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(54) Film-forming roller for liquid electrophotography.

(57) The invention is a relatively soft film-forming roller (FR), which may be conductive and electrically biased, in contact with the photoconductor surface downstream of the developer station from the perspective of travel of the photoconductor surface. The film-forming roller (FR) is internally heated to a surface temperature of approximately 40°C, and applied to the photoconductor surface at a pressure of approximately 1/2 lb/linear inch. The film-forming roller (FR) acts to dry the latent image by evaporating the liquid toner carrier medium, and by increasing the temperature of the toner film. The combined charge, heat and pressure of the film-forming roller (FR) will accelerate film forming of the latent image as it passes through the roller. Preferably, the film-forming roller (FR) is utilized in a liquid toner, laser printer with an intermediate, indirect image transfer system (T1,T2).

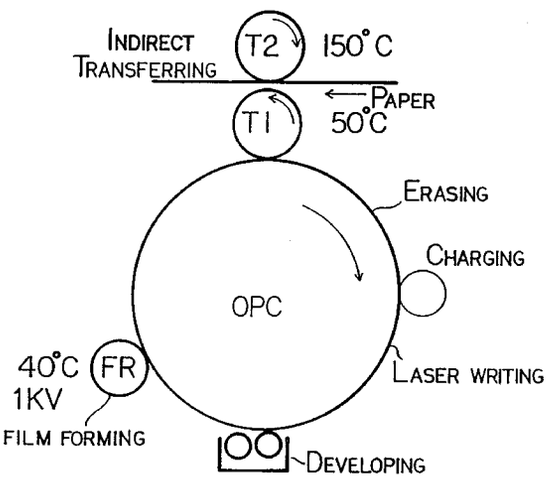

FIG. 1

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BACKGROUND OF THE INVENTION

Technical Field

This invention relates generally to image transfer technology, and more specifically to electrophotography. The invention is a soft film-forming roller which improves image integrity in a liquid toner electrophotographic apparatus and process.

Background Art

In electrophotography, a latent image is created on the surface of an insulating, photo-conducting material by selectively exposing areas of the surface to light. A difference in electrostatic charge density is created between the areas on the surface exposed and unexposed to light. For liquid toner systems, the visible image is developed by electrostatic toners containing pigment components dispersed in an insulating carrier liquid. The toners are selectively attracted to the photoconductor surface either exposed or unexposed to light, depending on the relative electrostatic charges of the photoconductor surface, development electrode and the toner. The photoconductor may be either positively or negatively charged, and the toner system similarly may contain negatively or positively charged particles. For laser printers, the preferred embodiment is that the photoconductor and toner have the same polarity, but different levels of charge.

A sheet of paper or an intermediate transfer medium is given an electrostatic charge opposite that of the toner and passed close to the photo-conductor surface, pulling the toner from the photoconductor surface onto the paper or the intermediate medium still in the pattern of the image developed from the photoconductor surface. A set of fuser rollers melts and fixes the toner in the paper, subsequent to direct transfer or indirect transfer when using an intermediate transfer medium, producing the printed image.

There is a demand in the laser printer industry for multi-colored images. Responding to this demand, designers have turned to liquid toners, with pigment components and thermoplastic components dispersed in a liquid carrier medium, usually aliphatic hydrocarbon liquids. Preferably, the liquid toners contain latex-like components, or "film-forming" components, as well as charge-accepting components so that the liquid toner may also be electrically biased. With liquid toners, it has been discovered, the basic printing colors - yellow, magenta, cyan and black, may be applied sequentially to a photoconductor surface, and from there to a sheet of paper or intermediate medium to produce a multi-colored image. Many types of film-forming toners may be used with this invention.

With liquid toners, however, there is a need to remove the liquid carrier medium from the photoconductor surface after the toner has been applied to it. This way, the photoconductor surface will not transfer the liquid carrier to the paper or to the intermediate medium in the image transfer step(s). Also, this way the liquid carrier may be recovered for recycle and reuse in the developer system, providing economy in terms of printing supplies, and eliminating environmental and health concerns from disposal of excess liquid carrier medium.

