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European Patent Office
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Publication number:

0 414 455 A2

12

EUROPEAN PATENT APPLICATION

21 Application number: **90309067.8**

51 Int. Cl.⁵: **G03G 15/08**

22 Date of filing: **17.08.90**

30 Priority: **21.08.89 US 396153**

43 Date of publication of application:
27.02.91 Bulletin 91/09

84 Designated Contracting States:
DE FR GB

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54 Hybrid development system.

57 An apparatus in which an electrostatic latent image recorded on a photoconductive member (10) is developed with toner. A magnetic roll (46) cooperates with a donor roll (40) to define a nip therebetween. The magnetic roll advances a developer material comprising carrier and toner to the nip where a substantially constant amount of toner having a substantially constant triboelectric charge is deposited on the donor roll. A plurality of electrode wires (42) are positioned in the space between the donor roll and the photoconductive member. The electrodes are electrically biased to detach the toner from the donor roll so as to form a toner cloud in the space between the electrodes and photoconductive member. Detached toner from the toner cloud develops the latent image.

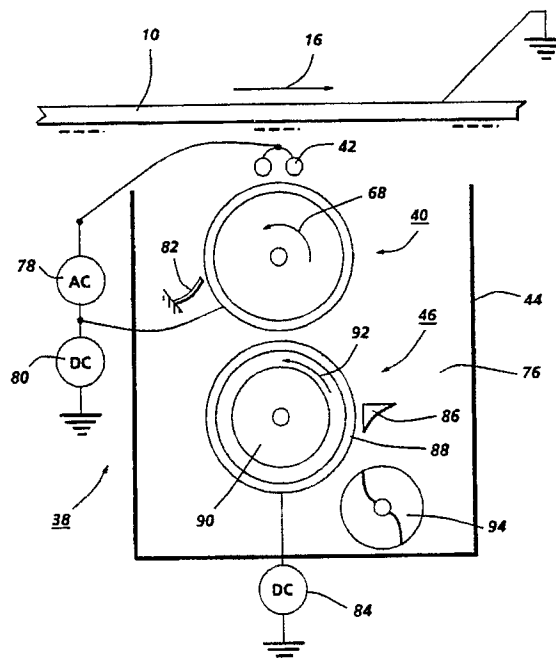


FIG. 2

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HYBRID DEVELOPMENT SYSTEM

This invention relates generally to an ionographic or electrophotographic printing machine, and more particularly concerns apparatus suitable for use in such a machine to develop a latent image recorded on a surface.

Generally, the process of electrophotographic 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.

Single component development systems use a donor roll for transporting charged toner to the development nip defined by the donor roll and photoconductive member. The toner is developed on the latent image recorded on the photoconductive member by a combination of mechanical and/or electrical forces. Scavengeless development and jumping development are two types of single component development. A scavengeless development system uses a donor roll with a plurality of electrode wires closely spaced therefrom in the development zone. An AC voltage is applied to the wires forming a toner cloud in the development zone. The electrostatic fields generated by the latent image attract toner from the toner cloud to develop the latent image. In jumping development, an AC voltage is applied to the donor roller detaching toner from the donor roll and projecting the toner toward the photoconductive member so that the electrostatic fields generated by the latent image attract the toner to develop the latent image. Single component development systems appear to offer advantages in low cost and design simplicity. However, the achievement of high reliability and easy manufacturability of the system may be present a problem. Two component development systems have been used extensively in many dif-

ferent types of printing machines. A two component development system usually employs a magnetic brush developer roller for transporting carrier having toner adhering triboelectrically thereto. The electrostatic fields generated by the latent image attract the toner from the carrier so as to develop the latent image. In high speed commercial printing machines, a two component development system may have lower operating costs than a single component development system. Clearly, two component development systems and single component development systems each have their own advantages. Accordingly, it is desirable to combine these systems to form a hybrid development system having the desirable features of each system. For example, at the 2nd International Congress on Advances in Non-impact Printing held in Washington, D. C. on November 4 - 8, 1984, sponsored by the Society for Photographic Scientists and Engineers, Toshiba described a development system using a donor roll and a magnetic roller. The donor roll and magnetic roller were electrically biased. The magnetic roller transported a two component developer material to the nip defined by the donor roll and magnetic roller. Toner is attracted to the donor roll from the magnetic roll. The donor roll is rotated synchronously with the photoconductive drum with the gap therebetween being about 0.20 millimeters. The large difference in potential between the donor roll and latent image recorded on the photoconductive drum causes the toner to jump across the gap from the donor roll to the latent image so as to develop the latent image. Various other types of development systems have been devised. The following disclosures are of interest:

US-A-3,929,098

Patentee: Liebman

Issued: December 30, 1975

US-A-4,540,645

Patentee: Honda et al.

