

Description

[0001] This invention relates to a developmental apparatus for developing with a developer.

[0002] Generally, the process of electrostatographic printing includes charging a photoconductive member to a substantially uniform potential so as to sensitize the surface thereof. The charged portion of the photoconductive surface is exposed to a light image of an original document being reproduced. This records an electrostatic latent image on the photoconductive surface. After the electrostatic latent image is recorded on the photoconductive surface, the latent image is developed by bringing a developer material into contact therewith. Two component and single component developer materials are commonly used. A typical two component developer material comprises magnetic carrier granules having toner particles adhering triboelectrically thereto. A single component developer material typically comprises toner particles. Toner particles are attracted to the latent image forming a toner powder image on the photoconductive surface. The toner powder image is subsequently transferred to a copy sheet. Finally, the toner powder image is heated to permanently fuse it to the copy sheet in image configuration.

[0003] Unsatisfactory print quality can be due to a number of causes including for example insufficient toner image density on the imaging member during the printing cycle. There is a need, which the present invention addresses, for new approaches to improving the print quality.

[0004] Conventional printing machines and development apparatus are disclosed in Brewington, U.S. Patent 5,493,370; Inaba et al., U.S. Patent 5,463,452; Knapp, U.S. Patent 5,212,522; and Ochiai et al., U.S. Patent 5,554,479, the disclosures of which are totally incorporated herein by reference.

[0005] The present invention is accomplished by providing a development apparatus for developing with a developer including toner particles an electrostatic latent image carried on an imaging member comprising:

- (a) a donor member positioned adjacent to the imaging member; and
- (b) AC means for establishing an AC voltage bias between the imaging member and the donor member, wherein the frequency of the AC voltage bias is adjustable to control the density of the toner particles on the electrostatic latent image.

[0006] Other aspects of the present invention will become apparent as the following description proceeds and upon reference to the Figures which represent preferred embodiments:

FIG. 1 is an elevational, schematic view of a single-component developer apparatus according to the present invention;

FIG. 2 is an elevational, schematic view of an electrostatographic printing machine incorporating the development apparatus of the present invention therein; and

FIG. 3 is a graph depicting the relationship between optical density and AC voltage bias frequency.

[0007] As used herein, "AC" refers to alternating current and "DC" refers to direct current.

[0008] Referring initially to FIG. 2, there is shown an illustrative electrostatographic printing machine incorporating the development apparatus of the present invention therein. The electrostatographic printing machine employs an imaging member which is shown as belt 10 having a photoconductive surface 12 deposited on a conductive substrate 14. Preferably, photoconductive surface 12 is made from a selenium alloy or an organic photosensitive material. Conductive substrate 14 is made preferably from an aluminum alloy which is electrically grounded. One skilled in the art will appreciate that any suitable photoconductive belt may be used. Belt 10 moves in the direction of arrow 16 to advance successive portions of photoconductive surface 12 sequentially through the various processing stations disposed about the path of movement thereof. Belt 10 is entrained about stripping roller 18, tensioning roller 20 and drive roller 22. Drive roller 22 is mounted rotatably in engagement with belt 10. Motor 24 rotates roller 22 to advance belt 10 in the direction of arrow 16. Roller 22 is coupled to motor 24 by suitable means, such as a drive belt. Belt 10 is maintained in tension by a pair of springs (not shown) resiliently urging tensioning roller 20 against belt 10 with the desired spring force. Stripping roller 18 and tensioning roller 20 are mounted to rotate freely.

[0009] Initially, a portion of belt 10 passes through charging station A. At charging station A, a corona generating device, indicated generally by the reference numeral 26, charges photoconductive surface 12 to a relatively high, substantially uniform potential. High voltage power supply 28 is coupled to corona generating device 26. Excitation of power supply 28 causes corona generating device 26 to charge photoconductive surface 12 of belt 10. After photoconductive surface 12 of belt 10 is charged, the charged portion thereof is advanced through exposure station B.

