

[54] **IMAGE REGISTRATION CORRECTION FOR NON-IMPACT PRINTERS**

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[51] **Int. Cl.** ..... **B41b 17/14**

[58] **Field of Search** ..... **95/4.5**

[56] **References Cited**

**UNITED STATES PATENTS**

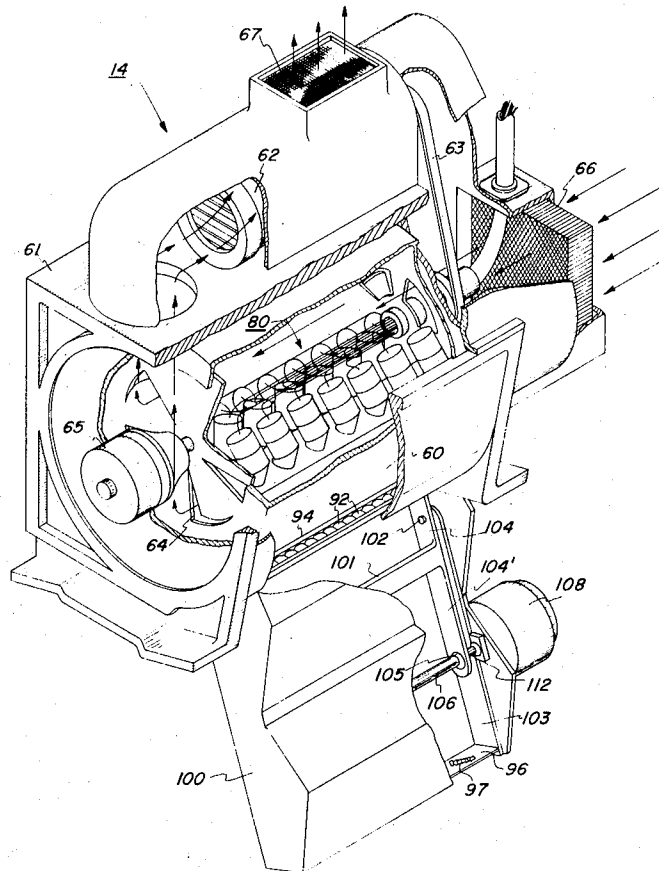
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| 2,963,947 | 12/1960 | Freer    | ..... | 95/4.5 |
| 3,249,028 | 5/1966  | Higonnet | ..... | 95/4.5 |

*Primary Examiner*—John M. Horan

[57] **ABSTRACT**

A non-impact printer adapted for on-line or off-line use with digital computers, combines a xerographic processor with an optical character generator, the latter having a continuously rotating character drum sectored into a predetermined number of character groups with a series of flash lamps operative to print out computer generated line copy. The character drum is operatively coupled with the photosensitive surface of the xerographic processor by a lens strip and mask assembly displaceable in predetermined steps corresponding to the character drum sectors. Stepping of the lens strip and mask assembly is effected when there is a lag in starting printout of the first line equal to one drum sector or more, such stepping movement of the lens strip and mask assembly resulting in incremental corrective displacement in the position of the character image generated by the character generator on the processor photosensitive surface.