Issued: September 10, 1985

US-A-4,565,437

Patentee: Lubinsky

Issued: January 21, 1986

US-A-4,809,034

Patentee: Murasaki et al.

Issued: February 28, 1989

The disclosures may be briefly summarized as follows:

US-A-3,929,098 describes a developer sump located below a donor roll. A developer mix of toner particles and ferromagnetic carrier granules is in the sump. A cylinder having a magnet disposed therein rotates through the developer mix and conveys the developer mix adjacent the donor roll. An

electrical field between the cylinder and donor roll loads the donor roll with toner particles.

US-A-4,540,645 discloses a development apparatus using a magnetic roll contained within a non-magnetic sleeve. A two component developer is supplied on the outer peripheral surface of the sleeve from a developer tank to form a magnetic brush. The developer material is brought into sliding contact with the photosensitive layer to develop the latent image with toner.

US-A-4,565,437 describes a development system in which a photoconductive belt is wrapped about a portion of a first developer roller and spaced from a second developer roller. Each developer roller uses a magnet disposed interiorly of a non-magnetic sleeve. The sleeves rotate to advance two component developer material into contact with the photoconductive belt to develop the latent image recorded thereon.

US-A-4,809,034 discloses a developing device having a non-magnetic developing sleeve. A magnetic roller is incorporated in the developing sleeve. A toner supply roller transports toner to the developing sleeve from the toner reservoir. The electrical potential on the supply roller is lower than that on the surface of the developing sleeve so that toner is attracted to the developing sleeve forming a brush of toner thereon. The developing sleeve conveys the brush of toner into contact with the photoconductive drum to develop the latent image recorded thereon.

In accordance with the present invention, there is provided an apparatus for developing a latent image recorded on a surface. The apparatus includes a housing defining a chamber storing a supply of developer material comprising at least carrier and toner. A donor member is spaced from the surface and adapted to transport toner to a region opposed from the surface. Means advance developer material in the chamber of the housing. The advancing means and the donor member cooperate with one another to define a region wherein a substantially constant amount of toner having a substantially constant triboelectric charge is deposited on the donor member. An electrode member is positioned in the space between the surface and the donor member. The electrode member is closely spaced from said donor member and electrically biased to detach toner from the donor member so as to form a toner cloud in the space between the electrode member and the surface. Detached toner from the toner cloud develops the latent image. The electrode member may include a plurality (e.g. a pair) of small diameter wires.

Pursuant to another aspect of the present invention, there is provided an electrophotographic printing machine of the type in which an electrostatic latent image recorded on a photoconductive

member is developed to form a visible image thereof. The machine includes a housing defining a chamber storing a supply of developer material comprising at least carrier and toner. A donor member is spaced from the photoconductive member and adapted to transport toner to a region opposed from the photoconductive member. Means are provided for advancing developer material in the chamber of the housing. The advancing means and the donor member cooperate with one another to define a region wherein a substantially constant amount of toner having a substantially constant triboelectric charge is deposited on the donor member. An electrode member is positioned in the space between the photoconductive member and the donor member. The electrode member is closely spaced from the donor member and electrically biased to detach toner from the donor member so as to form a toner cloud in the space between the electrode member and the photoconductive member. Detached toner from the toner cloud develops the electrostatic latent image recorded on the photoconductive member.

By way of example only, an embodiment of the present invention will be described with reference to the drawings, in which:

Figure 1 is a schematic elevational view of an illustrative electrophotographic printing machine embodying the present invention therein; and

Figure 2 is a schematic elevational view showing the development apparatus used in the Figure 1 printing machine.

Inasmuch as the art of electrophotographic printing is well known, the various processing stations employed in the Figure 1 printing machine will be shown hereinafter schematically and their operation described briefly with reference thereto.