[0010] At exposure station B, an original document 30 is placed face down upon a transparent platen 32. Lamps 34 flash light rays onto original document 30. The light rays reflected from original document 30 are transmitted through lens 36 to form a light image thereof. Lens 36 focuses this light image onto the charged portion of photoconductive surface 12 to selectively dissipate the charge thereon. This records an electrostatic latent image on photoconductive surface 12 which corresponds to the informational areas contained within original document 30.

[0011] After the electrostatic latent image has been

recorded on photoconductive surface 12, belt 10 advances the latent image to development station C. At development station C, a developer apparatus, indicated generally by the reference numeral 38, develops the latent image recorded on the photoconductive surface. The development system of the present invention will be described in detail below.

[0012] With continued reference to FIG. 2, after the electrostatic latent image is developed, belt 10 advances the toner powder image to transfer station D. A copy sheet 48 is advanced to transfer station D by sheet feeding apparatus 50. Preferably, sheet feeding apparatus 50 includes a feed roll 52 contacting the uppermost sheet of stack 54. Feed roll 52 rotates to advance the uppermost sheet from stack 54 into chute 56. Chute 56 directs the advancing sheet of support material into contact with photoconductive surface 12 of belt 10 in a timed sequence so that the toner powder image developed thereon contacts the advancing sheet at transfer station D. Transfer station D includes a corona generating device 58 which sprays ions onto the back side of sheet 48. This attracts the toner powder image from photoconductive surface 12 to sheet 48. After transfer, sheet 48 continues to move in the direction of arrow 60 onto a conveyor (not shown) which advances sheet 48 to fusing station E.

[0013] Fusing station E includes a fuser assembly, indicated generally by the reference numeral 62, which permanently affixes the transferred powder image to sheet 48. Fuser assembly 62 includes a heated fuser roller 64 and a back-up roller 66. Sheet 48 passes between fuser roller 64 and back-up roller 66 with the toner powder image contacting fuser roller 64. In this manner, the toner powder image is permanently affixed to sheet 48. After fusing, sheet 48 advances through chute 70 to catch tray 72 for subsequent removal from the printing machine by the operator.

[0014] After the copy sheet is separated from photoconductive surface 12 of belt 10, the residual toner particles adhering to photoconductive surface 12 are removed therefrom at cleaning station F. Cleaning station F includes a rotatably mounted fibrous brush 74 in contact with photoconductive surface 12. The particles are cleaned from photoconductive surface 12 by the rotation of brush 74 in contact therewith. Subsequent to cleaning, a discharge lamp (not shown) floods photoconductive surface 12 with light to dissipate any residual electrostatic charge remaining thereon prior to the charging thereof for the next successive imaging cycle.

[0015] FIG. 1 is a simplified sectional, elevational view of a developer apparatus made according to the present invention. The developer apparatus, generally indicated as 38, is disposed in the development portion along the process path of the imaging member 10. Spaced adjacent to, but not in contact with the imaging member 10, is a donor member in the form of donor roll 112. The surface of donor roll 112 preferably comprises phenolic plastic. The nip between the imaging member 10 and

the donor roll 112 is indicated as development zone 114. Donor roll 112 is caused to move in the direction shown by the arrow by a control motor schematically indicated as 116. The direction of motion of the donor roll 112 may be with or against the direction of the imaging member 10, depending on the design of the apparatus. Further, the donor roll 112 is itself provided with an AC voltage bias as shown by the AC source 118, relative to the imaging member conductive surface 12. This AC voltage bias between the donor roll 112 and imaging member conductive surface 12 creates the desired AC fields within the development zone 114, by which "AC jumping" development is enabled. The outer surface at least of donor roll 112 is preferably of a phenolic plastic of a predetermined resistivity. The resistivity of the surface of donor roll 112 will, as is well known, be coordinated with the frequency and amplitude of the fields to yield the most efficient possible development. The donor roll is provided with a DC voltage bias relative to the imaging member conductive surface 12 by the DC source 131. This DC voltage bias assists in controlling the amount of toner developed onto the latent image. To facilitate adjustment of the AC voltage bias frequency for AC source 118, an input 152 and controller 150 are coupled to the AC source 118. In embodiments, the AC means for establishing an AC voltage bias between the imaging member and the donor member includes AC source 118, controller 150, and input 152. Input 152 can be derived from customer controls, either digital (push-button switch operation) or analog (a variable resistor or capacitor which value is affected by the position of a rotatable shaft) or from an output port of the controller 150. Controller 150 is composed of circuitry that converts the input into frequency selection. That would be called a variable frequency circuit. The input could be derived from a measurement of the optical density of a test patch; the actual voltage to frequency conversion could be accomplished by adding or subtracting reactances (inductances or capacitances) to the resonant components of the high voltage oscillator that generates the AC voltage bias.

