sweep of said styli across said paper in either direction, and means for developing said latent images on said paper with a visible toner.

Various other objects, advantages and features of the invention will become more fully apparent in the following specification with its appended claims and accompanying drawings in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side view of an embodiment of an electrographic printer according to the invention;

FIG. 2 is a back view of the printer of FIG. 1;

FIG. 3 is a schematic showing the mechanical drive for the various parts of the printer of FIG. 1;

FIG. 4 is a cut-away view of the print head and slider assembly;

FIG. 5 is a detail drawing of the print head of FIG. 4;

FIG. 6 shows the printing face of the print head of FIG. 5;

FIG. 7 shows a spring-mounted print head according to the invention;

FIG. 8 is another view of the spring-mounted print head of FIG. 7;

FIG. 9 shows a second embodiment of a spring-mounted print head according to the invention;

FIG. 10 is another view of the spring-mounted print head of FIG. 9;

FIG. 11 shows an embodiment of the invention in which the print head is integral with the slider;

FIG. 12 shows the position sensing device according to the invention;

FIG. 13 is a sectional view of the position sensing device of FIG. 12;

FIG. 14 is a schematic diagram of the electronic drive and control circuitry for the printer according to the invention;

FIG. 15 is a more detailed schematic of a portion of the control circuitry of FIG. 14;

FIG. 16 serves the control circuitry for the motors and power supplies of the printer according to the invention;

FIG. 17 shows an embodiment of the device for sensing when the slider is at the end of the line;

FIG. 18 is a schematic diagram of a high voltage amplifier for driving a stylus of a print head according to the invention.

DETAILED DESCRIPTION

The invention can best be understood by referring to the following detailed description of the illustrated embodiments.

Referring to FIG. 1 of the drawings, there is shown an embodiment of an electrographic line printer according to the invention. The printing is performed on dielectric coated paper 11 which is threaded over the roller 13 from the back of the machine through successive stations where it is imaged, developed, dried and finally displayed. The latent electrostatic image is deposited on the dielectric coating by means of four print heads 17 which are mounted for movement normal to the plane of the drawing in a slider 19. The slider 19 slides in ways 20. The grounding bar 21 operates both to hold the paper web 11 firmly in contact with the print heads 17 and to act as the voltage reference for the activation of the styli of print heads 17. In order to insure good contact between the print heads 17 and the web 11, the grounding bar 21 should have a resilient or a solid surface facing the print heads 17 depending on whether the print heads 17 are fixedly or resiliently mounted respectively.

After being imaged, the paper web 11, which, for this embodiment of the invention has perforated feed holes along either side thereof, is fed by means of tractors 23 mounted for engagement with the perforated feed holes on the web 11 to the developing station 25.

The dielectric coated paper used in the printer according to the invention may be of the standard type used for electrographic printing and is available from several manufacturers. Preferably the coating should be such that it does not flake or smear and thereby interfere with the operation of the print heads 17.

In the illustrated embodiment of the invention, the latent image on the paper web 11 is developed by means of a liquid developer system which brings the developer into contact with only the imaged side of the web 11 by means of the developing roller 27. The developer roller 27 is rotated at a high speed (on the order of 850 to 1,500 rpm) in an inner tray 29 which is partially full with the liquid developer. The roller 27 picks up a wave of this developer and brings it into contact with the latent image on the dielectric coated side of the web 11. The web 11 is held slightly out of contact with the roller 27 by means of the roller 31. The spacing between the web and the roller 27 may be on the order of between 0.075 and 0.125 inches.

In order to keep the toner concentration in the developer uniform and at the proper level, the developer may be constantly recirculated. An overflow port (not shown) may be provided in the inner tray 29 to allow the developer to overflow into an outer tray 33. A drain tube 35 is provided for the outer tray 33 to allow the developer to flow at a preselected rate from the outer tray to a developer reservoir 37. Developer is pumped from the reservoir 37 back to the inner tray 29 by means of pump 39.

The volume of and toner concentration in the developer in tank 37 drops during use at different rates and must be controlled. In order to hold the volume of developer in tank 37 constant, developer at the proper concentration is metered into the developer tank 37 from the container 38 by means of a pump 40. The actuation of the pump 40 is controlled by a switch (not shown) which senses the level of the developer in the tank 37 and activates the pump 40 when the developer level falls below a predetermined level. The concentration of the developer is sensed by well known means (not shown) and concentrated developer is metered

into tank 37 from a concentrate container (not shown) as needed.

The use of the wave of developer on the roller 27 to develop the image on the web 11 has the advantage that, when the system is not in use, no developer is in contact with the paper. This avoids the presence of unsightly black splotches across the paper.

It should be apparent that other developing systems may also be used to develop the latent image on the paper web 11. Liquid fountain developing systems or magnetic brush dry toner systems, for example, would each be applicable.

In transporting the web 11 through the developing system 25, the rollers 41 and 43 receive the web 11 after it leaves the tractors 23. Guides 42 and 44 act to guide the leading edge of the web 11 around the lower side of roller 31.