**10 Claims, 5 Drawing Figures**



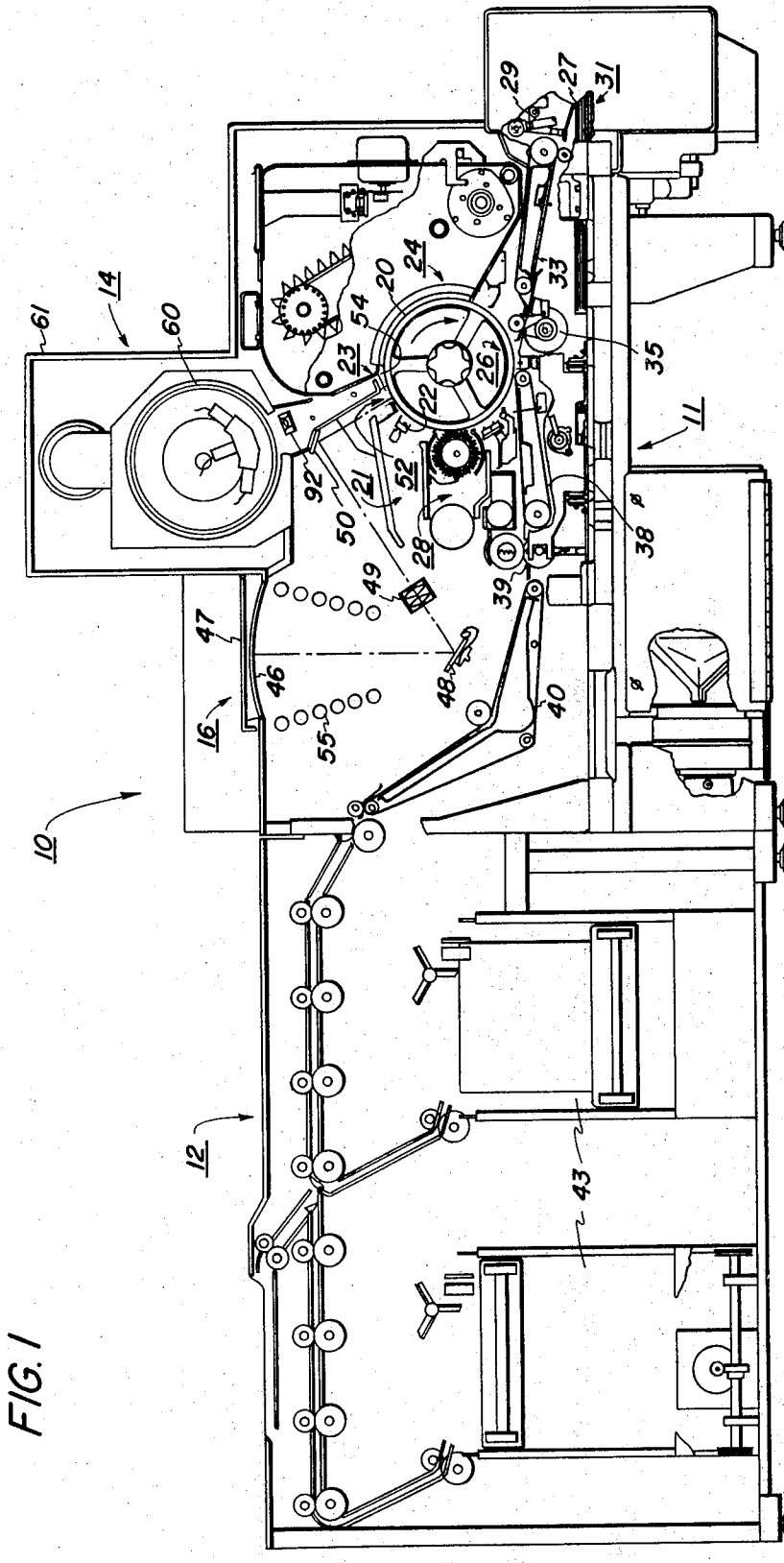
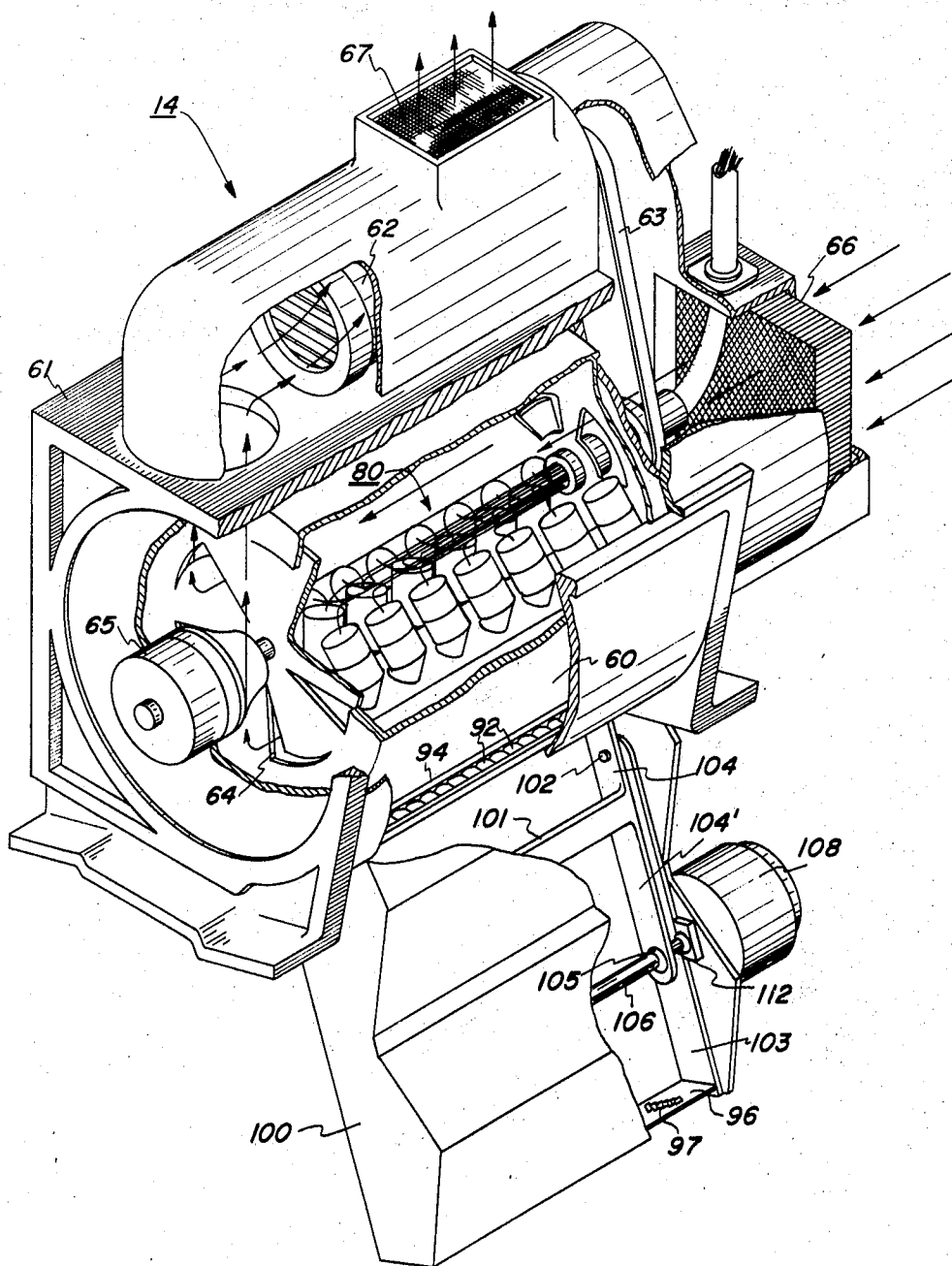