[0016] Illustrative parameters for the AC voltage bias and the DC voltage bias employed in the present development apparatus are as follows: The frequency of the AC voltage bias is adjustable for example from about 50 to about 3,000 Hz, preferably from about 100 to about 1,000 Hz, and more preferably from about 200 to about 900 Hz. The magnitude of the DC voltage bias may range for example from about 300 to about 1100 volts. The AC voltage bias may range for example from about 2 kV to about 4 kV. The AC voltage bias can be a sinusoidal wave or a square wave.

[0017] Turning now to the lower portion of the donor roll 112 as shown in FIG. 1, there is shown a toner mover indicated as 120. One suitable type of toner mover is described in U.S. Patent 5,128,723, which is totally incorporated herein by reference. The toner mover described in this patent fluidizes the toner therein

and causes new toner to be continuously entered into the toner mover. The force on the fluidized toner from the entering new toner causes the toner to be moved continuously through the toner mover. Another type of particle transport which may be used for toner mover 120 is disclosed in U.S. Patent 4,926,217, which is totally incorporated by reference herein. In this type of toner mover, an external source of positive or negative pressure, such as a blower, is used to move the fluidized toner through the toner mover. There is provided within the toner mover an elongated agitator which fluidizes or agitates the toner particles, although the agitator described in the patent does not provide direct longitudinal movement through the toner mover. Yet another type of toner mover, which is generally illustrated in FIG. 1, includes an auger 123 disposed within a hollow tube 125 extending along the length of the donor roll 112. This hollow tube 125 may have defined therein a plurality of openings, such as 127, on the side thereof, through which toner particles are extruded to be accessed by the donor roll 112. For present purposes, the key feature of the toner mover 120 is that it is able to convey toner particles throughout the length (going into the page in the view of FIG. 1) of the donor roll 112. In any of these above cases, there is typically provided one or more slots or openings in the side of the toner mover 120 so that extruded toner particles may be made available on the outer surface of the toner mover for transfer as needed to the donor roll 112.

[0018] Whatever the specific structure of the toner mover 120, fluidized toner particles are transported from one end of this toner mover 120 while simultaneously an electrical bias is applied between the toner mover 120 and the donor roll (by, for example, DC source 121) so as to attract toner from the toner mover to the donor roll 112. The purpose of biasing the toner mover 120 is to electrostatically load right sign toner onto the donor roll 112. Workable voltage biases of the toner mover referenced to the donor roll would be for instance -200 to -1500 volts, with the preferred range being -500 to -1000 volts (for negative toner). The non-contacting toner mover applies a relatively thick layer of toner to the donor roll 112. The layer applied by the toner mover 120 is sufficiently thick to ensure an adequate supply to smooth out any voids in the toner layer already on the donor roll 112.

[0019] It will also be apparent that, instead of using a relative electrical bias between the toner mover 120 and the donor roll 112, a magnetic-based system could be used in conjunction with magnetic toner, for example by providing a stationary assembly of permanent magnets within a rotatable sleeve forming the outer surface of donor roll 112.