After being developed by the roller 27, the web 11 passes through squeegee rollers 45 and 47 in order to remove the excess developer therefrom. The squeegee rollers 45 and 47 may be of standard type. In the preferred embodiment of the invention, roller 45 is metal, while roller 47 is a rubber roller. It is possible to use a rubber roller for roller 45 also. However, under some conditions, some of the image may be transferred from the paper onto the rubber roller which will then reprint on a following portion of the web 11 on the next revolution of the roller 45. The use of a metal roller avoids this problem. The excess developer which is removed from the web 11 by the squeegee rollers 45 and 47 drops into the outer tray 33.

After leaving the squeegee rollers, the web passes through guides 49 and 51 which guide the leading edge of the web 11 to the nip between rollers 53 and 55. Roller 53 also serves as one of the guide rollers for an "0" ring conveyor 57. The "0" ring conveyor passes over guide rollers 53, 59 and 61 and serves to transport the web past a drying blower 63 to a viewing station 65. After the web 11 is viewed it is carried rearwardly to the back of the machine.

Rollers 67 and 69 act in conjunction with rollers 49 and 61 respectively, for guiding the web on the "0" ring conveyor 57.

In the illustrated embodiment of the invention, the drying of the web is performed by the blower 63, which directs a stream of hot air at the web 11. The heating of the air may be performed by an electric heating element (not shown) disposed in the air stream of the blower. It would be equally possible to perform this drying function by the use of a heated roller, which the paper is wrapped around. Roller 59, for instance, could easily perform this function if a heating element were disposed therein.

Referring now to FIG. 2 of the drawings, there is illustrated a rear view of the electrographic line printer according to the invention, showing the driving mechanism for the slider 19. In the illustrated embodiment of the invention, the slider 19 carries four spaced printing heads 17, each of which images one-fourth of the width of the paper web 11. It is, of course, possible to use a different number of printing heads 17 in other embodiments of the invention. In practice there is a trade off between the amplitude of the oscillation of the slider 19 and the complexity of the electronics necessary to control the printing. The fewer printing heads 17, the simpler the electronics, but the larger the amplitude of os-

cillation of the slider 19 and, therefore, the lower the speed.

In the illustrated embodiment, the slider 19 is driven in an approximately sinusoidal manner by means of the cable 71 and the disc crank 73. The cable 71 extends from one end of the slider 19 around the pulley 75 to the pin 77 on the disc crank 73. From pin 77, the cable 71 extends around pulley 79 to the other end of the slider 19. The spring 81 is provided to allow for the difference in length of the cable 71 for each 90° rotation of the disc crank 73.

During operation of the printer, the disc crank 73 is driven at a constant rotational speed through a clutch/brake mechanism 83 (FIG. 1) by means of a motor. If the printer is operating at a printing speed of 600 lines per minute, the disc crank 73 must rotate at 300 cycles per minute.

The illustrated type of slider drive was chosen because of its simplicity and low moving mass. Other drives are of course also possible, however. A crank drive, or a pin-chain type drive, for example, could also be used. Some of these drives may drive the slider in a linear fashion as opposed to the sinusoidal fashion as in the present embodiment.

The mechanical drive for the various portions of the high speed printer illustrated in FIGS. 1 and 2 of the drawings is shown in FIG. 3. Paper tractors 23 are driven through gears by stepper motor 83 for stepping the web 11 past the print heads 17 in slider 19. The pause between each step must be long enough for the print heads 17 to traverse the web 11 once and the stepping speed must be fast enough to advance the web by one line in the turn-around time of the slider 19. In the illustrated embodiment the web 11 may be advanced at a speed on the order of 600 lines per minute or more.

As explained above, the slider 19 is driven by means of disc 73 through the cable 71 (FIG. 2). The disc 73 is driven through a magnetic clutch/brake mechanism 83 by a drive motor 87. During printing the drive motor 87 is operated at a constant speed so that the slider 19 traverses the web 11 at the desired frequency. For instance, if the printer is to operate at a 600 line per minute rate, the slider 19 must operate at 300 cycles per minute.

As will be explained in more detail later, means are provided for synchronizing the operation of stepper motor 85 and the slider 19 so that the web 11 remains still while the slider 19 traverses it. The magnetic clutch/brake mechanism 83 is provided so that, if it is desired to leave portions of the web 11 blank, the slider can be held immobile while the stepper motor 85 moves the web 11 at a faster rate.

The drive for the transport rollers of the processor portion 25 of the printer is provided by the processor motor 89 through a slip clutch 91. The slip clutch 91 is coupled by means of belt 93 to the transport roller 55 and to belt 95. Belt 95 in turn drives roller 45 and belt 97. Belt 97 is used to drive roller 43, the processor motor 89 operates at a speed which slightly overdrives the rollers of the processor 25 in order to keep the web 11 tensioned over roller 31. The slip clutch 91 prevents the rollers of the processor 25 from damaging the web 11 by insuring that they do not exert too much tensioning force on it.

The toning roller 27 is driven by the motor 99. The roller 55 of the "0" ring conveyor drives roller 53 through gears 58 by means of the motor 89.