FIG. 2



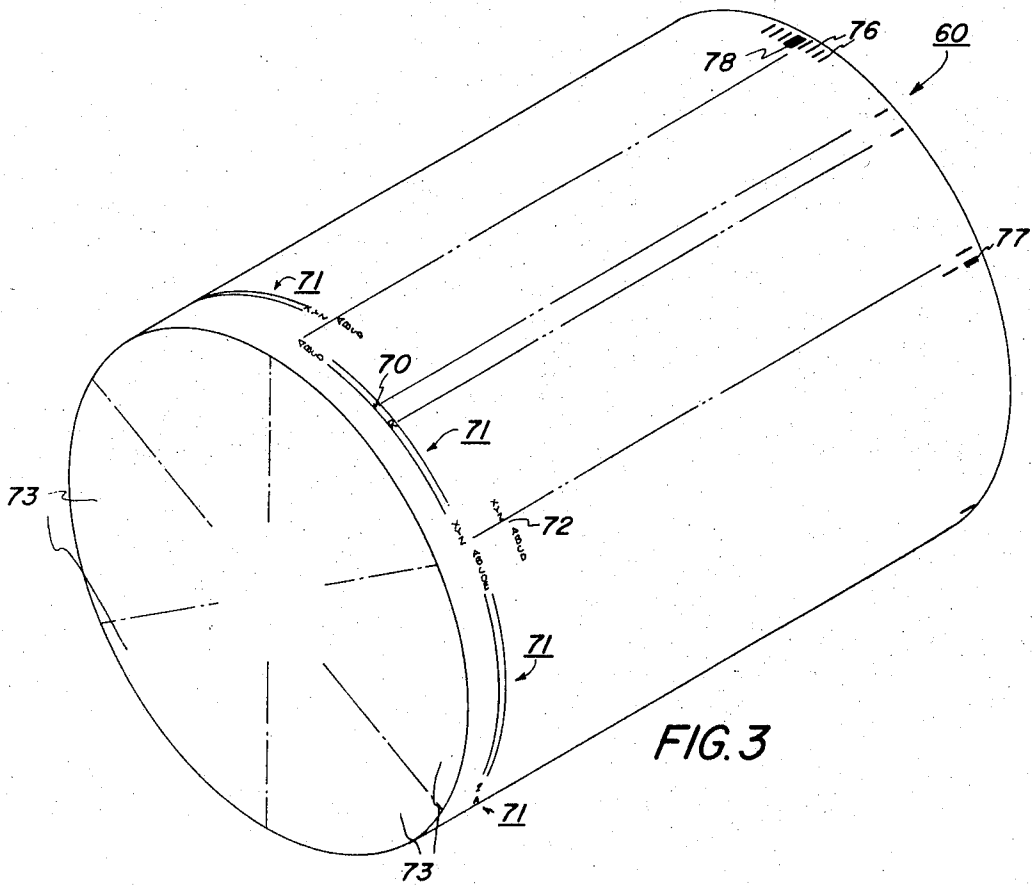


FIG. 3

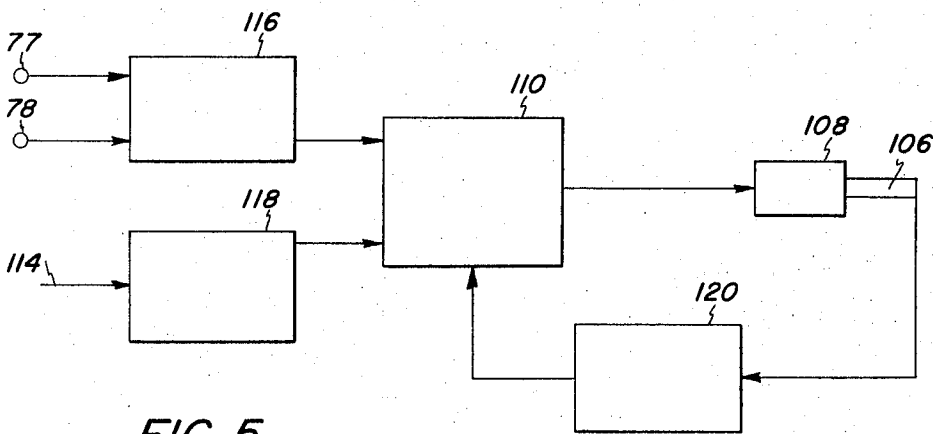
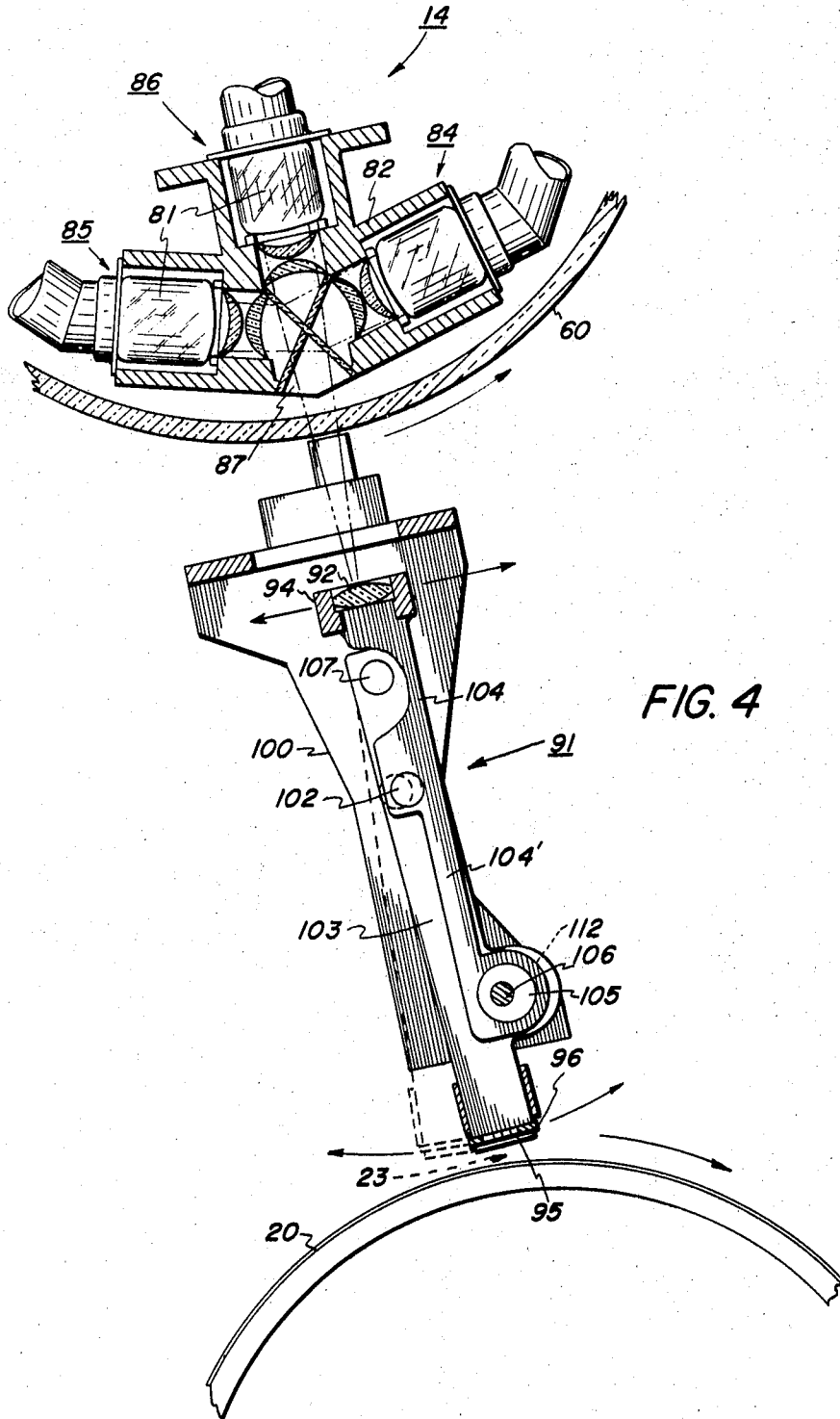


FIG. 5



## IMAGE REGISTRATION CORRECTION FOR NON-IMPACT PRINTERS

This invention relates to an electrostatic type non-impact printer for computer output, and more particularly, to an electrostatic type non-impact printer having an improved image registration correction means to automatically compensate for any out-of-phase condition that may exist between the rotating printer character drum and the moving photosensitive surface of the electrostatic processor.

One form of non-impact type printer utilizes a xerographic processor with an optical type character generator. In this type of printer, a high speed character bearing drum is used, the drum having individual character sets for each character space in a line together with flash illumination units disposed inside of the drum, to illuminate the characters in accordance with computer generated signal information. A lens assembly projects the flashed images onto the photosensitive surface of a xerographic processor.

