(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 065 574 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
03.01.2001 Bulletin 2001/01

(51) Int Cl.^{7}: **G03G 15/34**

(21) Application number: **99202107.1**

(22) Date of filing: **29.06.1999**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(71) Applicant: **AGFA-GEVAERT N.V.**
2640 Mortsel (BE)

(72) Inventors:
- **Desie, Guido**
B-2640 Mortsel (BE)
- **Leonard, Jacques**
B-2640 Mortsel (BE)

(54) **A direct electrostatic printing device incorporating an intermediate image receiving member and a printhead structure at constant distance from this intermediate image receiving member**

(57) A DEP device, wherein the gap (g) between a conveyor (101) for charged toner particles, i.e. a CTC, and an intermediate image receiving medium (103) is kept constant and wherein also the distance (d) between this intermediate image receiving medium (103) and the printhead structure (105) are kept constant. This results in the fact that the distance (d2) between the conveyor (101) for charged toner particles and the printhead structure (105) is kept constant without having the printhead structure contacting the CTC or having spacer means inserted between the CTC and the printhead structure.

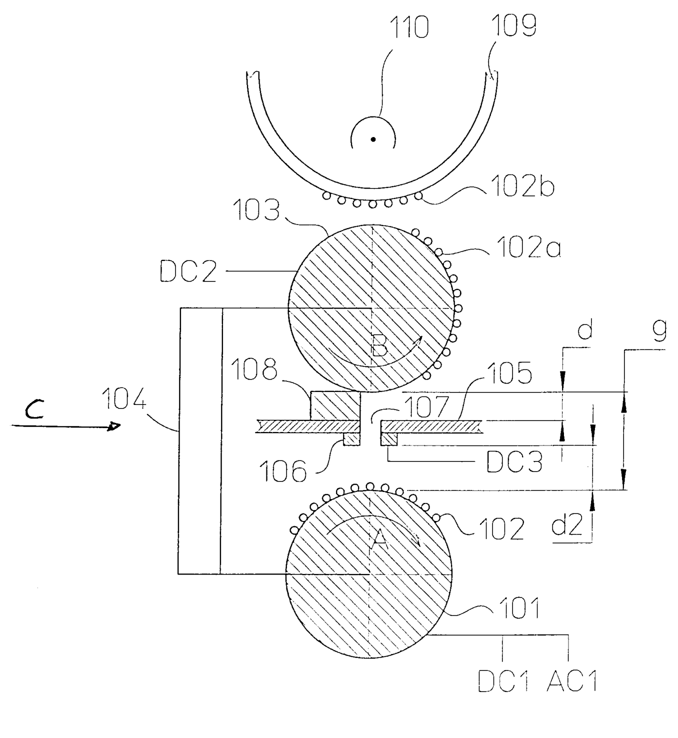

FIG 1

EP 1 065 574 A1

Description

FIELD OF THE INVENTION

[0001] This invention relates to a recording method and an apparatus for use in the process of Direct Electrostatic Printing (DEP), in which an image is created upon a receiving substrate by creating a flow of toner particles from a toner bearing surface to the image receiving substrate and image-wise modulating the flow of toner particles by means of an electronically addressable printhead structure.

BACKGROUND OF THE INVENTION

[0002] In DEP (Direct Electrostatic Printing) toner particles are deposited directly in an image-wise way on a receiving substrate, the latter not bearing any image-wise latent electrostatic image.

[0003] This makes the method different from classical electrography, in which a latent electrostatic image on a charge retentive surface is developed by a suitable material to make the latent image visible, or from electrophotography in which an additional step and additional member is introduced to create the latent electrostatic image (photoconductor and charging/exposure cycle).

[0004] A DEP device is disclosed in e.g. **US-A-3 689 935**. This document discloses an electrostatic line printer having a multi-layered particle modulator or printhead structure comprising :

- a layer of insulating material, called isolation layer ;
- a shield electrode consisting of a continuous layer of conductive material on one side of the isolation layer ;
- a plurality of control electrodes formed by a segmented layer of conductive material on the other side of the isolation layer ; and
- at least one row of apertures.

[0005] Each control electrode is formed around one aperture and is isolated from each other control electrode.

[0006] Selected electric potentials are applied to each of the control electrodes while a fixed potential is applied to the shield electrode. An overall applied propulsion field between a toner delivery means and a support for a toner receiving substrate projects charged toner particles through a row of apertures of the printhead structure. The intensity of the particle stream is modulated according to the pattern of potentials applied to the control electrodes. The modulated stream of charged particles impinges upon a receiving substrate, interposed in the modulated particle stream. The receiving substrate is transported in a direction perpendicular to the printhead structure, to provide a line-by-line scan printing. The shield electrode may face the toner delivery means and the control electrodes may face the receiving substrate. A DC-field is applied between the printhead structure and a single back electrode on the receiving substrate. This propulsion field is responsible for the attraction of toner to the receiving substrate that is placed between the printhead structure and the back electrode.

[0007] The printing device as described in the original Pressman patent is very sensitive to changes in distances from the toner application module towards said shield electrode, leading to changes in image density.

[0008] The problem of keeping this distance constant has been addressed in several ways.

[0009] In **EP-A-675 417** it is disclosed to use a magnetic brush as toner delivery means, using a two-component developer (comprising toner and carrier particles), and to provide "long hairs" on said brush so that the hairs touch the printing structure. In that case slight deviations in distance between the surface of the toner delivery means and the printhead structure do no longer present problems, while in any case the hairs of the brush, made up by carrier particles and toner particles are in contact with the printhead structure. It was found that such a device could provide very good printing results, but yielded only adequate optical density in the print when the printing speed was not too high. The problem of varying image density, that can remain in a device according to EP-A-675 417, due to a varying distance between the surface of the magnetic brush and the printhead structure can further be decreased by adapting the electrical conductivity of the carrier particles used on the magnetic brush as described in **EP-A-836 124.**

[0010] For devices working at quite high printing speeds, the use of a charged toner conveyer (a CTC), whereon the charged toner particles can be deposited by a magnetic brush or any other means known in the art, presents advantages. But the problem of uneven density (white banding) in a direction perpendicular to the printing direction has to be solved.

[0011] In **EP-A-740-224** a device is described in which the frequency of said density banding (in a direction perpendicular to the printing direction) due to the variation of the distance from the toner application module towards said printhead structure is diminished. To achieve this better evenness in printing, it is disclosed to give the toner bearing surfaces of the toner delivery means rather high rotational speeds. Since the surfaces that bear the toner particles rotate very fast and the distance between said toner bearing surfaces and the printhead structure is low, the particles are exposed to quite large shearing force. This high shearing force can give raise to agglomeration and/or deformation of the toner particles, especially when in the toner particles polymeric toner resins with low (< 60 °C) Tg are used. Thus the printing apertures can be clogged by agglomerated or deformed toner particles, leading to images with missing dots and bad image quality.