The structure of the slider 19 and print head 17 is illustrated in more detail in FIG. 4 of the drawings. The slider 19 is of trapezoidal cross section and slides in the ways 20 on either side of the slider. Each of the ways 20 consists of a lower portion 105 having a part cut out to allow the passage of the print heads 17 and a flat upper surface on which the base of the slider 19 rests. Each of the ways 20 also has an upper portion 107 attached to the lower portion 105 by means of bolts 109. The upper portion 107 includes an angled surface 111 which bears against the angled face of the slider 19 and holds it against both vertical and horizontal movements. This slider construction has the advantage of allowing the adjustment of both the horizontal and vertical forces on the slider 19 by the adjustment of only the bolts 109.

Various structures may be used for the print head 17 (FIG. 1) and several embodiments are illustrated in FIG. 5 through FIG. 11 in the drawings. An embodiment of a print head 17 which may be made by printed circuit techniques is illustrated in FIG. 5 of the drawings. According to this embodiment, the conductors 111 which form the seven styli of the printing head are etched on a printed circuit backing board 113 which may be formed of a polyphenylene oxide base material marketed under the trade name Z-tron by Polypenco Inc., or on a polyester such as Mylar (trademark). The conductors 111 which form the seven styli run from the printing face 115 of the printing head 17 back to the interconnection portion 117 of the printing head 17. Here a series of seven individual interconnection pads 119 are formed for connecting the individual styli 111 to the drive circuitry.

As can be better seen by FIG. 6 in conjunction with FIG. 5, the end portion 121 of writing head 17 consists of a laminate of several layers. The styli 111 are covered with a covering layer 123 which may be made of the same material as the substrate 113. The covering layer 123 may be glued to the styli 111 and substrate 113 by an epoxy-type glue, which glue also fills in the interstices between the adjacent styli 111. Metal plates 125, which may be formed of stainless steel, ceramic or glass-filled plastic, are attached to either side of the end portion 121 of the writing head 17. These plates 125 act to increase the mechanical strength and stability of the end portion 121, and also make for an extremely low wear, low friction printing face 115. The plates 125 may be attached to the end portion 121 by means of an epoxy glue or by bolts.

After the end portion 121 is laminated, the printing face 115 is ground in order to provide a very smooth flush face. Preferably the edges of the plate 125 are beveled in order to allow the printing head 17 to cam over the edge of the paper web 11 when the printing is being performed on a narrow web 11.

One problem encountered with the printer of the invention is the tendency of the writing head 17 to clog with particles from the dielectric coating on the paper web 11 if the stylus design is not correct. These particles are thought to result from the sliding contact between the printing heads 17 and the paper. The stylus designs described in relation to FIGS. 5 and 6 has been found to minimize this flaking tendency and thereby give good results.

The printing head 17 may be fixedly mounted in the sliders 19 as indicated schematically in FIG. 1. In this case it has been found preferable to have the printing head 17 extending slightly (0.005 inch has been found suitable) from the slider 19. This is preferable both to decrease the frictional contact between the slider and print head assembly and also because, if they were mounted flush with the slider 19, any particles from the coating of the web 11 getting between the slider 19 and the web 11 might bring the printing head 17 out of contact with the paper and thereby cause a malfunction.

Although, as stated above, the writing head 17 may be fixedly mounted in the slider 19, it has been found preferable to spring-mount them as shown in FIGS. 7 and 8 of the drawings. According to this embodiment, the end portion 121 of the writing head 17 is slidably mounted in a close fitting aperture in the slider 19. A spring 127 is connected between an extension 129 attached to the printing head 17 and a mounting piece 131 attached to the slider 19 for forwardly biasing the writing head 17.

The use of the spring-mounted writing head 17 has been found to improve printing quality. It is thought that this is because it insures good contact between the writing face 115 and the web 111. The strength of the spring 127 is chosen so that, during printing, the printing face 115 extends about 0.005 inch from the surface of the slider 19.

Another embodiment of a spring-mounted writing head is illustrated in FIGS. 9 and 10 of the drawings. According to this embodiment, the writing head 133 is formed of a slug of plastic material having a rectangular cross section which is slidably mounted in a close fitting aperture in the slider 19. A mounting member 135 which may be bolted to the slider 19 holds one end of a compressed spring 137, and the other end of the spring 137 bears against a plate 139 which may be formed as part of the writing head 133. The spring 137 biases the writing head 133 in the forward direction so that it extends slightly from the surface of the slider 19. According to this embodiment the writing head 133 and the bearing plate 139 may be formed as a single piece by injection molding technique out of a suitable plastic material. In order to be suitable, the plastic material must wear very slowly when in contact with the paper and have a very low coefficient of friction. One material which has been found to be suitable is Delrin AF, which is a teflon-filled Delrin marketed by DuPont.

Holes for the styli 141 may be drilled in the head. The styli are then inserted in the holes and potted. An extension 143 of the printing head 133 may be provided to carry the styli 141 back through an aperture 145 in the mounting bracket 135. Connections are made to the styli at the back face of the extension 143. Good results have been achieved with printing heads constructed according to the embodiment illustrated in FIGS. 9 and 10. This embodiment has the advantage of being somewhat simpler and cheaper to make than that described in relation to FIGS. 5 through 8.