The xerographic processor, which is normally only operational when copies are being processed, has a relatively inflexible internal timing cycle. Although the character drum is continuously rotated at high speed to avoid the need to bring the drum up to speed each time the printer is started, the character drum may nevertheless not be in start-print position at the exact moment that the xerographic processor cycle demands it. Hence, there may be a delay in the character generator starting the first line even though the processor is operational. As a result, the lines printed out by the printer may be mislocated on the copy sheet. This result can also occur during a printing run if the operational speeds of the character drum and the processor photosensitive surface are not in exact synchronization. In this instance, any slight speed differential between the character drum and the photosensitive surface accumulates and ultimately leads to a noticeable change in line orientation on the copy sheet.

As can be appreciated, any misorientation of the image on the copy sheet may or may not be a problem depending on severity. However, where preprinted forms are used or a forms overlay capability is provided, accurate location of the line image on the copy sheet becomes essential if the relationship between the line copy and the background form material is to be visually acceptable.

It is a principal object of the present invention to provide a new and improved non-impact printer for computer output.

It is a further object of the present invention to provide an improved xerographic type non-impact printer utilizing an optical character generator.

It is an object of the present invention to provide a non-impact printer for computer output combining an optical character generator with rotatable character drum and xerographic processor, the optical projecting means therefor being displaceable in steps to enable the optical character generator and processor individual timing characteristics to be matched.

It is an object of the present invention to provide a displaceable lens system for projecting light images of characters from a character drum to the photosensitive surface of a xerographic processor, with control means responding to a predetermined delay in printout of the first line to move the lens system through one or more

steps designed to offset such delay by displacing the projected image on the processor photosensitive surface.

It is an object of the present invention to provide a character generator incorporating control means for the lens assembly thereof adapted to compensate for the difference between the start print position required of the character drum and the actual position of the drum at the time the start signal is given.

It is an object of the present invention to provide an optical type character generator combined with an electrostatic processor incorporating control means to step the projection lens assembly through the number of steps required to mate the projected image with the copy sheet.

It is a further object of the present invention to provide an improved optical system for a non-impact type printer.

This invention relates to an apparatus for operatively relating the cyclicly operated photosensitive surface of a xerographic processor with the continuously rotating character drum of a character generator in an impactless printer, the combination comprising: optical projection means operatively disposed between the character drum and the photosensitive surface of projecting character images generated onto the processor photosensitive surface, the character generator being adapted to start printout at a predetermined character drum position; and means responding to a delay by the character generator in starting printout while the character drum rotates to the predetermined position to move the optical projection means and reposition the projected image on the photosensitive surface so as to compensate for the delay in starting printout.

Other objects and advantages will be apparent from the ensuing disclosure and drawings in which:

FIG. 1 is a schematic view showing a xerographic type non-impact printer for computer generated output incorporating the improved optical projection means of the present invention;

FIG. 2 is an enlarged isometric view showing details of the character generator together with the projection means of the present invention;

FIG. 3 is an enlarged isometric view of the character drum shown in FIG. 2;

FIG. 4 is an enlarged view in section showing details of the optical projection means of the present invention; and

FIG. 5 is a block diagram of the control mechanism for the optical character generator of the present invention.

Referring to FIG. 1 of the drawings, there is shown schematically a xerographic type non-impact printer 10 incorporating the improved image registration correction means of the present invention. Printer 10 includes a xerographic processor 11, with output stacking station 12 and optical type character generator assembly 14. Processor 11 has a platen 16 designed to permit forms overlay material to be copied in conjunction with the line copy generated by character generator 14 as will appear more fully herein.

Processor 11 includes a xerographic plate 20 bearing a photoconductive layer or a light receiving surface on a conductive background and formed in the shape of a drum. Drum 20 is suitably journaled in the processor frame to rotate in the direction indicated (clockwise in FIG. 1) to move the surface of drum 20 sequentially

past a series of xerographic processing stations arranged about the periphery of drum 20. The xerographic processing stations include charging station 21 wherein a uniform electrostatic charge is deposited on the photoconductive layer of drum 20 by means of a suitable corona charging device 22, exposure station 23 wherein a light or radiation pattern of the information being copied is projected onto the surface of drum 20 to form latent electrostatic images, developing station 24 wherein a suitable xerographic developer material is applied to the surface of drum 20 to provide a toner delineated image, transfer station 26 wherein the toner delineated image is electrostatically transferred from drum 20 to a suitable transfer material such as copy sheets 27, and drum cleaning station 28 wherein residual toner remaining on drum 20 is removed in preparation for reuse.

A sheet feeder 29 is provided for advancing copy sheets 27 one by one from supply stack 31 to paper transport 33. Transport 33 carries the individual sheets forward to sheet register 35 just upstream of drum 20, register 35 serving to align and time the sheets 27 in correspondence with movement of drum 20 and the toner delineated image thereon. As the copy sheets move through transfer station 26, the developed image is transferred from drum 20 to the sheet.

Following transfer, the image bearing copy sheet is conveyed by conveyor 38 to fuser 39 where the toner delineated image is permanently fixed. Thereafter, the copy sheet is conveyed by discharge conveyor 40 to stacking station 12 wherein it is disposed in one of stacking trays 43.