[0012] In **US-A-5 552 814** it is disclosed to use a device wherein the CTC and the printhead structure are in close contact. Such a device does indeed decrease the banding in the direction perpendicular to the printing direction, but, as with the fast moving CTC's in **EP-A-740 224** referred to above, the particles are exposed to quite large shearing force. This high shearing force can give raise to agglomeration and/or deformation of the toner particles and thus to some clogging of printing apertures. To diminish that problem it has been proposed in **US-A-5 497 175** to provide a layer with very low coefficient of friction on the face of the printhead structure contacting the CTC or, in **US-A-5 539 438**, to provide a layer with low coefficient of friction on the surface of the CTC. These layers may influence the charge or the chargeability of the toner particles and can thus, in some instances, negatively influence the printing quality.

[0013] In **US-A-5 666 147** the distance between the CTC and the printhead structure is regulated by a kind of doctor blade, but again here the particles are exposed to quite large shearing force.

[0014] In **US-A-5 448 272** an other approach to diminish the shearing forces on the toner particles in a DEP device wherein the CTC contacts the printhead structure has been disclosed. On the face of the printhead structure contacting the CTC a kind of guiding members are provided in the spacing between the printing apertures, and only these guiding members are in contact with the CTC. The guiding members are wedge shaped, with the point of the wedge against the toner feeding direction. In operation the guiding members, that keep the distance between the printhead structure and the CTC constant, "plough" through the layer of toner particles on the CTC and guide the particles to the printing apertures. A drawback of this device is the difficulty of manufacturing such a printhead structure with the desired accuracy for high resolution printers (50 dpi (dot per inch) or 20 dots/cm) or higher. A high resolution printer necessitates a printhead structure with small apertures and small spacing between the printing apertures, necessitating a very accurate positioning of the guiding members.

[0015] In **JP-A-08/300715** a printhead structure with "guiding means" is disclosed, wherein the guiding means are placed before the printing apertures and form an angle with the direction of movement of the toner delivery means. Again at least one guiding means per printing aperture is provided. Thus also in this device a very accurate positioning of the guiding members is required, which complicates the manufacture of the printhead structure.

[0016] In **EP-A-816 944** a DEP device is disclosed wherein the printhead structure is kept at a constant distance from a CTC by spacing means extending in the print direction. In this way the toner particles are not subjected to excessive shear and the printhead structure is relatively simple to manufacture.

[0017] In **US-A-5 495 273** a DEP device is shown wherein the distances between the CTC and the printhead structure and the back electrode are kept constant. The printhead structure is in contact with the CTC and between the back electrode and the printhead structure spacers are mounted for defining a constant gap between the printhead structure and the back electrode. In this gap the image receiving member is moved. This design of a DEP device does indeed overcome all problems with possibly varying distances between those elements of the device that are used to create the image, but since the printhead structure is in contact with the CTC, the toner particles are exposed to quite large shearing forces. This high shearing force can give raise to agglomeration and/or deformation of the toner particles and thus to clogging of printing apertures, furthermore the shearing contact between the printhead structure and the toner particles can change the tribo-electric charge on the particles, so that the charge of the toner particles is not constant over the printing time.

[0018] It is thus still desired to have DEP printing devices wherein the distance between the toner delivery mean, the printhead structure and the back electrode is kept constant, and wherein the toner particles are not subjected to excessive shear and that is relatively simple to manufacture.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] Fig. 1 shows a schematic illustration of a DEP device of this invention.

[0020] Fig. 2 shows schematically a possible implementation of a DEP device of this invention.

[0021] Fig. 3 shows schematically an other possible implementation of a DEP device of this invention.

DETAILED DESCRIPTION OF THE INVENTION

[0022] It was now found that by incorporating an intermediate image receiving member in a DEP device, the distances between those parts of the device that are most important for having a constant high printing quality could be kept constant without applying shearing forces on the toner particles.

[0023] DEP device incorporating an intermediate image receiving member are well known in the art. In, e.g., **US-A-5 305 026** a device is described comprising an intermediate recording medium upon which the toner image is jetted by using a DEP-process, after which said toner image is transferred to a final receiving member by means of an electrostatic field. The toner image is then fixed on said final receiving member. This apparatus has the advantage that images can be recorded on relatively thick recording media. In, e.g., **US-A-5 353 105** an apparatus for imaging on a heated intermediate member is described. In a specific embodiment a DEP-device jets a toner image upon said intermediate member that is continuously heated so that the image can be transferred to a final receiving member in a single transfusing step. In, e.g., **US-A-5 781 217** an DEP device having an intermediate image receiving member with a surface having a specified surface energy is disclosed. These disclosures remain however silent as to the possibility to keep the distances between those parts of the device that are most important for having a constant high printing quality constant without applying shearing forces on the toner particles.

[0024] It was now found that in a DEP device, wherein both the distance between a conveyor for charged toner particles, a CTC, and an intermediate image receiving medium and the distance between this intermediate image receiving medium and a printhead structure are kept constant, the distance between the conveyor for charged toner particles and the printhead structure could be kept constant without having the printhead structure contacting the CTC or having spacer means inserted between the CTC and the printhead structure. This means that in such a DEP device the distances between those parts of the device that are most important for having a constant high printing quality are kept constant without applying shearing forces on the toner particles.

[0025] In figure 1 such a device is very schematically shown, the surface of a conveyor for charged toner particles (101) carrying charged toner particles (102) on its surface and rotatably mounted for rotating in the direction of arrow A, is kept at a constant gap, g, from the surface of an intermediate image receiving member (103) rotatably mounted for rotating in the direction of arrow B, by spacing means (104). A printhead structure (105) with printing apertures (107) and control electrodes (106) associated therewith is kept at constant distance, d, from the intermediate image receiving member by a regulation blade (108). A final image receiving member (109) can be passed near the intermediate image receiving member (103), and a means (110) for transferring charged toner particles from the intermediate image receiving member onto the final image receiving member is provided behind the final image receiving member. The CTC is coupled to a DC-voltage source, so that the CTC is kept at a DC voltage DC1 (optionally the CTC is also coupled to an AC-voltage source AC1). The intermediate image receiving member is coupled to a DC-voltage source, so that it is kept at a DC voltage DC2, different from DC1. In the electric field created by the electric potential difference |DC2 -DC1|, charged toner particles (102) are attracted from the CTC to the intermediate image receiving member and a flow of toner particles is generated. The printhead structure (105) is placed in this flow and the control electrodes (106) associated with the printing apertures (107) are coupled to a DC-voltage source DC3. The output voltage of this source is image wise modulated for image wise modulating the flow through the printing apertures, by doing so an image of charged toner particles (102a) is present on the intermediate image receiving member. From this member, the toner image is transferred to the final image receiving member (109) by transfer means (here a corona wire (110)) thus forming a toner image (102b) on the final image receiving member. In figure 1, the spacing means (104) is shown to act between the central axis of the CTC and the intermediate image receiving member, but it is preferred that these spacing means is implemented for acting between the surfaces of the CTC and the intermediate image receiving member.