It is also possible to form a printing head such as shown in FIGS. 9 and 10 in two halves split at the line A — A in FIG. 10. In making the printing head according to this method seven parallel axial channels for receiving the seven styli 141 are formed in one-half of the writing head in the face A — A which is then coated with copper of such a thickness that the channels are filled in. The face A — A is then ground down to re-

move the copper plated on the face, thereby leaving only the seven individual styli in the channels. The two halves of the writing head may then be attached together, for instance by means of an epoxy glue.

In FIG. 11 there is shown still another embodiment in which the need for a separate writing head is eliminated altogether. According to this embodiment, the slider 19 is itself the writing head. For each of the four writing heads a line of seven holes is drilled in the slider 19, as is illustrated in FIG. 11. The styli 147 are then inserted into the holes and fixedly mounted therein, preferably by means of an epoxy type glue. The face 149 of the slider 19 is then ground so that it provides a very flat, smooth surface with the tips of the styli being flush therewith.

In this embodiment the material of the slider 19 must have a very low coefficient of friction so that it does not cause the generation of particles from the coating on the web 11. Delrin AF mentioned above has been found to be a suitable material for the slider 19 in this embodiment.

With this embodiment of the writing head and slider assembly, it is preferable that the grounding bar 21 (FIG. 1) have a flexible resilient surface facing toward the web 11 in order to insure good contact between the styli 147 and the web 11.

An eighth stylus 150 may also be included in the printing head of FIG. 11, or for that matter in any of the printing head configurations illustrated in FIGS. 4 through 10. This eighth stylus 150 may be used for underlining selected portions of the information being printed.

Print heads similar to that illustrated in FIGS. 9 and 10 of the drawings may be constructed using a flat wire cable which is assembled with supporting metal or plastic side pieces. The printing face of the printing head should be ground so that the conductors are flush with the face.

An important feature of the printer according to the invention is that the dots of the characters are printed while the print heads 17 are moving across the web 11 rather than while stopped. As a result of this, the problem of the tendency of prior art printers to print "doughnuts" is solved since the edges of the styli are wiped across the web 11 during the time they are energized for depositing charge and thus deposit dots having a uniform charge distribution which, when developed, appear dark and solid.

In order to maximize the uniformity of the charge distribution, it is preferable to use styli with a thin rectangular cross section as opposed to ones with a round cross section.

Since, during printing, the motion of the slider 19 is approximately sinusoidal, it is not possible to time the enabling of the print heads for printing the dots of the successive columns with a free-running clock signal. Rather, an optical position encoder illustrated in FIGS. 12 and 13 of the drawings, is used in conjunction with the slider 19 for generating timing pulses to enable the printing of the successive columns of dots by the print head 17.

In the illustrated embodiment of the invention each print head 17 prints 32 characters. Each character position contains seven columns positions, five columns positions of which are used to form the 5 × 7-dot character matrix and the other two serving as the inter-character spaces. It is necessary to generate 224 posi-

tion signals each time the slider 19 traverses the web 11. FIG. 13, which is a sectional view of FIG. 12, along the line A — A shows the circuitry which may be used to sense the position of the slider 19. Light from the bulb 151 is collected by a bundle of glass fibers 153 and passed through a slit 155 in housing 157. The slit 155 may, for instance, be 150 microns wide by 0.5 inch high. Light from the slit 155 is interrupted by a transparent mask 159, which is fixedly attached to the slider 19. The mask 159 has 224 parallel black lines 161 ruled on it, each of which may be 175 microns wide by 0.5 inch high. The lines may be spaced from each other by 175 microns.

The light passing through the mask 159 passes through a slit in housing 163 which may be identical to the slit 155 in housing 157, and which must be directly opposite slit 155. The light is then collected by a fiber optic bundle 165 which may be substantially identical to the bundle 153, and fed to the input of a phototransistor 167. This output is amplified by amplifier 169. The output amplifier 169 may then be used to enable the printing of the successive columns of dots by the printing heads 17.

Each time the light source 151 is interrupted by one of the lines 161 a voltage pulse appears at the output of the amplifier 169. This pulse may then be used to enable the printing heads 17 for printing the successive columns of dots.

The phototransistor 167 may, for instance, be a Fairchild type FPT-100.

If the drive used for the slider imparts a uniform speed to it, the position encoder would not be necessary.

An embodiment of circuitry which may be used to control the printer according to the illustrated embodiment of the invention is illustrated in FIG. 14 of the drawings. The data to be printed is received in a serial-by-bit fashion from a computer and fed into the six-bit serial-to-parallel converter 171. From the converter 171 the data is transferred one six-bit character at a time to the one-line buffer 173. The one-line buffer 173 holds a full line of 128 six-bit characters to be printed on a single sweep of the print head 17 across the web 11. The six-bit code for the successive characters to be printed by the print heads 17 are sent by the buffer 173 to the individual character decoders 175. Four of these character decoders are provided, one for each of the print heads 17.

The character decoders 175 also receive five inputs from the seven-bit shift register 177. Shift register 177 is controlled by the slider position sensor whose operation is described in relation to FIGS. 12 and 13. The pulse output of the amplifier 169 is first shaped by the square wave shaper circuit 179 and then used to control a monostable multivibrator 181. Monostable multivibrator 181 in turn controls the seven-bit shift register 177.