Platen 16 of processor 11 consists of a transparent surface such as glass 46 on which the forms document being used is placed face down. A suitable platen cover 47 is provided to protect glass 46 and retain the forms document in place. The document on platen glass 46 is scanned by moving mirror 48 operated in timed relationship to the drum 20, the resulting light image being projected by lens 49 and mirror 50 onto the surface of drum 20 at exposure station 23. The forms image strikes drum 20 at a point designated generally by the numeral 52, slightly ahead of the point, designated generally by the numeral 54, where the line image produced by generating assembly 14 strikes drum 20. Lamps 55 below platen 16 serve to illuminate the forms document resting on platen glass 46.

Referring particularly to FIGS. 2 - 4 of the drawings, optical character generator 14 comprises a transparent character mask or drum 60 on which a series of individual sets 70 of alphanumeric characters are arranged in predetermined orientation as will appear more fully herein. Drum 60 is suitably journaled for rotation by bearings 65 within tower 61 supported on processor 11. Tower 61 is configured to form a protective enclosure encasing drum 60 and the operating components thereof together with drum drive motor 62. A toothed belt 63 drivingly interconnects motor 62 with drum 60. To cool the flash illumination mechanism 80, which is arranged inside drum 60, cooling fins 64 are provided at one end of drum 60. Air inlet and exhaust openings 66, 67 respectively in tower 61 complete the air flow path.

Referring particularly to FIG. 3, character sets 70 are arranged around the circumference of drum 60 in a series of groups 71, each group comprising six character sets which together with flash recover gaps 72 form a

complete band around the periphery of drum 60. The character sets 70 comprising each group 71 are progressively offset by one character space with the result that a series of the groups 71 are provided extending axially along the drum 60 to provide one complete set 70 for each character in a line. The resulting center line spacing between adjoining character sets 70 in each sector 73 of drum 60, equal to the width of six character sets, times the optical magnification of the system serves to prevent horizontal cross talk between adjoining character sets. In the exemplary arrangement shown in FIG. 3, 132 sets of characters are provided, there being 22 groups of six character sets (total 132 character sets). The flash illumination mechanism 80 consists of an individual flash lamp and cooperating condenser lens unit 81 for each character set group 71 as will appear.

To provide the requisite timing and character identification, a series of timing marks are provided adjacent one end of drum 60. The aforesaid timing marks comprising individual timing marks 76 for each letter or number in the character sets equivalent to one group 71. The last timing mark 77 of each sector has extra width to mark the end of each drum sector 73. The last timing mark of last sector 78, denoting the point where line printing out starts, has even greater width than the marks 77, the different widths of the various timing marks 76, 77, 78 permitting control signal differentiation therebetween. A photocell type detector (not shown) is provided opposite the path of timing marks 76, 77, 78 for generating a signal in accordance with movement of the marks thereunder.

As best seen in FIGS. 2 and 4 of the drawings, flash units 81 are supported in an illumination frame 82 in three rows 84, 85, 86 about the top, bottom, and rear of a prism or mirror structure 87. Each lamp unit 81 is separated from the next adjoining lamp in the same row by a space equal to the width of one lamp unit, the lamp units being off-set relative to one another so that there results an uninterrupted series of lamps for each character group 71. The collected light from the lamp units comprising top and bottom rows 84, 85, respectively is reflected 75° by prism or mirror structure 87 in the forward direction toward exposure station 23 and imaging point 54. As can be understood, the collected light from the lamp units making up row 86 requires no reflecting prism or mirror.

The character image produced by the momentary illumination of the characters on drum 60 is projected from drum 60 by a lens assembly 91, lens assembly 91 consisting of a series of individual lenses 92 and cooperating field mask 95. Lenses 92 are arranged in a strip 94, there being an individual lens 92 for each character set group 71. As noted heretofore, the arrangement of the character sets 70 on drum 60 provides a space between adjoining character sets to prevent horizontal cross-talk between adjacent character images.

Field mask 95, disposed between lenses 92 and the xerographic drum 20, provides center to center compression of characters on drum 20 to prevent vertical cross-talk. Field mask 95 consists of an opaque segment 96 having a series of apertures or windows 97 there-through, one window being provided for each character set 70. Each group of six windows in mask 95 forms a stepped pattern designed to accommodate the delay caused by generating the character images at various

times during a single revolution of drum 60 while xerographic drum 20 rotates.

Lens assembly 91 is housed in a support 100 appended to housing 61 and projecting toward imaging station 23 of xerographic drum 20. Lens strip 94 is carried by a generally rectangularly shaped bracket 101, arms 104 thereof being pivotally mounted within support 100 to arms 103 of field mask 95 by means of pins 102. The outwardly projecting terminal ends 104' of arms 104 have eccentric portion 105 of step motor control shaft 106 rotatably journaled therein. Support arms 103 for field mask 95 are pivotally appended to support 100 by pins 107, eccentric portion 112 of control shaft 106 being rotatably journaled therewithin.