Referring initially to Figure 1, there is shown an illustrative electrophotographic printing machine. The electrophotographic printing machine employs a belt to having a photoconductive surface 12 deposited on a conductive substrate 14. Preferably, photoconductive surface 12 is made from a selenium alloy. Conductive substrate 14 is made preferably from an aluminum alloy which is electrically grounded. Belt to 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 to in the direction of arrow 16. Roller 22 is coupled to motor 24 by suitable means, such as a drive belt. Belt to is maintained in tension by a pair of springs (not shown) resiliently urging tensioning roller 20 against belt to with the desired

spring force. Stripping roller 18 and tensioning roller 20 are mounted to rotate freely.

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.

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.

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 development system, indicated generally by the reference numeral 38, develops the latent image recorded on the photoconductive surface. Preferably, development system 38 includes donor roller 40 and electrode wires 42. Electrode wires 42 are electrically biased relative to donor roller 40 to detach toner therefrom so as to form a toner powder cloud in the gap between the donor roller and photoconductive surface. The latent image attracts toner particles from the toner powder cloud forming a toner powder image thereon. Donor roller 40 is mounted, at least partially, in the chamber of developer housing 44. The chamber in developer housing 44 stores a supply of developer material. The developer material is a two component developer material of at least carrier granules having toner particles adhering triboelectrically thereto. A magnetic roller disposed interiorly of the chamber of housing 44 conveys the developer material to the donor roller. The magnetic roller is electrically biased relative to the donor roller so that the toner particles are attracted from the magnetic roller to the donor roller. The development apparatus will be discussed hereinafter, in greater detail, with reference to Figure 2.

With continued reference to Figure 1, after the electrostatic latent image is developed, belt 10 advances the toner powder image to transfer sta-

tion 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.

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 60 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.

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.

It is believed that the foregoing description is sufficient for purposes of the present application to illustrate the general operation of the electrophotographic printing machine.

Referring now to Figure 2, there is shown development system 38 in greater detail. As shown thereat, development system 38 includes a housing 44 defining a chamber 76 for storing a supply of developer material therein. Donor roller 40, electrode wires 42 and magnetic roller 46 are mounted in chamber 76 of housing 44. The donor roller can be rotated in either the 'with' or 'against' direction relative to the direction of motion of belt 10. In Figure 2, donor roller 40 is shown rotating in the

direction of arrow 68, i.e. the against direction. Similarly, the magnetic roller can be rotated in either the 'with' or 'against' direction relative to the direction of motion of belt 10. In Figure 2, magnetic roller 46 is shown rotating in the direction of arrow 92 i.e. the against direction. Donor roller 40 is preferably made from anodized aluminum.

Development system 38 also has electrode wires 42 which are disposed in the space between the belt 10 and donor roller 40. A pair of electrode wires are shown extending in a direction substantially parallel to the longitudinal axis of the donor roller. The electrode wires are made from one or more thin (i.e. 50 to 100 diameter) tungsten wires which are closely spaced from donor roller 40. The distance between the wires and the donor roller is approximately 25 μ or the thickness of the toner layer on the donor roll. The wires are self-spaced from the donor roller by the thickness of the toner on the donor roller. To this end the extremities of the wires supported by the tops of end bearing blocks also support the donor roller for rotation. The wire extremities are attached so that they are slightly below a tangent to the surface, including toner layer, of the donor structure. Mounting the wires in such a manner makes them insensitive to roll runout due to their self-spacing.

As illustrated in Figure 2, an alternating electrical bias is applied to the electrode wires by an AC voltage source 78. The applied AC establishes an alternating electrostatic field between the wires and the donor roller which is effective in detaching toner from the surface of the donor roller and forming a toner cloud about the wires, the height of the cloud being such as not to be substantially in contact with the belt 10. The magnitude of the AC voltage is relatively low and is in the order of 200 to 500 volts peak at a frequency ranging from about 3 kHz to about 10 kHz. A DC bias supply 80 which applies approximately 300 volts to donor roller 40 establishes an electrostatic field between photoconductive surface 12 of belt 10 and donor roller 40 for attracting the detached toner particles from the cloud surrounding the wires to the latent image recorded on the photoconductive surface. At a spacing ranging from about 10 μ to about 40 μ between the electrode wires and donor roller, an applied voltage of 200 to 500 volts produces a relatively large electrostatic field without risk of air breakdown. The use of a dielectric coating on either the electrode wires or donor roller helps to prevent shorting of the applied AC voltage. A cleaning blade 82 strips all of the toner from donor roller 40 after development so that magnetic roller 46 meters fresh toner to a clean donor roller. Magnetic roller 46 meters a constant quantity of toner having a substantially constant charge on to donor roller 40. This insures that the donor roller