The seven-bit shift register 177 therefore shifts each time the print heads 17 come into position for printing the next column of dots. The outputs 2 through 6 of the shift register 177 correspond to the five columns of the 5 × 7 character matrix. The outputs 1 and 7 correspond to the intercharacter spaces.

The outputs 2 through 6 of the shift register 177 are fed to the character decoders 175. The decoders 175, on the basis of the six-bit character code from the buffer 173 and the activated column input from the

shift register 177, generate drive pulses to selected ones of the corresponding set of seven high-voltage amplifiers 183. The outputs of the seven high-voltage amplifiers are used directly to activate the seven styli of the print heads 17.

The web advance stepper motor 85 (FIGS. 1 and 14) is controlled through the stepper driver circuitry 185. The web 11 is line-spaced by the stepper motor 85 during the time that the stylus and print head assembly is changing direction at the end of a sweep across the web 11. When a portion of the web 11 is to be left blank, the slider 19 is stopped at one end of its sweep by the clutch/brake mechanism 83 (FIGS. 1 and 2) and the driver circuitry 185 pulses the stepper motor 85 at a high rate so that the web 11 is moved quickly past the slider 19 for that portion which is to be left blank.

The control and timing signals for the stepper motor driving circuitry 185, the clutch/brake 83, and the character data handling circuitry are provided by the control unit 187. The control unit 187 receives control signals from the computer to which the printer is coupled and in turn controls the flow of data received by the printer from the serial-to-parallel converter 171 to the printing head driver circuitry 183. The control unit 187 also controls the motion of the slider 19 through the clutch/brake 83 and the movement of the web 11 through the stepper motor 85 and the associated drive circuitry 185.

The slider and printing head assembly sweeps across the web 11 alternately from right-to-left and left-to-right. It is therefore necessary for the control unit 187 to control the data handling circuitry in such a manner that the data signals delivered to the high voltage amplifiers 183 cause the print heads 17 to print the successive lines of characters on the web 11 alternately forwards and backwards. In the illustrated embodiment of the invention, the data input from the computer to the converter 171 is in the left-to-right reading mode.

Therefore the control unit 187 must invert alternate lines of data signals supplied to the high voltage amplifiers 183. This is accomplished by inverting the order of character readout from the buffer 173 to the character decoders 175 and by inverting the order of energization of the output by the seven-bit shift register 177, thereby inverting the order in which the columns of dots for each character are printed by the print heads 17.

A more detailed diagram of portions of the control unit 187 and the buffer 173 is illustrated in FIG. 15 of the drawings. The buffer 173 may include four sets 189 of six 32-bit end around shift registers 191. Each set 191 is associated with one of the character decoders 175 and print heads 19. The bits of the six-bit character code for each character to be printed are stored in the corresponding bit location in the shift registers 191. Thus the bits of the six-bit code for a particular character to be printed may be stored, for instance, in the first, or third, or 32-bit location of each of the six shift registers 191 of a set 189. The following character to be printed would be stored in an adjacent bit location of each of the shift registers 191.

When the printer is turned on by closing switch 193 (FIG. 16), the high voltage power supply 281, the low voltage power supply 283, the slider drive motor 87, the developer roller motor 99, the processor motor 89, the developer pump 39 and the blower 63, shown in FIG. 16, are actuated. After a predetermined delay to

allow these components to get over any transient conditions the control logic 195 sends a ready signal to the computer on line 197 which tells the computer that the computer is ready to print and essentially turns over the control of the operation of the printer to the computer.

The computer continually sends clock pulses on line 199 to the control logic 195 for controlling the loading of the characters to be printed into the buffer 173. While the computer is sending data to the printer, it also generates a voltage level on line 201 to the control logic 195. While this voltage level is present on line 201, the control logic 195 transmits the clock signals received on line 199 to the six-bit serial-to-parallel converter 171 for enabling the serial-to-parallel converter 171 to receive and store the contemporaneously received data bits from the computer. The frequency of the enabling pulses being sent to the serial-to-parallel converter 171 is divided by six by the frequency divider circuit 203 whose output is transmitted through OR gate 205 to shifting line 207, which causes the contents of the shift register 191 to shift one place to the right. This causes the contents of the serial-to-parallel converter 171 to be transmitted through the gating circuit 209 to the first bit place of the six registers 191 of a set of registers 189 selected by the gating circuit 209.

Thus, each time the serial-to-parallel converter 171 is filled with a six-bit character code, its contents are transmitted through gating circuit 209 to the first bit place of a set 89 of shift registers 191.

The gating circuit 209 is controlled by the output of the frequency divider circuit 211, which divides the frequency of the shift pulses received from the frequency divider 203 through OR gate 205 on line 207 by 32. In this way the first 32 six-bit character codes received from the computer are successively loaded into the shift registers 191 of the set 189 which controls the leftmost print head 19. Therefore, when the 32nd character is loaded into the first set 189 of shift registers 191, the six-bit code of the character to be printed in the leftmost character position on the web 11 on the next sweep of the print head and slider assembly across the web 11 is located in the 32nd bit place of the registers 191 of the first set 189.