Step motor 108 is suitably mounted on support 100, with shaft 106 thereof suitably journaled therewithin. Step motor 108 is arranged to turn control shaft 106 back and forth through six predetermined increments or steps corresponding to each of the six sectors 73 on character drum 60 to provide corresponding indexing motion to both lens strip 92 and field mask 95. By virtue of the aforescribed supporting structure for lens strip 92 and mask 95, stepping movement of control shaft 106 swings, via eccentric portion 112, field mask 95 about the axis of pins 107 in predetermined increments or steps. At the same time, eccentric portion 105 swings or steps lens strip 94 about pivot 102 with the result that lens strip 92 undergoes stepwise displacement in a substantially straight line direction tangent to character drum 60 at the optical axis as shown by the solid line arrow in FIG. 4. This is due to the fact that the lens strip pivot point, pin 102, is itself displaced as mask 95 swings about the axis of pins 107.

The aforescribed movement of lens strip 92 and mask 95 in turn displaces the optical image projected onto drum 20 in steps designed to compensate for any misalignment of the line image generated by character generator 14 on copy sheet 27 due to the character drum 60 being or becoming out of phase with drum 20 of processor 11 as will appear more fully herein.

During the copying cycle, the image generated by the optical character generator 14 with or without a forms overlay image from platen 16 is electrostatically formed on the surface of the rotating xerographic drum 20. As drum 20, turns, this latent electrostatic image is first developed at station 24 following which the toner delineated image is transferred to copy sheet 27 at transfer station 26. The timing relationship between feeding of copy sheet 27 and the position of the image on the moving drum 20 is critical if the image is to be matched with and transferred to the copy sheet in proper position. To accomplish this, register 35 aligns the advancing copy sheet with the image on drum 20.

However, the image itself must be formed on drum 20 within predetermined limits if proper registration of the image with the copy sheet 27 is to be attained. Since the point at which printout of the first line is begun by character drum 60 is fixed by timing mark 78 and the flash illumination mechanism 80, the drum 60 may not be in printing position when the print cycle of processor 11 demands that imaging begin. In this circumstance, start of imaging of the first line on drum 20 is delayed until the character drum 60 rotates to the printing position defined by the timing mark 78. Since the xerographic drum 20 has started to turn commensurate with the initiation of the processor print cycle,

the delayed line copy generated by the character drum may not be within desired margin requirements on copy sheet 28. And, where a forms overlay or a preprinted form is used, the line printout from character generator 14 may be misplaced relative to the form overlay or preprinted form image.

To offset any delay in character generator line printout due to the character drum 60 not being in print position when the start of line printout signal is given as well as any delay accumulated as a result of speed differences between the xerographic drum 20 and character drum 60 occurring during a printing run, the lens assembly 91 may be stepped through a series of movements equal to the number of drum sectors that character drum 60 is behind at the instant the print signal is given. To accommodate error accumulated during an extended run, the relative positions of the drums 20 and 60 are compared at the start of each page. In this latter instance, when the comparison indicates an accumulated error of at least one sector, motor 108 is actuated and lens assembly 91 is stepped through one position to realign the projected line image on the xerographic drum 20.

Referring now particularly to FIG. 5 of the drawings, a suitable comparator circuit 110 is provided to control operation of stepping motor 108, circuit 110 functioning to compare the actual position of character drum 60 at the time line print start signal 114 is given versus the position of drum 60 required to start line printout. Based on this comparison, which is the measure of the delay in starting printout of the first line, lens assembly 91 is moved through the requisite number of steps required to offset such delay and prevent any misorientation of the line image on copy sheets 28.

A suitable circuit 116 is provided to monitor the instantaneous position of drum 60 based upon signals from sector marks 77 and start print mark 78, the output of circuit 116 forming one input to comparator circuit 110. Circuit 118 identifies the start print position of character drum 60. Circuit 120 is provided to monitor the step position of lens assembly 91, the signal from circuit 120 being fed to comparator circuit 110.

In operation, lens assembly 91 is returned to the index position corresponding to start of line timing mark 78, shown for convenience in FIG. 3 as between sectors 1 and 6, at the termination of each copy run. Thus, on start up of a printing run, the print signal 114 to character generator 14 triggers comparator circuit 110 and a comparison is made between the actual position of character drum 60 at that time relative to the position drum 60 should be in to start printout. When drum 60 is in correct print start position, i.e. in the first sector following timing mark 78, stepping motor 108 is not actuated and lens assembly 61 remains in its initial setting.

Where the start print mark 78 on drum 60 is more than one sector removed from the drum start print position, comparator circuit 110 actuates step motor 108 to step the lens assembly 91 through one or more steps equal to the number of full sectors drum 60 is out of print start position. For example, if character drum 60, is found to be between sectors 3 and 4 at the print start signal, circuit 110 operates step motor 108 through four steps equal to the number of full sectors through which drum 60 must rotate before mark 78 on drum 60 reaches the drum print start position. This in turn steps

the position of the projected image on xerographic drum 20 through four gradients to offset the delay in starting printout of the first line so that the line copy stays within the margins of copy sheet 27.