[0020] Further "downstream" of the toner mover 120 along the path of rotation of donor roll 112 is a metering blade 122, which is urged against the surface of donor roll 112 by a spring means such as 124 at a predetermined pressure. Because a relatively thick layer of toner

is placed on the donor roll 112 by toner mover 120, the purpose of the metering blade 122 is to ensure that a smooth layer of this toner is presented ultimately to the development zone 114. A problem typical of single component developer systems is that excess toner on the donor roll, which is desirable from the standpoint of insuring that there is enough toner on the roll, floods the pre-nip region just upstream of the metering blade 122 and thus increases the possibility of agglomerate formation. The clogging under the metering blade 122 caused by the accumulation of toner agglomerates will cause streaks in the toner layer and eventually push the metering blade 122 away from the donor roll 112, thus causing the unwanted agglomerates to enter the development zone 114, with deleterious effects on print quality. In order to permit relatively thick layers of toner on the donor roll, while avoiding the problem of accumulating agglomerates, the present invention preferably provides a system whereby the donor roll 112 is caused by controlling motor 116 to rotate in a "reverse jog" of a half rotation or less, for the specific purpose of clearing out any accumulation of agglomerates under the metering blade 122. In one possibility, the reverse jog may occur after any given number of prints are made with the copier or printer, or after a certain number of rotations of the donor roll 112 are experienced, or after a fixed period of time in which the machine as a whole is operative; such a count of prints made or rotations of the donor roll or real time can be made by counting means, such as generally indicated as 117, associated with the controlling motor 116 and which may, for example, include a computer therein. Alternately, as shown in FIG. 1, the reverse jog may be initiated when a certain amount of pressure is sensed against the bottom of metering blade 122, which will have an effect on the spring means 124. This upward pressure may be detected by known means and can be used to "trigger" a reverse jog as necessary of the donor roll 112 by controlling motor 116. When this reverse jog occurs, as can be seen in FIG. 1, the accumulated toner under the metering blade 122 is essentially dumped back into the area around the toner mover 120.

[0021] Ideally, the toner layer on the surface of donor roll 112 just downstream of the metering blade 122 is of a uniform thickness, and also is of a uniform statistical distribution of sizes of toner particles. One problem which has been experienced with single component development systems is that areas along the length of the donor roll 112 which experience a relatively high turnover of toner particles tend to be statistically biased in favor of larger particles. With successive rotations of the donor roll 112, these high-turnover areas are statistically biased toward having large-sized toner particles, which tend to create darker than expected images on the imaging member and prints made therefrom.

[0022] To eliminate this phenomenon, known as "ghosting," there is provided downstream of the development zone 114 a rotating roll seal indicated as 126.

The rotating roll seal comprises a rotating member, as shown, but the seal is preferably not in contact at all with the surface of the donor roll 112. The rotating roll seal 126 is electrically biased, as shown by sources 127, relative to the donor roll 112 to remove a significant portion of the remaining toner on the donor roll 112 after the development step. The DC bias on the roll seal provides the electrostatic attraction of the toner to the roll seal. This step effectively "erases" any "memory" of toner particle size distribution caused by the printing of a previous image. Thus, when the toner mover 120 replenishes the toner supply on the donor roll surface for the next cycle, there will be an even statistical distribution of all toner particle sizes along the entire length of the donor roll 112.

[0023] Workable biases of the roll seal referenced to the donor roll would be 50 to 400 volts with the preferred range 150 to 250 volts. For the spaced roll seal 126, an AC voltage bias can be used to form a toner cloud to enable toner deposition onto the roll seal. The AC voltage bias can be the same as that applied to the donor roll in the development nip. To mitigate the ghosting, at least 50% of the toner should be removed from the donor roll, so complete toner removal is not necessary for a satisfactory practical system. The roll seal 126 has a scraper 132 in contact with the surface thereof, so that toner is returned to the housing sump and the roll seal is renewed for repeated cycling. The roll seal 126 is preferably a rigid metal member for the noncontact configuration. A soft conformable seal made of skinned foam can, however, be run either in contact or out of contact with the donor roll 112.

[0024] The roll seal 126, being spaced from the surface of donor roll 112, has been shown to have the additional benefit of enabling air flow management into the interior of the developer apparatus, such as by an external source of air pressure or vacuum (not shown) to bring any airborne toner back into the interior of the apparatus through the gap as shown by arrow 128. A type of air pump, which may be independent or mechanically connected to other moving parts within the machine, is generally indicated as 130. As the AC jumping method of development is particularly prone to toner clouding, i.e., the presence of a fine mist of airborne toner particles circulating generally through the machine, and eventually contacting the final print sheets, this airborne control of toner particles will have a substantial and real effect on ultimate print quality.