When the divider 211 signals the gating circuit 209 that the 32nd character code is loaded into the first set 189 of shift registers 191, the gating circuit 209 switches so that the following characters are loaded in an identical manner into the second set 189 of shift registers 191 which may be identical with the first set 189. The second set 189 of shift registers 191 hold the information to be printed by the second writing head 19.

This process continues with the divider 211 signalling the gating circuit 209 on every 32nd six-bit character code received so that the gating circuit 209 loads successive groups of 32 characters into the successive sets 189 of shift registers 191 until all four sets 189 are filled with 32 characters each.

When the computer has sent the 128 character field to the printer, the voltage level on line 201 to the control logic 195 drops, thereby causing the control logic 195 to cease sending the enabling signals to the serial-to-parallel converter 171.

If the slider 19 is beginning its sweep across the web 11 from the left-hand side of the web 11, the multivibrator 213 has its output which is connected to AND gate set, thus enabling the AND gate 215 to transmit pulses generated on line 7 of the seven-bit shift register

177 (FIG. 14) to the OR gate 205 to act as shift pulses on the line 207 to the shift registers 191.

The output from the shift registers 191 is taken from the 32nd bit place of each of the registers which, at the end of the loading operation described above, stores the bits of the characters to be printed in the leftmost printing position of each of the print heads 19. Thus, the six-bit codes of the first, thirty-third, sixty-fifth, and ninety-seventh characters to be printed on the 128-character line are present on the input line of the character decoders 175 from the buffer 173.

The operation of the printer electronics will first be described in relation to the situation when the slider 19 is traversing the web 11 from left to right. When the print heads 19 reach the position where they are to begin printing, the first line ruled on the transparent mask 159 passes between the lamp 151 and the photodiode 167 causing a pulse output from the phototransistor 167. This pulse is amplified by amplifier 169 shaped by square wave shaper 179 and then used to trigger the monostable multivibrator 181. The output of the monostable multivibrator 181 activates the line number 1 of the seven-bit shift register 177. Since the printing of the characters takes place in columns 2 through 6 of the seven-column matrix provided for each character, the output number 1 of the shift register 177 is not connected to the character decoders 175 but may be used for housekeeping functions. When the next line on the mask 159 passes between the lamp 151 and the photodiode 167, the pulse output of the phototransistor 167 is coupled to the seven-bit shift register 177 through the aforementioned circuitry and causes the shift register 177 to shift, thereby activating output line number 2. This line corresponds to the leftmost column position of the character to be printed and is coupled to column input number 1 of each of the character decoders 175.

The character decoders, on the basis of the six-bit character code signal present at their inputs from the buffer 173 and the column select input present at one of the input lines from the seven-bit shift register 177, activate selected ones of their outputs to the corresponding groups of seven high voltage amplifiers 183, which, in turn, activate the corresponding styli on the corresponding print heads 19. In this manner charge dots are deposited on the web 11 for forming the latent image of the first column of the first character to be printed. The passage of the successive third through sixth lines on the mask 159 between the light source 151 and the phototransistor 167 cause the seven-bit shift register 177 to activate successively its third through sixth lines, which in turn cause the character decoders 175 to energize the proper styli on the corresponding print heads 19 through the corresponding group of high voltage amplifiers 183 for printing the latent image of the characters present on the output of the one-line buffer 173.

When the seventh line on the mask 159 passes between the lamp 151 and the phototransistor 167, the shift register 177 energizes line number 7 which is connected through AND gate 215 (FIG. 15) to OR gate 205 to act as a shift pulse for the shift registers 191 of all four groups 189. The AND gate 215 is enabled to pass the input from line 7 of the shift register 177 since its other input is activated by the multivibrator 213 because the slider 19 is moving from left to right.

The shift pulse on line 207 causes the shift registers to shift their contents end around one place to the right thereby shifting the bits of the second character to be printed by each of the print heads into the 32nd bit place. This makes the bits of the second character to be printed present on the inputs of the character decoders 175. This process continues as the successive lines on the mask 159 pass between the lamp 151 and the phototransistor 167 causing the shift register 177 to shift on each line and the shift register 191 of the buffer 173 to shift on every seventh line. In this way each of the print heads are controlled through the high voltage amplifiers 183 to latently image the web 11 with a 32-bit character portion of the 128-character line being printed.

When the print heads 17 have printed their 32nd character an end-of-line pulse is generated. This may be done, for instance, in the manner illustrated in FIG. 17 of the drawings by using a pair of magnetically operated reed switches 217 and 219 which are actuated by the magnetic pole piece 221 mounted on the slider 19. The reed switches 217 and 219 are positioned so that when the slider 19 reaches the left-hand margin of the printed area, switch 217 is closed by the action of the magnet 221 and when the slider 19 reaches the right-hand margin (i.e., when each of the print heads 17 have printed their 32-character segment of the line to be printed), the switch 219 is closed by the magnet 221. One side of the reed switches 217 is connected to a voltage source V, while the other sides are connected to opposite sides of the multivibrator 213 (FIG. 15). Therefore, when the slider 19 reaches the lefthand margin of the area to be printed, indicating that the subsequent line is to be printed from left to right, the switch 217 sets the multivibrator 213 so that the output of the multivibrator 213 connected to the AND gate 215 is actuated. When the slider reaches the righthand margin, it actuates switch 219 which resets multivibrator 213 and actuates its output which is connected to the AND gate 223.