[0026] In figure 2, a schematic view of DEP device wherein the spacing means acts between the surfaces of the CTC and the intermediate image receiving member is shown. Basically the view in this figure, except for the spacing means (104) between the central axis of the CTC and the intermediate image receiving member, corresponds to a lateral view in the direction of arrow C of the schematic representation in figure 1.

[0027] The conveyor for charged toner particles (101), CTC, as shown in figure 2 is a cylindrical body that has flanges (104) that contact the surface of the intermediate image receiving member, thus the flanges on the CTC act as spacers for keeping the gap, g, between the surface of the CTC and the surface of the intermediate image receiving member. The printhead structure (105) is kept at a distance, d, from the intermediate image receiving member by a spacer (108). The spacer (108) and the printhead structure (105) are arranged between the flanges on the CTC. In this figure the final image receiving member is shown to be in contact with the intermediate image receiving member and is moved around a cylinder (111) in the direction of arrow C past the intermediate image receiving member. The transfer means, e.g. a corona wire can be placed in the cylinder (111) or the cylinder (111) can be coupled to a voltage source (DC4) for attracting the toner image from the intermediate image receiving member to the final one.

[0028] The spacer means (104) can instead of being flanges on the edges of the CTC be spacing bars or strips kept between the surface of the CTC and the surface of the intermediate image receiving member by resilient means. This is illustrated schematically in figure 3, which is the same view as in figure 2, except that the gap, g, is regulated with spacers (104) kept in place between the surface of the CTC and the surface of the intermediate image receiving member by coil springs (112). It is clear that the coil springs in figure 3 can be replaced by any resilient means that is suited for the job, it can be replaced by rubber bands around the axis, by endless coil spring forming a band, etc.

[0029] The spacers (104, 108) can be in sliding contact with the surface of the CTC and the surface of the intermediate image receiving member. The spacing means in a device according to this invention can have different shapes, it can be a row of dots, a row of bars, a bar, they can be rectangular, cylindrical, triangular, etc. as long as they perform the effect of keeping the distance between the printhead structure and the toner delivery means constant. The spacing means can be made of any material, although spacing means made of insulating material, e.g. polymeric material, ceramic material, are largely preferred. The insulating material can preferably be a flexible polymeric material as e.g. a polyester, a polyimide, a polyamide, a polyurethane, a polycarbonate, etc.

[0030] The face of the spacing means contacting the outer surface of the toner delivery means or of the intermediate image receiving member can be provided with a friction reducing layer for aiding the smooth gliding of the face of the spacing means over the surfaces. Such a layer can comprise a solid lubricant dispersed in a binder, e.g. disulfide of molybdenum dispersed in a binder, as disclosed in US 5,497,175, the layer can be made with a perfluorpolymer (e.g. TEFLON (trade name), the friction reducing layer can comprise matting agents protruding above the layer, which diminish the surface of the spacing means contacting the surface of the toner delivery means. Such spacing particles can advantageously comprise a lubricant (e.g. a wax) as described in EP-A 241 600 or comprise fluor-containing compounds as described in EP-A 281 848.

[0031] The spacer (108) used to keep the printhead structure and the intermediate image receiving member at a constant distance, d, can be omitted and the printhead structure, in a DEP device of this invention, can be mounted in direct contact with the surface of the intermediate image receiving member. In that case the surface of the printhead structure that is in contact with the surface of the intermediate image receiving member can be coated with a friction reducing substance, e.g. TFPE (tetrafluoropolyethylene), MoS2, BN3, PbO, graphite and/or may comprise spacing particles, e.g. polymeric or inorganic beads, incorporated in the surface of the printhead structure.

[0032] The intermediate receiving member can have any form, as long as it is possible to bring it in the neighborhood of a printhead structure and of a final image receiving substrate. An intermediate image receiving member being a roller structure or a flexible belt offers very good possibilities to build a compact and durable DEP device, according to the present invention. An intermediate image receiving member useful in this invention, can have a rigid roller structure. Said roller structure can be made of any material having enough rigidity e.g. metal, rigid plastics etc. Behind the surface of the intermediate image receiving member, facing the printhead structure, a back electrode kept at DC-voltage DC2 may be present for creating the electric field between the surface of the CTC and the intermediate image receiving member. It is preferred, according to this invention, to use an intermediate image receiving member in the form of a rigid cylinder made of metal, e.g., aluminum, copper, stainless steel, etc.. By doing so the DC-voltage source delivering DC-voltage DC2 to said intermediate member can directly be coupled to the metal roller, which then serves as back electrode. It is preferred that the surface of the intermediate image receiving member is adapted so as to have a limited surface energy, that is lower than 40 mN/m and has a limited surface roughness, that is lower than 3 μm when measured as a Ra-roughness according to ANSI/ASME B46.1-1985. Such an intermediate image receiving member has been disclosed in US-A-5 781 217 that is incorporated herein by reference.

[0033] The gap, g, between the surface of the intermediate image receiving member and the CTC is chosen so that $0 < g \leq 3000$ μm and the distance, d, between the surface of the intermediate image receiving member and the printhead structure is chosen so that $0 \leq d \leq 2000$ μm. Both distances are chosen so that the distance, d2, between the front side of the printhead structure, facing the CTC and the surface of said CTC is such that $0 < d2 \leq 300$ μm, preferably $0 < d2 \leq 200$ μm, most preferably $0 < d2 \leq 100$ μm. Since it is the aim of this invention to provide a DEP device wherein no shearing force is applied to the toner particles on the surface of the CTC when they pass under the printhead structure, it preferred in a DEP device according to this invention that the lower limit for d2 is chosen so that a layer of toner particles is present on the CTC does not contact the printhead structure, thus the lower limit of d2 equals at least two, preferably at least three times the diameter of the toner particles that are used. Generally speaking this means that $d2 \geq 20$ μm. It was also found that the printing quality, in a DEP device of this invention, could be improved by relating the distance d2 to the optional AC voltage that can be applied to the CTC. When said distance, d2, is such that $0 < d2 \leq 250$ μm, and an AC voltage, AC1, having a voltage V_{ptp}, is applied to said charged toner conveyer and $V_{ptp}/d2 \leq 0.15$.

[0034] It is further preferred that the gap, g, and the distance, d, are smaller than 1000 μm. The gap, g, is most preferably chosen as small as possible taking in account the thickness of the printhead structure and the necessity to have workable distances for machining and mounting the CTC, intermediate image receiving member and printhead. This means that the lower limit for the gap, g, lays around 200 μm. As already stated above, the surface of the printhead structure facing the intermediate image receiving member, may directly contact the intermediate image receiving member and thus the lower limit for the distance d is 0 μm. It proved very beneficial if the distance, d, is chosen so that $d \leq 500$ μm and is related to the voltage, DC2, applied to the intermediate image receiving member, in a ratio so that $DC2/d \geq 1.00$ V/μm. It was even more beneficial when said distance, d, is chosen so that $d \leq 300$ μm and $DC2/d \geq 1.00$ V/μm.