[0025] In embodiments of the present invention, it is intended that the combination of certain individual features together form a practical high-quality single component development system which in particular avoids the twin problems of ghosting and streaking. The high quality of the images produced with the developer system of the present invention results from the action of these individual elements in concert. The toner mover 120 applies a relatively thick layer of toner onto the surface of donor roll 112; this thick layer is metered by

metering blade 122; after the development step, a great deal of the leftover toner is removed by biased roll seal 126. In order to eliminate streaking, the donor roll 112 is, periodically or as needed, jogged in a reverse direction to clear the accumulation of toner under the metering blade 122. The roll seal 126 removes enough left over toner from the donor roll surface to erase any memory of previous images that have been developed, and in this way decreases the possibility of ghosting. Further, because the rotating roll seal 126 is preferably not in contact with the toner on the surface of donor roll 112, an air flow 128 may be introduced to draw in any airborne toner created in the jumping development step. This unique combination of elements thus facilitates a high-quality practical single component development system.

[0026] It is theorized that the invention works because the lower the AC voltage bias frequency, the longer the time that the toner, jumping back and forth between the electrostatic latent image on the imaging member and the donor roll, remains in contact with the electrostatic latent image. That time is believed to be inversely related to the frequency (or directly related to the period) of the AC voltage bias. The reason that a fixed low AC voltage bias frequency is not better is because "one size does not fit all". The higher densities resulting from lower AC voltage bias frequency are ideal for solid area development (graphics or even large size character text). For absolute zero background development (as would be ideal for small text characters only), a somewhat higher frequency is optimal. In addition, the variations in ambient temperature, altitude and humidity can affect the exact performance of the development system. So conceivably, by leaving the frequency selection up to the customer feedback or to machine internal development measurement (as in optical measurements of developed density of a reference patch), those variations also can be optimally dealt with.

[0027] The present development apparatus can be adapted for use in a broad spectrum of environments such as single component developer or two component developer; the imaging member can be a belt, a web, or a cylinder; and the imaging member can be any component that can retain an electrostatic latent image such as a photoreceptor or an electroreceptor.

[0028] All percentages and parts are by weight unless otherwise indicated.

EXAMPLE 1

[0029] The relationship between optical density and AC voltage bias frequency for the development apparatus was determined using the following procedures. A xerographic printer was used that employed a cylinder type photoreceptor having an aluminum or nickel substrate and single component magnetic toner. The printer was equipped with external AC and DC voltage biasing apparatus to assist removal of toner from the

magnetic donor roll to the photoreceptor. The AC voltage bias between the donor roll and the photoreceptor was 2.2 kV peak to peak where the AC voltage bias had a square wave form. There was a DC voltage bias of -220 volts superimposed on the AC voltage bias. As shown in FIG. 3, the AC voltage bias frequency had a profound influence on the density of the image. When the frequency of the AC voltage bias was reduced to less than about 1 kHz, the developed densities (i.e., optical density) dramatically increased to about 1.1-1.3. All other conditions were held at their nominal values while obtaining the data of FIG. 3. When other parameters were changed, such as the DC voltage bias or AC voltage bias peak to peak, the changes in density were small compared with that from changing the frequency of the AC voltage bias.

Claims

1. A development apparatus for developing with a developer including toner particles an electrostatic latent image carried on an imaging member comprising:
 - (a) a donor member positioned adjacent to the imaging member; and
 - (b) AC means for establishing an AC voltage bias between the imaging member and the donor member, wherein the frequency of the AC voltage bias is adjustable to control the density of the toner particles on the electrostatic latent image.
2. Apparatus according to claim 1, wherein the developer is a single component developer.
3. Apparatus according to claim 1, wherein the developer is a two component developer.
4. Apparatus according to any one of the claims 1 to 3, further including DC means for establishing a DC voltage bias between the imaging member and the donor member.
5. Apparatus according to any one of the claims 1 to 4, wherein the frequency of the AC voltage bias is adjustable from about 50 Hz to about 3,000 Hz.
6. Apparatus according to claim 5, wherein the frequency of the AC voltage bias is adjustable from about 100 Hz to about 1,000 Hz.
7. Apparatus according to claims 5 or 6, wherein the frequency of the AC voltage bias is adjustable from about 200 Hz to about 900 Hz.
8. Apparatus according to any one of the claims 1 to 7, further comprising a metering blade positioned adjacent the donor member.
9. Apparatus according to any one of the claims 1 to 8, wherein the AC means includes a controller.