It is known from U.S. Patent No. 3,955,533 (Smith, et al.), to employ a reverse direction roller spaced about 50 microns (about 0.002 inches) from the photoconductor surface to shear off the carrier liquid and excess pigmented solids in the region beyond the outer edge of the image to leave relatively clean background areas on the photoconductor surface.

Also, from U. S. Patent No. 3,957,016 (Yamada, et al.) it is known in a negative toner system to use a positive biased reverse roller maintained at a voltage intermediate the image and background voltages to help clean the background and compact the image on the photoconductor surface.

Also, from U. S. Patent No. 4,286,039 (Landa et al.) it is known in a positive toner system to use a reverse roller followed by a negatively biased squeegee roller. The squeegee roller both compacts the latent image and removes excess carrier liquid.

U.S. Patent No. 4,325,627 (Swidler et al.) discloses an arcuate field electrode positioned between a squeegee roller and a transferring station where the freshly developed image is transferred to a carrier sheet. The field electrode is biased to a potential of a sign opposite to the charge of the toner particles.

U. S. Patents Nos. 4,974,027, 4,999,677 and 5,028,964 (Landa et al.) all disclose a positively biased reverse roller followed by a negatively biased rigidizing roller followed by a squeegee roller, separate from the rigidizing roller, for removing excess carrier liquid from the image after rigidization. The charge on these rollers may be reversed if the charge on the toner is reversed. In these patents, an intermediate transfer drum is downstream of the rigidizing roller for receiving the toner image from the photoconductor surface and transferring the image to a sheet of paper.

Therefore, there is a need in the liquid toner electrophotography industry to more effectively transfer a semi-wet image to the transfer medium. Also, there is a need to accelerate film forming of the latent image on the photoconducting material prior to the image transfer step.

Also, there is a need to dry the semi-wet image by evaporating the liquid toner carrier medium, and by increasing the temperature of the toner film. Also, there is a need, in indirect transfer electrophotographic systems, to efficiently transfer the latent image to a first transfer roller, and from there to the print-

ing medium, paper or transparency, with the aid of a second transfer roller. The present invention was made in response to these needs.

SUMMARY OF THE INVENTION

The invention is a relatively soft film-forming roller mounted to be in rotational contact with the photoconductor surface downstream of the developer station from the perspective of travel of the photoconductor surface in an electro-photographic apparatus. Depending on the type of toner used, the film-forming roller can be conductive. The film-forming roller of the preferred embodiment is conductive and is electrically biased at between about 500 - 1000(+) V when used with a positive charging photoconductor. The film-forming roller is internally heated to a surface temperature of approximately 40°C, and applied to the photoconductor surface at a pressure of approximately 1/2 lb./linear inch. The film-forming roller acts to dry the latent image by evaporating the liquid toner carrier medium, and by increasing the temperature of the toner film. The combined charge, heat and pressure of the film-forming roller will accelerate film forming of the latent image as it passes through the roller.

Preferably, the film-forming roller is utilized in a liquid toner, laser printer with an intermediate, indirect image transfer system.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic side view of one embodiment of the present invention, showing the film forming roller and the optional indirect transfer system in a liquid electro-photographic system.

DETAILED DESCRIPTION OF THE INVENTION

Referring to the Figure, there is depicted a liquid electrophotographic apparatus constructed around a photo-conductor drum in conventional manner. In this case, the photoconductor is an organic photoconductor (OPC) which rotates in the clockwise direction as indicated by the arrow.

The OPC in the preferred embodiment is of the positive charging type, and has the following components or subsystems placed around its circumference in the order of its clockwise rotation:

a. an erase lamp at approximately the two o'clock position to restore the electrostatic condition of the OPC to an initial condition;

b. a positive-charging roller or corotron at approximately the three o'clock position;

c. a laser scanner at approximately the four o'clock position; and,

d. a liquid toner developer at approximately the six o'clock position.

In addition, according to the present invention, the OPC has a special film-forming roller (FR) mounted to be in rotational contact with the OPC at approximately the eight o'clock position. Also, the OPC has an optional indirect transferring system, with first and second transfer rollers T1 and T2, respectively, at approximately the twelve o'clock position.