[0035] The surface of the CTC, 101, used in this invention can be loaded with charged toner particles by any means known in the art. The surface of the CTC can be loaded from a magnetic brush carrying a two-component developer having non-magnetic toner particles and magnetic carrier particles. It can be loaded from a magnetic brush carrying magnetic mono-component developer. It can be loaded from a dispenser with non-magnetic mono-component developer, while the dispensing roller of the cartridge with non-magnetic mono-component developer is kept at a given distance from the CTC, as disclosed in, e.g., DE-A-197 45 561 as well as while the dispensing roller of the cartridge with non-magnetic mono-component developer is arranged so that the layer of toner particles on the dispensing roller of the cartridge touches the surface of the CTC. The surface of the CTC can also be loaded with charged toner particles by an electrostatic spraygun. The CTC can be a magnetic brush in the case it is loaded with magnetic mono-component developer or it can be the dispensing roller in a cartridge for dispensing non-magnetic mono-component developer.

[0036] The CTC for use in this invention can have any form known in the art, it can be an endless belt, drum, a hollow cylinder, etc.. When a drum or hollow cylinder is used as CTC, the curvature of it can be adapted to the extension of the rows of printing apertures in the printhead structure as described in, E.g., EP-A-740 224.

[0037] The CTC in a device according to this invention can be equipped, as disclosed in European Patent application 98202607 filed on August 3, 1998, with cleaning means for recovering the non-used toner particles and with means for recycling those toner particles.

[0038] Any printhead structure known in the art can be used in a DEP device of this invention, it can be, e.g., a matrix of woven wires as disclosed in, a.o., EP-A-390 847. It can also comprise an insulating substrate having printing apertures made therethrough and carry control electrodes associated with those apertures and optionally a common shield electrode. Typical examples of useful printhead structures for use in DEP devices of this invention have been disclosed in, e.g., US-A-5 889 540, US-A-5 714 992, EP-A-753 413, EP-A-780 740, EP-A-812 696, etc. Apart from control electrodes and a common shield electrode, a printhead structure for use in a DEP device according to this invention can carry deflection electrodes, as disclosed in, e.g., US-A-5 774 159, WO-A-97 35725, European patent Application 98201965, filed on June 9, 1998, European patent Application 99200479, filed on February 18, 1999, European patent Application 98200478, filed on February 18, 1999, etc..

[0039] Any toner particles known in the art can be used in a DEP device according to this invention although it is preferred to use round toner particles as disclosed in, e.g., US-A-5 633 110. The toner particles used in a DEP device according to this invention are further preferably toner particles having an average volume diameter d_{v50} smaller than 10 um, more preferable d_{v50} is such that $2 \leq d_{v50} \leq 9$ µm. The particle size distribution of the toner particles is preferably a Gaussian distribution wherein the ratio of the standard deviation to the d_{v50} (i.e. the coefficient of variability, ν) is lower than 0.5, more preferably lower than 0.3. It proved to be beneficial when toner particles with an absolute average charge to mass ratio ($|q|$) to $2\ \mu C/g < |q| < 15\ \mu C/g$, preferably to $5\ \mu C/g < |q| < 8\ \mu C/g$. The absolute average charge to mass ratio was measured by mixing a mixture toner particles (4 to 8 % by weight) and carrier particles in a standard tumbling set-up for 10 min. The developer mixture was run in the development unit (magnetic brush assembly) for 5 minutes, after which the toner particles were, via a magnetic brush assembly, applied as a monolayer of charged toner particles on a charged toner conveyer (a CTC). From said CTC the toner particles were under vacuum pulled to an accurately weighed filter paper (weight was WP in g), which was shielded in a Faraday cage. The amount of charge that arrived, after 5 minutes vacuum pulling, at said filter paper was measured with a Coulomb meter in uC. The filter paper with the toner particles was weighed again, giving weight WPT in g. The charge to mass ratio was then determined as µC/(WPT - WP). Such toner particles have been described in EP-A-811 894.

[0040] Moreover it is preferred that the charge distribution, measured, as described in EP-A 675 417 is narrow, i.e. shows a distribution wherein the coefficient of variability (ν), i.e. the ratio of the standard deviation to the average value, is equal to or lower than 0.33, preferably equal to or lower than 0.25. Means for producing toner particles with a low average charge and a narrow charge distribution have been disclosed, for positively chargeable toners in EP-B 654 152 and for negatively chargeable toners in EP-B 650 609 and EP-A 650 610. These three references are incorporated herein by reference. In essence the method for producing toners with low average charge and narrow charge distribution consists in mixing in the toner resin a compound having a volume resistivity lower than the volume resistivity of the toner resin. Preferred compounds having lower volume resistivity than the toner resin are onium compounds.

EXAMPLES :

The printhead structure (106)

[0041] A printhead structure (106) was made from a polyimide film of 50 µm thickness, coated on both sides with a 5 µm thick film of copper. The printhead structure (106) had two rows of printing apertures. On the back side of the printhead structure, facing the image receiving member, a rectangular shaped control electrode (106a) was arranged around each aperture. Each of said control electrodes was connected over 2 MΩ resistors to a HV 507 (trade name) high voltage switching IC, commercially available through Supertex, USA, that was powered from a high voltage power amplifier. The printing apertures were rectangular shaped with dimensions of 360 by 120 µm. The dimension of the central part of the rectangular shaped copper control electrodes was 500 by 260 µm. The apertures were spaced so to obtain a resolution of 33 dots/cm (85 dpi). On the front side of the printhead structure, facing the charged toner conveyer roller, a common shield electrode (106b) was arranged around the aperture zone leaving a free polyimide zone of 1620 μm. Said printhead structure was manufactured as follows : First of all the control and shield electrode pattern was etched by conventional copper etching techniques. The apertures were made by a step and repeat focused excimer laser making use of the control electrode patterns as focusing aid. After excimer burning the printhead structure was cleaned by a short isotropic plasma etching cleaning. Finally a thin coating of PLASTIK70, commercially available from Kontakt Chemie, was applied over the control electrode side of said printhead structure.

The non-magnetic mono-component toner delivery means

[0042] The toner delivery means was a commercially available non-magnetic mono-component toner applicator (cartridge) comprising non magnetic mono component developer, the COLOR LASER TONER CARTRIDGE MAGENTA (M3760GIA), for the COLOR LASER WRITER (Trade names of Apple Computer, USA). The toner bearing surface is the surface of an aluminum roller (101), whereon tone particles were applied by a feeding roller. The toner particles carried a negative charge. Thus when using such a toner applicator, the CTC (conveyor for charged toner particles) is the aluminum roller in the toner cartridge.

The two-component charged toner conveyer (CTC)

[0043] The CTC was a cylinder with a sleeve made of aluminum, coated with TEFLON (trade name of Du Pont, Wilmington, USA) with a surface roughness of 2.2 μm (Ra-value) and a diameter of 30 mm. Toner particles were applied to said cylinder from a magnetic brush assembly, comprising non-magnetic toner particles and magnetic carrier particles.