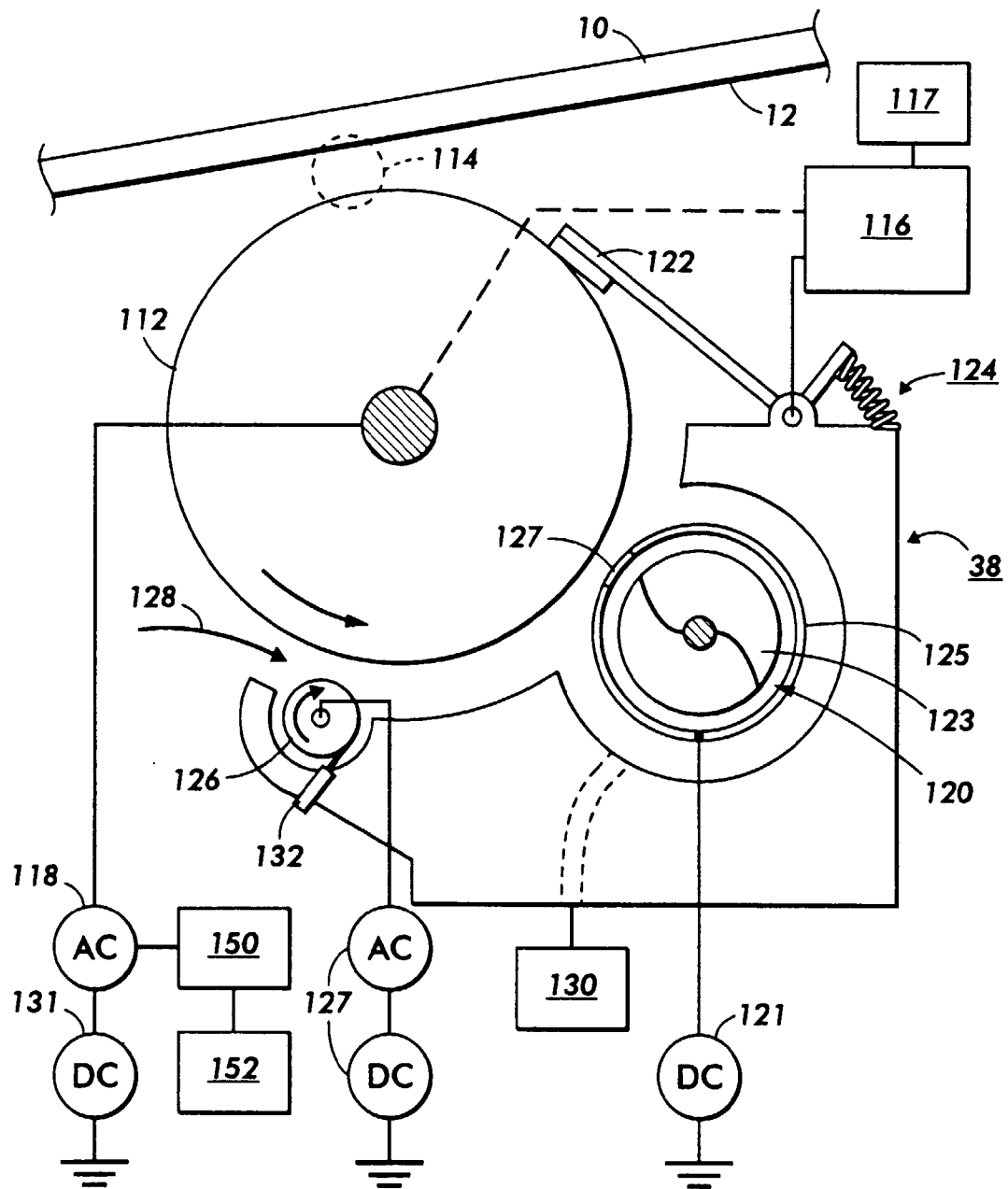


FIG. 1