The output pulses from the end-of-line signalling switches 217 and 219 are also connected through OR gate 225 to the control logic 195 as an end-of-line signal. This end-of-line signal is sent to the computer on request line 227 as a request for the computer to send the next line of data to be printed. The computer then sends the next line in the same manner as was described previously, thereby loading the buffer 173 with the next line of characters to be printed. After printing a line from left to right the next line printed is printed from right to left. Thus the 32nd, 64th, 96th and 128th characters are printed first by the respective print heads 19. Also each of the printed characters is printed backwards.

Since the output of the shift registers 191 in the illustrated embodiment is taken from the 32nd bit place which, at the beginning of the sweep, holds the character to be printed last by the print heads when they are printing from right to left, it is necessary to shift the characters in the shift registers 191 to supply them to the character decoders 175 in the correct order. It is also necessary that the inputs to the character decoders 175 from the seven-bit shift register 177 be activated in the reverse order from the way in which they are activated in printing from left to right.

In order to cause the shift register 177 to activate its output in reverse order, it is possible to include gating

in the register controlled by the output of the multivibrator 213 to reverse the order of counting, or to include two shift registers, one of which is used when printing from left to right and the other which is used when printing from right to left. Either of these alternatives would be well within the skill of one skilled in the art, and therefore will not be described in greater detail here.

In order to bring the bits of the correct character to be printed to the 32nd bit place of the registers 191, it is possible to shift the contents of the register 31 places to the right each time a new character is to be printed. As illustrated in FIG. 15, this may be accomplished by using a clock circuit 227 which is turned on by output 7 of shift register 177 through the AND gate 223 to generate 31 shift pulses to the OR gate 205. In this way the 31 shift pulses are passed to line 207 and shift the contents of the shift registers 191 by the required amount. The AND gate 223 is enabled to pass the pulse on its input from line 7 of shift register 177 since its input from multivibrator 215 is actuated. The clock circuit 227 should have a high enough frequency, (e.g. 1 mhz) in order that the shift registers 191 may be shifted the requisite 31 places between each character to be printed.

Counter 229 and AND gate 231 are provided to turn off the clock 227 each time after it has generated the required 31 shift pulses to the shift registers 191. The counter 229 may, for instance, be a standard five-stage binary counter which counts the pulses from the clock circuit 227. The outputs of all five stages are connected to the AND gate 231. When all five stages are actuated, (i.e., when the counter 229 has counted 31 pulses), the output of AND gate 231 goes high which turns off the clock 227 and clears the counter 229.

The operation of the electronics is then essentially identical to that described above in regard to printing from left to right with the exceptions that the shift register 177 counts in the reverse direction and the contents of the shift registers 191 are shifted 31 places between each character place in order to bring the proper character to be printed to the 32nd bit place of the shift registers 191.

If the computer wants to leave some lines blank instead of printing, it merely sends a line step signal to the control logic 195 on line 233 which causes the control logic to operate the brake portion of the clutch/brake 83 for stopping the slider 19 at the end of its travel and actuates the stepper motor 85 for line spacing the paper. If several lines are to be left blank, the computer sends the required number of blank space pulses to the control logic 195 for stepping the paper the required amount. The slider 19 is kept at one end of its travel for the entire procedure.

Other signals which may pass between the computer and the control logic 195 includes an end-of-print signal on line 237 from the computer to the control logic 195 which tells the printer that the printing is finished. The control logic 195 may also send an error signal on line 239 to the computer when an error condition occurs such as when a paper jam occurs or when the paper is exhausted.

An example of a high-voltage amplifier circuit which may be used to drive a stylus on a print head 19 is illustrated in FIG. 18 of the drawings. Normally high voltage transistor 241 is turned off so that voltage source V_B charges capacitor 243 through resistor 245 and

diode 247 up to approximately V_B . When the character decoder 175 energizes the input at the base of the transistor 241 with a positive going pulse, the transistor 241 turns on, thereby causing its collector potential to drop to a voltage level slightly above ground. Since the voltage across capacitor 243 cannot change instantaneously, the voltage at the anode of diode 247 is driven negatively to a voltage near minus V_B , thereby shutting off diode 247. This negative voltage pulse also appears at the stylus 251 causing a voltage difference of approximately V_B between the diode 247. This negative voltage pulse also appears at the stylus 251 causing a voltage difference of approximately V_B between the stylus and the grounded platen 251 thereby causing a dot of negative charge to be deposited on the dielectric coating of web 11. A V_B voltage on the order of between 500 and 800 volts has been found to be suitable for the amplifier. Resistor 253 is provided in order to protect the transistor 241 from high current should there be a puncture in the web 11 that would short the stylus 249 to ground.