The carrier particles

[0044] A macroscopic "soft" ferrite carrier consisting of a MgZn-ferrite with average particle size 50 μm, a magnetization at saturation of 36 Tm^3/kg (29 emu/g) was provided with a 1 μm thick acrylic coating. The material showed virtually no remanence.

The toner particles

[0045] The toner used for the experiment was magenta toner, commercially available for the Agfa CHROMAPRESS (trade name)Printer.

The developer

[0046] An electrostatographic developer was prepared by mixing said mixture of toner particles and colloidal silica in a 5% ratio (wt/wt) with carrier particles.

Bringing charged toner particles to the CTC

[0047] Charged toner particles were propelled to this conveyer from a stationary core / rotating sleeve type magnetic brush comprising two mixing rods and one metering roller. One rod was used to transport the developer through the unit, the other one to mix toner with developer.

[0048] The magnetic brush was constituted of the so called magnetic roller, which in this case contained inside the roller assembly a stationary magnetic core, having three magnetic poles with an open position (no magnetic poles present) to enable used developer to fall off from the magnetic roller (open position was one quarter of the perimeter and located at the position opposite to said CTC.

[0049] The sleeve of said magnetic brush had a diameter of 20 mm and was made of stainless steel roughened with a fine grain to assist in transport (Ra = 3 μm) and showed an external magnetic field strength in the zone between said magnetic brush and said CTC of 0.045 T, measured at the outer surface of the sleeve of the magnetic brush. The magnetic brush was connected to a DC power supply with a voltage of +155V.

[0050] A scraper blade was used to force developer to leave the magnetic roller. On the other side a doctoring blade was used to meter a small amount of developer onto the surface of said magnetic brush. The sleeve was rotating at a linear surface speed (LSM) four times higher than the linear surface speed (LSC) of said CTC roller, and in a direction opposite to the rotation direction of said CTC-roller.

[0051] The reference surface of said CTC was placed at a distance of 750 μm from the reference surface of said magnetic brush.

The printing engine

[0052] The printhead structure, mounted in a PVC-frame, was bent with frictional contact over the surface of the roller of the intermediate image receiving member (103), and placed at a certain distance of this intermediate image receiving member by use of a self-regulating spacer means (108) made of polyurethane elastomer and having a thickness depending on the experiment of 50 to 1000 μm. The intermediate image receiving member was connected to a DC voltage source (DC2) of + 400 to + 1500 V, depending on the experiment.

[0053] Said intermediate image receiving member was rotated at a speed of 300 cm/min and was in contact with a conductive rubber drum. In between the roller structure of the intermediate image receiving member and the conductive rubber drum, a final image receiving member was moved at said speed of 300 cm/min. Said conductive rubber roller structure was connected to a DC voltage of + 1000 V to + 2500 V, again depending on the experiment, transferring said toner image from said intermediate image receiving member to said final image receiving member.

[0054] The shield electrode was connected to a DC voltage of + 130 V. To the individual control electrodes an (image-wise) voltage DC3 between 0 V and + 280 V was applied.

PRINTING EXAMPLES

[0055] The printing results of the examples below are summarized in table 1.

COMPARATIVE EXAMPLE 1

[0056] The non-magnetic mono-component applicator, commercially available from Apple computer as described above, was placed in a rigid frame at a distance of 230 μm of the front side of said printhead structure. The outer sleeve of said applicator roller was connected to an AC voltage source applying a sinusoidally changing voltage of 1600 V_{ptp} (peak to peak) with frequency of 2.8 kHz and a DC offset voltage of + 180 V. The shield electrode at said front side of said printhead was connected to a voltage source of + 130 V. To said control electrodes on the back side of said printhead structure a voltage was applied image-wise varying between 0 to + 280 V. Said back side of said printhead structure was placed at a distance of 1000 μm from a back electrode roller, which was connected to a DC voltage source of + 1250 V. A final image receiving member was traveling in contact with said back electrode roller at a linear speed of 300 cm/min.

[0057] Full density areas were printed using this printer configuration in which toner applicator, printhead and back electrode were fixed rigidly in a printer frame. Thus in this example NO intermediate image receiving member and the distances between the printhead structure and the CTC is not regulated by spacer means but only by the rigidity of the frame. Due to a certain eccentricity of the applicator roller in the non-magnetic mono-component applicator, the distance between the surface of said applicator roller (CTC) and said front side of said printhead structure was not constant. As a result banding of differing image density was observed in said image printout. Measured with a MACBETH TR1224 (trade name) densitometer in reflectance mode a maximum density was measured fluctuating between 1.30 and 0.98. After 10 minutes of printing said maximum density readout peaked to 1.43.

EXAMPLE 1

[0058] The printing proceeded as in comparative example 1, except that an intermediate image receiving member was used and spacing means for keeping the conveyor for charged toner particles at a constant gap, g, from the surface of an intermediate image receiving member (103) and for keeping the printhead structure at a constant distance, d, from the intermediate image receiving member. Thus central intermediate image receiving member was present, made of aluminum with a diameter 80 mm and a surface roughness (Ra) of 0.2 μm, rotating at a linear speed of 300 cm/min, and rotating in contact with a cylinder made of a stainless steel axis and conductive rubber outer layer with a total diameter of 35 mm. Said rubber roller was pressed against said intermediate image receiving member with two spring coils exerting a force of 40 N each. In between said sandwich of cylinders the final image receiving member was pressed and transported at a linear speed of 300 cm/min.

[0059] The intermediate image receiving member was connected to a DC voltage source of + 1250 V, said rubber drum was connected to a DC voltage source of + 2500 V. Said commercially available non-magnetic mono-component toner applicator (Apple Laserwriter 1200C) was placed over 1.3 mm thick polyurethane spacer means in contact with said intermediate image receiving member. As a result the gap, g, between said charged toner conveyor and said intermediate image receiving member was kept constant to about 1300 μm, irrespective of the rotation movement or the eccentricities of both of said cylinders. Said printhead structure was kept at constant distance, d, from said intermediate image receiving member by using a 1000 μm thick polyurethane spacer located on top of said control electrodes on the back side of said printhead structure. The distance g - d was thus 300 μm. As a result the distance, d2, between said charged toner conveyor and said front side of said printhead structure, was kept at about 230 µm, irrespective of the rotation movement or eccentricities of said roller structures. The distance, d2, between said charged toner conveyor and said front side of said printhead structure, 230 µm, results from said 1300 µm spacer, said 1000 µm spacer, giving a difference g - d of 300 µm, whereon 50 µm has to be allowed from the thickness of the polyimide in the printhead structure and 2 x 5 µm has to be allowed from the thickness of the copper electrodes and 2 x 5 µm has to be allowed for the thickness of the isolation coating on the electrodes, thus reducing the distance, d2, between the CTC and the printhead structure to 230 µm. Here again, images of full density were printed and measured using a MACBETH TR1224 (trade name) densitometer. The measured image density was within the range 1.24 to 1.21. After 10 minutes of printing said measured image density increased to 1.40.