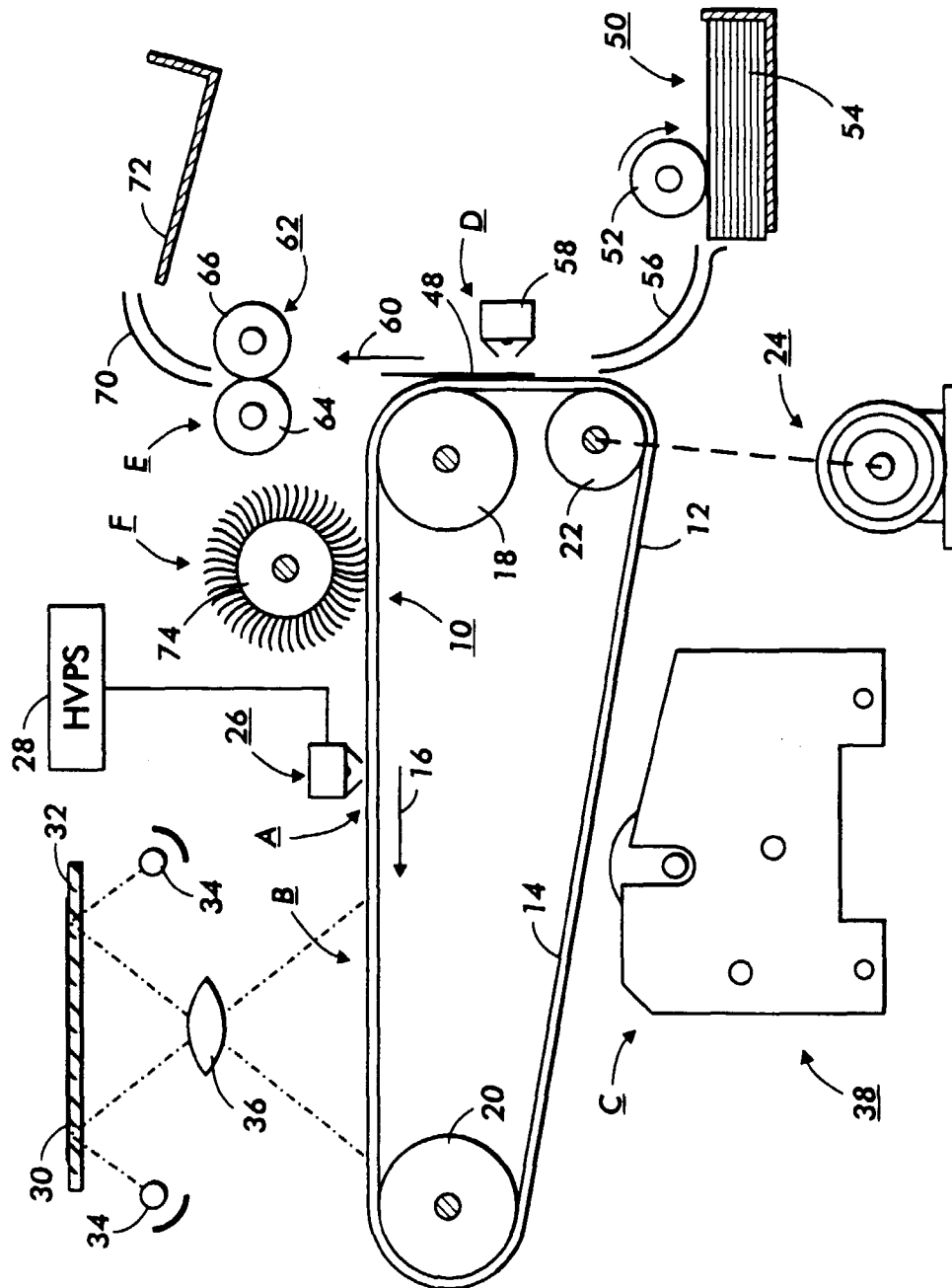


FIG. 2

FIG. 3