Although the printer, according to the invention, has been described in relation to a line printer, it should be apparent that with minor modifications the printer could find many other uses. For instance, the printer could equally well be used for printing graphics if the paper stepping distance were adjusted so that each step was equal to the character height of a character printed by seven styli. In this case some changes would have to be made in the electronics also in the decoding of the input and in order to eliminate the intercharacter spaces.

We claim:

1. An electrographic printer for printing dot matrix-type characters on a web of dielectric coated paper comprising:

means for moving said web along a path;

a printing assembly including a slidable member and a plurality of print heads mounted in said slidable member, the spaces between adjacent print heads being equal, each of said print heads having a plurality of styli, said slidable member being mounted for movement transverse to the path of the said web with said styli in contact with the dielectric coated face thereof;

means for transporting said slidable member in an oscillatory fashion across said web; the amplitude of the oscillations being at least equal to the distance between adjacent print heads;

means for selectively energizing said styli for depositing dots of electric charge in image configuration on said dielectric coated face of said web as said slidable member traverses said web in either direction, each of said print heads being operational to print a portion of a line simultaneously with the printing of other portions of the line by the other print heads of said plurality of print heads;

means coupled to said slidable member for sensing the position of said slidable member as it traverses said web in either direction and for enabling said selective energizing means for depositing dots of electrical charge on said dielectric coated face of said web only when said slidable member is in predetermined positions in its path across said web, said means for moving said web operating to advance said web by a predetermined amount after

each traverse of said slidable member across said web; and

processor means for developing said dots of electrical charge deposited by said styli of said print heads.

2. The printer of claim 1 wherein said position sensing means includes:

a light transmitting mask mounted for movement with said slidable member;

a plurality of parallel opaque lines on said mask, said lines being spaced by the intercolumn distance between the columns of dots of said matrix-type characters being printed and being oriented orthogonally with respect to the path of movement of said slidable member;

means fixedly mounted for projecting light through said mask at a point in its path from one side thereof;

means fixedly mounted opposite said light projecting means on the other side of said mask for sensing the amount of light transmitted through said mask at a point in its path; and

means responsive to the sensing of the passage of said opaque lines by said sensing means for controlling the actuation of said selective energizing means.

3. The printer of claim 2 wherein said light projecting means include a lamp and a fiber optic bundle for transmitting light from said lamp to a line portion of said path, said line portion being parallel to said opaque lines on said mask.

4. The printer of claim 3 wherein the width of said line portion in the path of said mask is less than the width of said opaque lines on said mask.

5. The printer of claim 3 wherein said transmitted light sensing means includes a photosensitive device and a fiber optic bundle for delivering light from a line portion of the path of said mask directly opposite the line portion illuminated by the fiber optic bundle of said light projecting means to said photo-sensitive device.

6. The printer of claim 1 wherein said means for transporting said slidable member includes:

a motor;

a disc rotated at a constant angular velocity by said motor;

cable means connecting a point proximate the periphery of said disc to both ends of said slidable member; and

resilient means connected in series with said cable means for compensating for changes in length of said cable means during the rotation of said disc.

7. The printer of claim 1 wherein said slidable member transporting means include a motor, and a clutch brake mechanism between said motor and said slidable member for selectively stopping said slidable member at either end of its traverse of said web and wherein said printer further includes means for causing said web moving means to advance said web by a selected amount while said slidable member is held at an extreme of its path by said clutch brake mechanism.

8. The printer of claim 1 wherein said styli on said print heads are oriented in a line perpendicular to the direction of motion of said print heads and are spaced from one another by the row distance of the dots of the matrix-type characters to be printed, and further including an underlining stylus spaced from said plurality of styli and selectively energizable for underlining information printed by said plurality of writing styli.

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9. The printer of claim 1 further including a grounding plate directly opposite said print heads on the opposite side of said web, said grounding plate being urged toward said print heads.

10. The printer of claim 9 wherein said print heads are slidably mounted in said slidable member for movement perpendicular to said web and said printing assembly further includes:

means for resiliently biasing said print heads against said web.

11. The apparatus of claim 1 wherein said styli of said print heads are arranged in a spaced linear relationship and wherein said print heads further include:

insulating layers on either side of said line of spaced styli; and

bearing members having a substantially higher resistance to wear than said insulating layers attached to either side of said insulating layers, said bearing members, insulating layers and styli being arranged with a smooth flush face oriented towards said web.

12. An electrographic printer for printing characters on the web of dielectric coated paper comprising:
means for moving said web along a path;
a printing assembly including a slider having a print-

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ing face and a plurality of groups of linearly arranged spaced styli therein, the ends of said styli being substantially flush with said printing face, said slider being mounted for oscillatory movement transverse to the path of said web with said printing face in contact with the dielectric coated face thereof;

means for transporting said slider in an oscillatory fashion across said web;

means for selectively energizing said styli for depositing dots of an electric charge in image configuration on the said dielectric coated face of said web as said slider traverses said web in both directions, said groups of said styli being arranged in equal spaced relationship with one another for depositing charge on equal adjacent segments of said web, each of said groups of styli being operational to print a portion of a line simultaneously with the printing of the other portions of the line by the other groups of styli; and

processor means for developing said dots of electric charge deposited by said styli.

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