EXAMPLE 2

[0060] The printing proceeded as described in example 1, except that the distance, d, between said intermediate image receiving member and said back side of said printhead structure was changed to 1050 µm by using polyurethane spacers with a thickness lower than the thickness of the ones used in example 1. The gap, g, was kept at 1300 µm, so that the distance, d2, between said charged toner conveyer and said front side of said printhead was changed to 180 µm. The AC voltage applied to said front roller of said charged toner conveyor was set to 1300 V_{ptp} with the same + 180 V DC offset. Here again, images of full density were printed and measured using a MACBETH TR1224 (trade name) densitometer and the measured density was within the range 1.26 to 1.24. After 10 minutes of printing, said measured image density increased to 1.36.

EXAMPLE 3

[0061] The same experiment as described in example 2 was repeated , except that the polyurethane spacers were changed so that the gap, g, between said charged toner conveyor and said intermediate image receiving member was kept constant to about 500 µm and the distance, d, between said intermediate image receiving member and said back side of said printhead structure was changed to 250 µm. In such configuration, g -d = 250 µm and thus the distance, d2, between said charged toner conveyer and said front side of said printhead is 180 µm. The AC voltage applied to said front roller of said charged toner conveyor was set to 1300 V_{ptp} with the same + 180 V DC offset. The DC voltage applied to said intermediate image receiving member was set to + 400 V, and the DC voltage applied to said rubber transfer roller was set to + 1200 V. Here again, images of full density were printed and measured using a MACBETH TR1224 (trade name) densitometer and the measured density was within the range 1.24 to 1.20. After printing full image density for 10 minutes, the density was measured again and did not exceed the 1.26 level.

EXAMPLE 4

[0062] The same experiment as described in example 3 was repeated , except that as toner application module a charged toner conveyor being fed from a magnetic brush assembly using two component developer was used. The magnetic roller in said magnetic brush assembly was connected to a DC voltage of + 155 V. The distance between said magnetic brush and said charged toner conveyor transporting said charged toner particles towards said printhead structure was set to 750 µm. Said charged toner conveyer roller was connected to an AC voltage source of 1280 V_{ptp} with + 180 V DC offset at a sinusoidally changing frequency of 2.8 kHz. Said shield electrode was also connected to a voltage source of + 130 V. The charge-to-mass ratio of the toner applied to said charged toner conveyor was measured to be -17 µC/g. The DC voltage applied to said intermediate image receiving member was set to +400 V, and the DC voltage applied to said rubber transfer roller was set to 1200 V. Here again, images of full density were printed and measured using a MACBETH TR1224 (trade name) densitometer and the measured density was within the range 1.32 to 1.28. Here also, even after printing full image density for 10 minutes, said measured density values did not exceed the 1.33 level.

EXAMPLE 5

[0063] The same experiment as described in example 3 was repeated , except that the polyurethane spacers were changed so that the gap, g, between said charged toner conveyor and said intermediate image receiving member was kept constant to about 1300 µm and the distance, d, between said intermediate image receiving member and said back side of said printhead structure was changed to 1150 µm. This results in a distance, d2, between said charged toner conveyer and said front side of said printhead of 80 µm. The AC voltage applied to said front roller of said charged toner conveyor was set to 550 V_{ptp} with the same + 180 V DC offset. The DC voltage applied to said intermediate image receiving member was set to + 1400 V, and the DC voltage applied to said rubber transfer roller was set to +

2500 V. Said shield electrode was connected to a DC voltage source of + 130 V. To said control electrodes an image wise modulated voltage was applied of 0 to 175 V. Here again, images of full density were printed and measured using a MACBETH TR1224 (trade name) densitometer and the measured density was within the range 1.25 to 1.20. After printing full image density for 10 minutes, said measured density values did enhance till a level of 1.34.

EXAMPLE 6

[0064] The same experiment as described in example 5 was repeated , except that the polyurethane spacers were changed so that the gap, g, between said charged toner conveyor and said intermediate image receiving member was kept constant to about 300 µm, and the distance, d, between said intermediate image receiving member and said back side of said printhead structure was changed to 150 µm. This resulted in a distance, d2, between said charged toner conveyer and said front side of said printhead of 80 µm. The AC voltage applied to said front roller of said charged toner conveyor was set to 500 V_{ptp} with the same + 180 V DC offset. The DC voltage applied to said intermediate image receiving member was set to + 250 V, and the DC voltage applied to said rubber transfer roller was set to + 1000 V. Said shield electrode was connected to a DC voltage source of + 130 V. To said control electrodes an image wise modulated voltage was applied of 0 to + 175 V. Here again, images of full density were printed and measured using a MACBETH TR1224 (trade name) densitometer and the measured density was within the range 1.22 to 1.19. After printing full image density for 10 minutes, said measured density values did not exceed the level of 1.24.

EXAMPLE 7

[0065] The same experiment as described in example 5 was repeated , except that as toner application module a charged toner conveyor being fed from a magnetic brush assembly using two component developer, as described in example 4, was used. Here again, images of full density were printed and measured using a MACBETH TR1224 (trade name) densitometer and the measured density was within the range 1.28 to 1.26. Here also, even after printing full image density for 10 minutes, said measured density values did not exceed the 1.30 level.

EXAMPLE 8

[0066] The same experiment as described in example 6 was repeated , except that as toner application module a charged toner conveyor being fed from a magnetic brush assembly using two component developer, as described in example 4, was used. Here again, images of full density were printed and measured using a MACBETH TR1224 (trade name) densitometer and the measured density was within the range 1.25 to 1.22. Here also, even after printing full image density for 10 minutes, said measured density values did not exceed the 1.25 level.

TABLE 1

#	applicator	g (µm)	d (µm)	d2 (µm)	DC2 in V	D range	Dmax (10 sec)	Dmax (10 min)
CE1	NMMC	na+	na	230	1250*	0.32	1.30	1.43
E1	NMMC	1300	1000	230	1250	0.03	1.24	1.40
E2	NMMC	1300	1050	180	1250	0.02	1.26	1.36
E3	NMMC	500	250	180	400	0.04	1.24	1.26
E4	CTC/MB	500	250	180	400	0.04	1.32	1.33
E5	NMMC	1300	1150	80	1400	0.05	1.25	1.34
E6	NMMC	300	150	80	1400	0.03	1.22	1.24
E7	CTC/MB	1300	1150	80	1400	0.04	1.28	1.30
E8	CTC/MB	300	150	80	1400	0.03	1.25	1.25

* coupled to the final image receiving substrate by a back electrode, since no intermediate member is present.
NMMC = Non-Magnetic-Mono-Component developer
CTC/MB = is a CTC whereon charged toner particles are applied from a magnetic brush carrying two component developer
na = not applicable

[0067] It must be clear for those skilled in the art that many alternate embodiments are possible without departing from the spirit of the present invention. It is e.g. perfectly well possible to make frictional contact between the printhead structure and said intermediate image receiving member in a zone that is different of the nozzle printing zone so that in the actual nozzle printing zone said distance from said printhead structure towards said cylindrical intermediate image receiving member is larger that said diameter of said toner particles. Thus it is not necessary for this invention to use a separate elastomeric spacer means on top of the printhead structure in order to create a fixed distance towards said intermediate image receiving member.