provides a constant amount of toner having a substantially constant charge in the development gap. In lieu of using a cleaning blade, the combination of donor roller spacing, i.e. spacing between the donor roller and the magnetic roller, the compressed pile height of the developer material on the magnetic roller, and the magnetic properties of the magnetic roller in conjunction with the use of a conductive, magnetic developer material achieves the deposition of a constant quantity of toner having a substantially constant charge on the donor roller. A DC bias supply 84 which applies approximately 100 volts to magnetic roller 46 establishes an electrostatic field between magnetic roller 46 and donor roller 40 so that an electrostatic field is established between the donor roller and the magnetic roller which causes toner particles to be attracted from the magnetic roller to the donor roller. Metering blade 86 is positioned closely adjacent to magnetic roller 46 to maintain the compressed pile height of the developer material on magnetic roller 46 at the desired level. Magnetic roller 46 includes a non-magnetic tubular member 88 made preferably from aluminum and having the exterior circumferential surface thereof roughened. An elongated magnet 90 is positioned interiorly of and spaced from the tubular member. The magnet is mounted stationarily. The tubular member rotates in the direction of arrow 92 to advance the developer material adhering thereto into the nip defined by donor roller 40 and magnetic roller 46. Toner particles are attracted from the carrier granules on the magnetic roller to the donor roller.

With continued reference to Figure 2, augers, indicated generally by the reference numeral 94, are located in chamber 76 of housing 44. Augers 94 are mounted rotatably in chamber 76 to mix and transport developer material. The augers have blades extending spirally outwardly from a shaft. The blades are designed to advance the developer material in the axial direction substantially parallel to the longitudinal axis of the shaft.

As successive electrostatic latent images are developed, the toner particles within the developer material are depleted. A toner dispenser (not shown) stores a supply of toner particles. The toner dispenser is in communication with chamber 76 of housing 44. As the concentration of toner particles in the developer material is decreased, fresh toner particles are furnished to the developer material in the chamber from the toner dispenser. The augers in the chamber of the housing mix the fresh toner particles with the remaining developer material so that the resultant developer material therein is substantially uniform with the concentration of toner particles being optimized. In this way, a substantially constant amount of toner particles are in the chamber of the developer housing with the toner

particles having a constant charge. The developer material in the chamber of the developer housing is magnetic and may be electrically conductive. By way of example, the carrier granules include a ferromagnetic core having a thin layer of magnetite overcoated with a non-continuous layer of resinous material. The toner particles are made from a resinous material, such as a vinyl polymer, mixed with a coloring material, such as chromogen black. The developer material comprise from about 95% to about 99% by weight of carrier and from 5% to about 1% by weight of toner. However, one skilled in the art will recognize that any suitable developer material having at least carrier granules and toner particles may be used.

In recapitulation, the development apparatus described above includes electrode wires positioned closely adjacent the exterior surface of a donor roller and being in the gap between the donor roller and the photoconductive member. A magnetic roller receives magnetic two component developer material. The magnetic roller and the donor roller are electrically biased relative to one another so that a constant quantity of toner particles having a substantially constant triboelectric charge is deposited on the donor roller. An AC voltage is applied to the electrode wires to detach toner particles from the donor roller so that a toner powder cloud is formed in the gap between the photoconductive member and the donor roller. Detached toner particles from the toner powder cloud are attracted to the latent image recorded on the photoconductive member to develop the latent image.

Claims

1. An apparatus for developing a latent image recorded on a surface (12), including:
a housing (44) for storing a supply of developer material comprising at least carrier and toner;
a donor member (40) spaced from the surface and being adapted to transport toner to a region opposed from the surface;
means (46) for advancing developer material in the housing, said advancing means and said donor member cooperating with one another to define a region wherein a substantially constant quantity of toner having a substantially constant triboelectric charge is deposited on said donor member; and
an electrode member (42) positioned in the space between the surface and said donor member, said electrode member being closely spaced from said donor member and being electrically biased to detach toner from said donor member so as to form a toner cloud in the space between said electrode member and the surface with detached

toner from the toner cloud developing the latent image.

2. An apparatus according to claim 1, further including means (84) for electrically biasing said donor member and said advancing means relative to one another so as to deposit toner on said donor member.

3. An apparatus according to claim 1 or claim 2, further including means for removing the toner from said donor member after development of the latent image.