At each succeeding page in a copy run, the start print signal for the first line of the page triggers comparator circuit 110 to again compare the instantaneous position of character drum 60 with the drum print start position. Where a difference of at least one sector is found, circuit 110 actuates step motor 108 to step the lens assembly one step. The aforesaid continues until the print run is ended at which point lens assembly 61 is returned to the index position corresponding to timing mark 78. Since drum 20 and 60 rotate in the same direction, the step movement of lens assembly 61 is unidirectional. Thus, lens assembly 61, when on the last step (i.e. that corresponding to sector 6) resets back to the first step on actuating of step motor 108.

While the invention has been described with reference to the structure disclosed herein it is not confined to the details set forth and this application is intended to cover such modification or changes as may come within the purpose of improvements or the scope of the following claims.

What is claimed is:

1. In an apparatus for operatively relating the cyclicly operated photosensitive surface of a xerographic processor with the continuously rotating character drum of a character generator in an impactless printer, the combination of:

optical projection means operatively disposed between said character drum and said photosensitive surface for projecting character images generated by said character generator onto said processor photosensitive surface, said character generator being adapted to start printout at a predetermined character drum position; and

means responding to a delay by said character generator in starting printout while said character drum rotates to said predetermined position to move said optical projection means and re-position the image projected thereby on said processor photosensitive surface so as to compensate for the delay in starting printout.

2. The apparatus according to claim 1 in which said character drum is segregated into sectors of at least one character set each,

said moving means including means adapted to drive said optical projection means through a series of steps, there being at least one step for each of said character drum sectors, and comparator means for identifying the sector position of said character drum at the start-print signal and comparing said drum sector position with said drum predetermined start printout position; and

control means for actuating said drive means to step said optical projection means through the step or steps equal to the number of full sectors difference in drum position as sensed by said comparator means.

3. The apparatus according to claim 1 in which said optical projection means includes at least one projection lens of predetermined magnification together with at least one character mask in operative association therewith;

said moving means being adapted to move said mask relative to said lens in a ratio substantially equal to the magnification ratio of said lens.

4. In an electrostatic line printer, the combination of:

a xerographic processor having a photosensitive imaging surface;

character generating means including a rotatable character drum separated into equal sectors with plural alpha-numeric character columns in each of said sectors;

one of said sectors defining start of line printing position for said drum;

means to illuminate selected ones of said character at a predetermined printing position of said drum whereby to provide light images of those characters comprising the lines being printed;

optical means to project said light images onto said processor photosensitive imaging surface;

means to step said optical means through a series of incremental movements corresponding to said drum sectors whereby the light image projected by said optical means on said imaging surface is incrementally displaced; and

control means responsive to an enabling signal from said processor to actuate said step means and step said optical means when the instantaneous position of said drum at the time of said enabling signal is at least one sector apart from said one start of line printing sector, said control means being adapted to sustain actuation of said step means until said optical means is moved through steps equal to the number of sectors by which said drum instantaneous position is apart from said one start of line printing sector.

5. The electrostatic type line printer according to claim 4 in which said optical projection means includes at least one lens and cooperating mask for projecting character images from said character drum to said photosensitive surface;

said step means including a first driver for said lens;

a second driver for said mask;

said second driver being adapted to move said mask by an amount equal to the movement of said lens times the magnification ratio of said lens.

6. The electrostatic type line printer according to claim 4 in which said processor enabling signal reflects start of page printing.

7. In a non-impact printing apparatus,

a xerographic processor having a member with a photosensitive surface, said xerographic processor generating a start-print signal when said photosensitive surface is at a predetermined position,

a character generator having a continuously rotating, character-bearing member, said character generator being adapted to start printout when said character-bearing member is at a predetermined printout position,

optical projection means operatively disposed between said continuously rotating member and said photosensitive surface for projecting character images generated by said character generator onto said photosensitive surface, and

means responding to a delay by said character generator in starting printout, due to said character-bearing member not being at said predetermined

printout position when said xerographic processor generates said start-print signal, to move said optical projection means to compensate for the delay in starting printout.

8. The apparatus of claim 7 in which said character-bearing member is a drum segregated into sectors of at least one character set each,

said moving means includes means adapted to drive said optical projection means through a series of steps, there being at least one step for each of said character drum sectors, and comparator means for identifying the sector position of said character-bearing drum at the start-print signal and comparing said drum sector position with said predetermined printout position, and

control means for actuating said drive means to step said optical projection means through the step or steps equal to the number of full sectors difference in drum position as sensed by said comparator means.

9. The method of operatively coupling the continuously rotating character-bearing drum of a character

generator with the copy processing cycle of an electrostatic copier to which said character generator is optically coupled whereby to assure that the line copy generated thereby is located within the desired margin limits on the copy sheets processed by said copier, said characters of said drum being separated into character-set sectors, the steps comprising:

determining the number of sectors said drum must rotate after the start-print signal of said copier to bring said character drum to its first line printout position; and

moving the point where the optically projected character image strikes the copier photosensitive surface by a distance determined by said number of sectors.

10. The method of claim 9 wherein said movement is achieved by displacing the means optically coupling said character bearing drum with said photosensitive surface in step-wise fashion, one step for each sector difference.

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