Claims

1. A direct electrostatic printing device for printing a toner image onto a final image receiving substrate comprising :

   an intermediate image receiving member coupled to a first electric potential, DC2,
   a charged toner conveyor with a surface carrying charged toner particles, said surface being kept at a gap, g, form said intermediate image receiving member by spacer means and being maintained at a second electric potential, DC1, different from said first electric potential, for creating an electric field wherein a flow of charged toner particles is generated from said conveyor to said intermediate image receiving member
   a printhead structure with a first and a second side located in said flow of toner particles for image wise modulating said flow so that a toner image is formed on said intermediate image receiving member, said first side facing said intermediate image receiving member and being held at a distance, d, from said member by spacing means,
   means for conveying the final image receiving substrate near said intermediate image receiving member and means for transferring said toner image from said intermediate image receiving member to the final image receiving substrate.

2. A device for direct electrostatic printing according to claim 1, wherein said charged toner conveyor is a rotating cylinder and said spacer means for keeping said conveyor at a gap, g, from said intermediate image receiving member are flanges at both ends of said cylinder.

3. A device for direct electrostatic printing according to claim 1 or 2, wherein said gap, g, and said distance, d, are chosen so that said printhead structure and said surface of said CTC are kept at a distance, d2, from each other wherein $0 < d2 \leq 300$ µm.

4. A device for direct electrostatic printing according to claim 1 or 2, wherein said gap, g, and said distance, d, are chosen so that said printhead structure and said surface of said CTC are kept at a distance, d2, from each other wherein $0 < d2 \leq 100$ µm.

5. A device for direct electrostatic printing according to claim 1, wherein said first side of said printhead structure contacts directly said intermediate image receiving member.

6. A device for direct electrostatic printing according to claim 5, wherein said first side of said printhead structure contains spacing particles selected from the group of inorganic beads and polymeric beads.

7. A device for direct electrostatic printing according to any of the previous claims, wherein said distance, d, is chosen so that $d \leq 500$ µm, and said first voltage, DC2, has a value chosen so that $DC2/d \geq 1.00$ V/µm.

8. A device for direct electrostatic printing according to claim 7, wherein said distance, d, is chosen so that $d \leq 300$ µm.

9. A device for direct electrostatic printing according to any of the previous claims, wherein said distance, d2, is such that $0 < d2 \leq 250$ µm, and an AC voltage, AC1, having a voltage V_{ptp}, is applied to said charged toner conveyer and $V_{ptp}/d2 \leq 0.15$ V/µm.

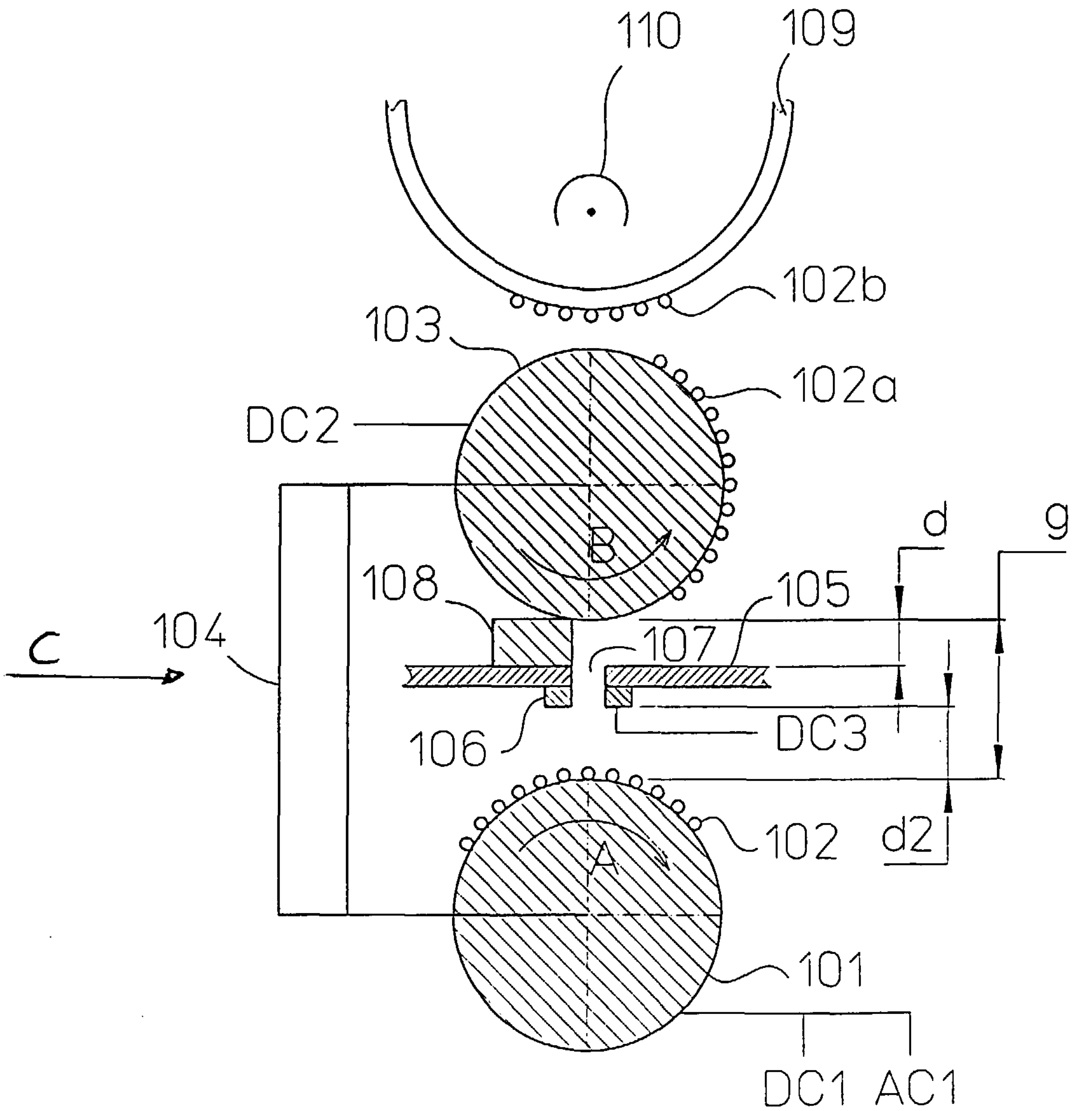
110
109
102b
103
102a
DC2
d
g
108
105
B
C
104
107
DC3
106
102
d2
A
101
DC1 AC1