4. An apparatus according to any one of the preceding claims, wherein the developer material in the housing is magnetic.

5. An apparatus according to claim 4, wherein said advancing means includes means for magnetically attracting developer material, from the supply in the said housing, to the exterior surface of the advancing means.

6. An apparatus according to claim 5, wherein said advancing means includes:

a non-magnetic tubular member (88) mounted rotatably so as to advance developer material to said donor member; and

an elongated magnetic member (90) disposed interiorly of said tubular member for attracting developer material to the surface of said tubular member.

7. An apparatus according to any one of the preceding claims, wherein said donor member includes a roll.

8. An apparatus according to claim 7, wherein said roll is substantially non-electrically conductive.

9. An apparatus according to any one of the preceding claims, wherein said electrode member includes a plurality of electrode wires.

10. An electrophotographic printing machine of the type in which an electrostatic latent image recorded on a photoconductive surface is developed to form a visible image thereof, the machine including an apparatus according to any one of the preceding claims for developing the image.

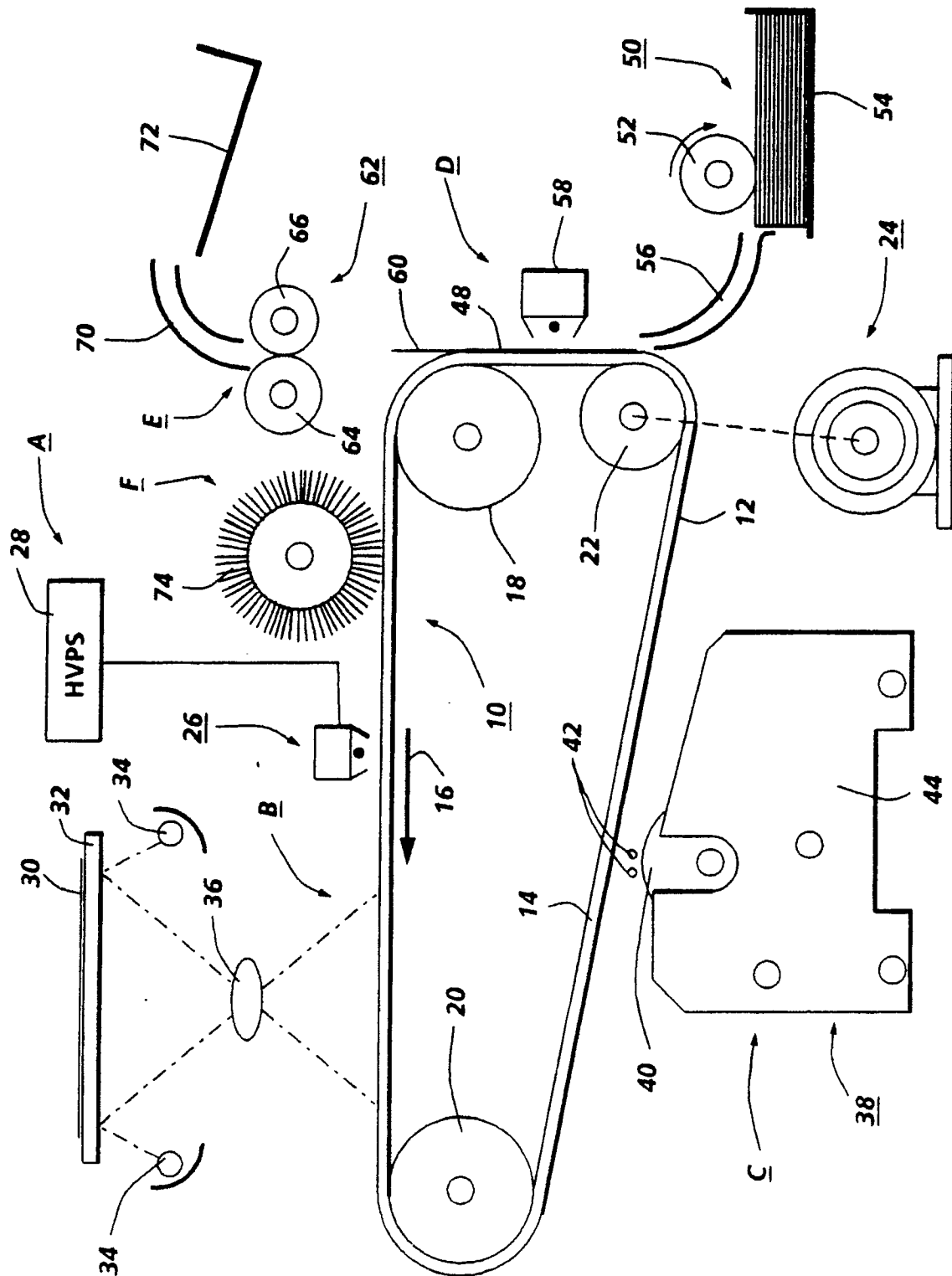


FIG. 1

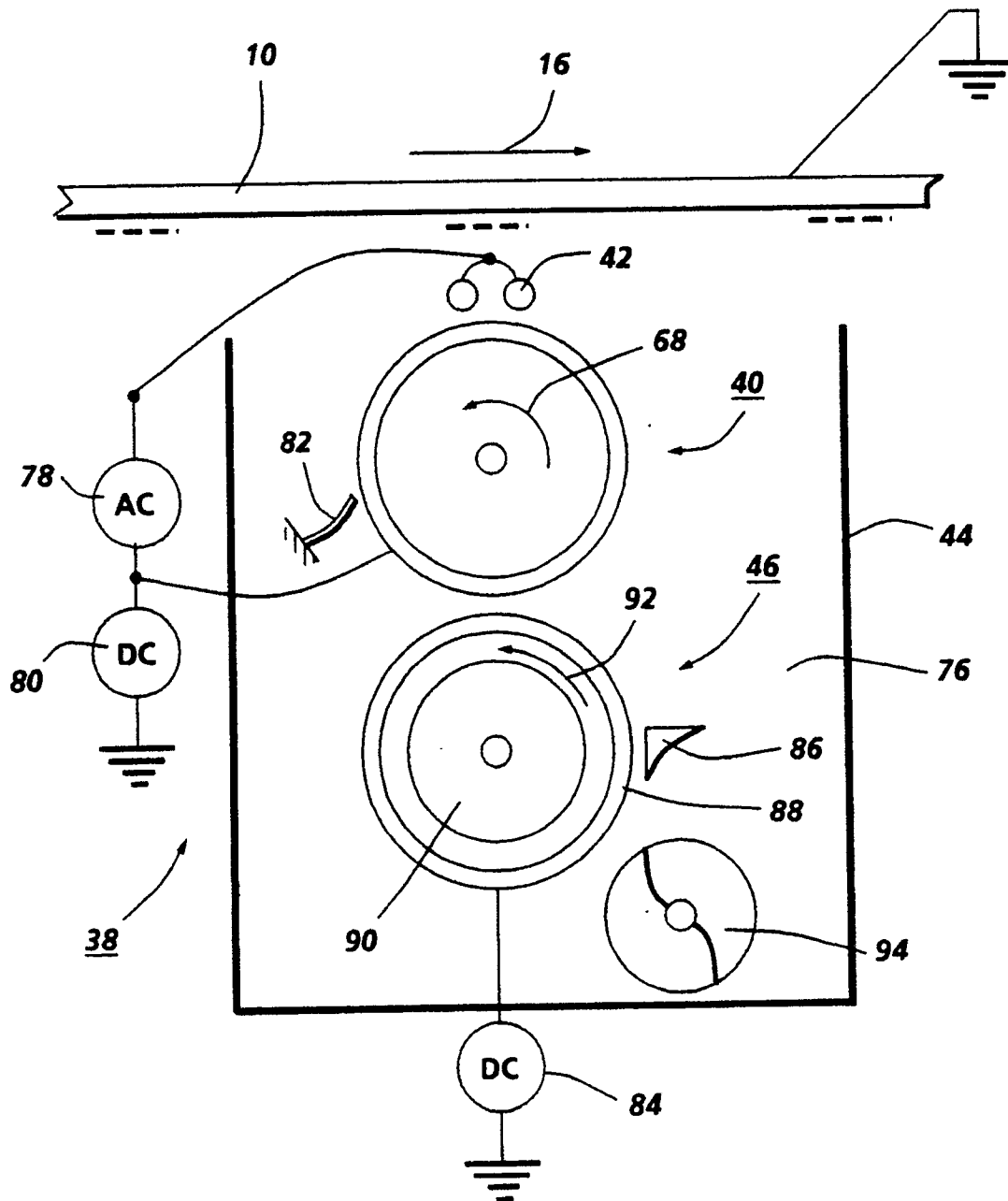


FIG. 2