FIG 1

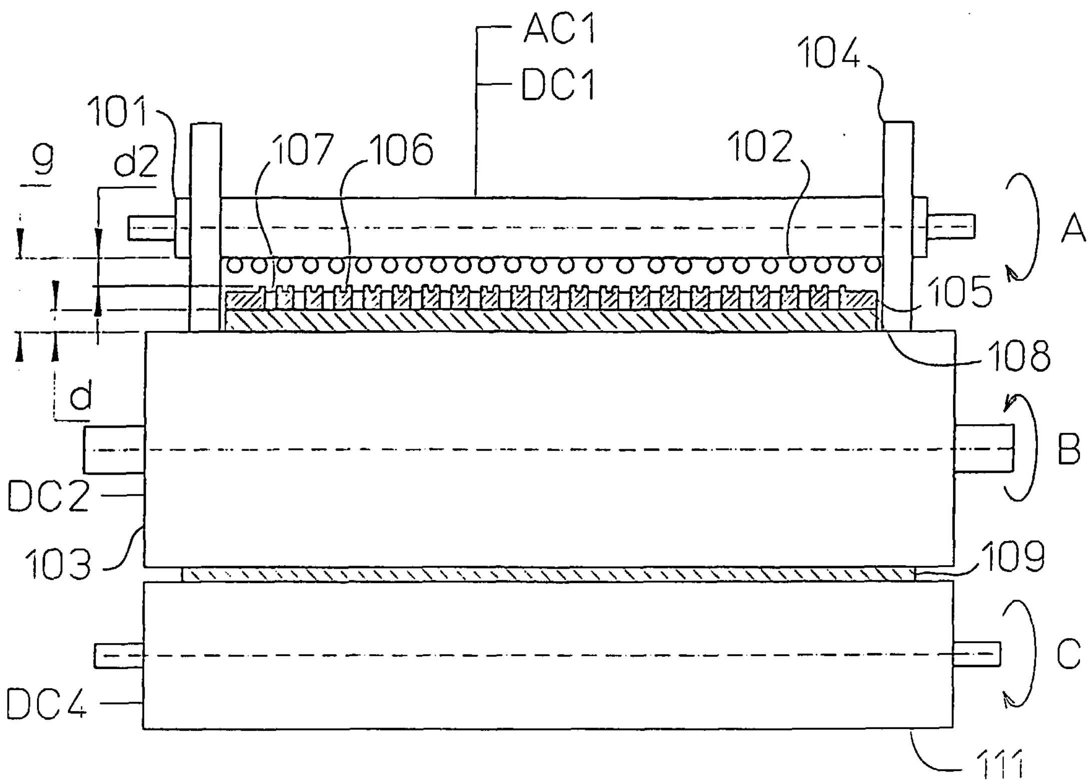

FIG 2

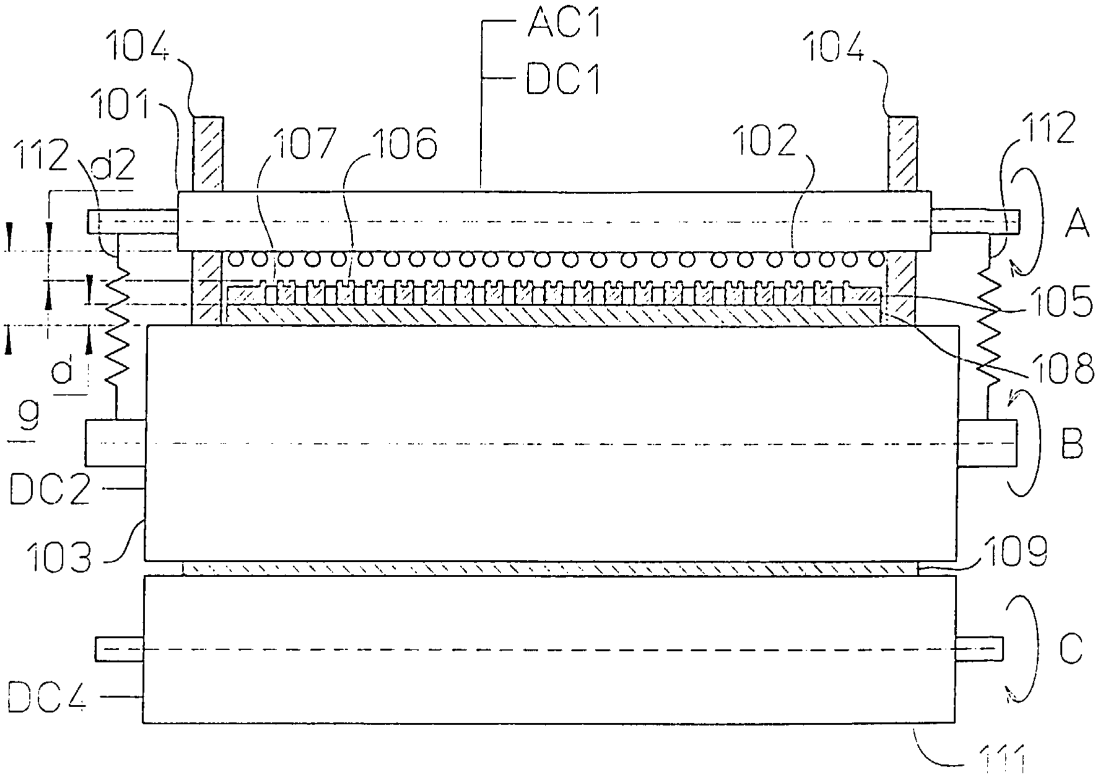
AC1
DC1
104
104
101
112
d2
107
106
102
112
A
105
108
d
g
B
DC2
103
109
C
DC4
111

FIG 3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 99 20 2107

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
D,A	US 5 305 026 A (KAZUO SANGYOJI ET AL) 19 April 1994 (1994-04-19) * column 3, line 17 - column 5, line 33; figure 1 *	1,2	G03G15/34
D,A	EP 0 816 944 A (AGFA GEVAERT NV) 7 January 1998 (1998-01-07) * page 5, line 18 - line 24; figures 1,2 *	1,2	
D,A	US 5 495 273 A (KITAMURA TETSUYA) 27 February 1996 (1996-02-27) * abstract; figures 4-9 *	1,2	
D,A	US 5 781 217 A (DESIE GUIDO) 14 July 1998 (1998-07-14) * column 4, line 20 - line 60; figures 1,2 *	1,2	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)
G03G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	24 November 1999	Cigoj, P

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 99 20 2107

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

24-11-1999

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5305026 A	19-04-1994	JP 4153677 A	27-05-1992
EP 0816944 A	07-01-1998	DE 69700075 D	04-02-1999
		DE 69700075 T	15-07-1999
		JP 10305609 A	17-11-1998
US 5495273 A	27-02-1996	JP 6255161 A	13-09-1994
US 5781217 A	14-07-1998	EP 0743572 A	20-11-1996
		DE 69508386 D	22-04-1999
		DE 69508386 T	07-10-1999
		JP 2919781 B	19-07-1999
		JP 8336999 A	24-12-1996

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82