The operations of the erase lamp, charging device and laser exposing device are conventional, and therefore will not be described in detail here. The developer may be of conventional construction, but is preferably a liquid toner bath with an open top surface in close proximity (approximately 50-75 microns, or .002 - .003 inches) to the outer bottom of the OPC surface for applying a thin film of toner to the surface. Preferably, the toner bath is charged to an intermediate level, between the level of the charged and discharged areas of the photoconductor surface, but of the same sign.

Slightly downstream of the liquid toner bath, in the direction of movement of the OPC surface, is a positively-charged developer roller, the outer surface of which is also in close proximity (approximately 50-75 microns, or .002 - .003 inches) to the outer bottom of the OPC surface. The developer roller rotates so that its outer surface moves in the opposite direction of movement of the OPC surface. Downstream from the developer roller, and in relatively close relationship to it, is a rigidizing squeegee roller in contact with the outer bottom of the OPC surface. The rigidizing squeegee roller may also be electrically biased and rotates so that its outer surface moves in the same direction, and at the same speed, as the OPC surface. Therefore, there is no relative motion between the squeegee roller and the OPC surface. This way, the rigidizing squeegee roller removes residual toner liquid from the OPC surface, resulting in a dryer image.

The latent image is already formed on the surface of the OPC by the time it exits the liquid developer station. However, at this point the image is semi-wet, with a solids content of approximately 60 - 75%, and it has formed no film yet. Before such an image may be effectively transferred, it must first be further dried and film-formed to improve image integrity. There are two ways to accelerate the film-forming event: one, dry the image by evaporating the solvent or carrier material for the toner; and, two, increase the temperature of the toner film. A special film-forming roller (FR) according to this invention at approximately the eight O'clock position on the OPC drum accelerates the film forming in both ways.

The film-forming roller (FR) is relatively soft or of semi-rigid construction, with a durometer index of about 40 shore A. The film-forming roller is here conductive, having an electrical resistivity of about 1E6 ohm-cm, and is electrically biased at between about 500 - 1000 (+)V when used with positive-charging photoconductors and positively-charged liquid to-

ners, however, it should be noted that the conductivity and electrical biasing of the film-forming roller is related to the type of toner used and may not be necessary. The film-forming roller is internally heated to a surface temperature of approximately 40°C, and applied to the photoconductor surface at a pressure of approximately 1/2 lb/linear inch. The combined charge, heat and pressure of the film-forming roller will accelerate film forming of the latent image on the photoconductor surface as it passes through the roller.

Preferably, the film-forming roller (FR) is utilized in a liquid toner, laser printer with an intermediate, indirect image transfer system. After the latent image is fixed on the photoconductor surface by the film-forming roller, it is transferred to a first transfer roller (T1) which is in contact with the photoconductor surface downstream of the film-forming roller. The first transfer roller is of 2-ply construction, with the inner layer being pliant silicon rubber and the outer layer being fluoro silicon material. A preferred fluorosilicon material is DC93004, available from Dow Chemical Co. The fluorosilicon material has a durometer index of between about 40 - 70 and a higher adhesion force with respect to the toner film than the adhesion force between the toner and the photoconductor surface. The first transfer roller is internally heated to a surface temperature of between about 45° - 80°C, preferably about 50°C, and applied to the photoconductor surface at a pressure of approximately 10 lb/linear inch. When the toner on the photoconductor surface moves past the first transfer roller, it is picked up by the roller. Optionally, one or both of the transfer rollers T1 and T2 may also be electrically charged to further enhance the image integrity.

The first transfer roller (T1) is in contact also with a second transfer roller (T2). The second transfer roller (T2) is a hard roller of either steel or aluminum construction. It is internally heated to a surface temperature of between about 100° - 150°C, preferably about 150°C when high cycle speeds are desired, and applied to the first transfer roller surface at a pressure of 15 - 20 lb/linear inch. The printing media, paper or transparency material, is transported between the first and second transfer rollers. When the transferred image on the first transfer roller is rotated to the position where the first transfer roller contacts the second transfer roller, the image is pressed against the paper passing through the rollers. As a result of the high temperature of the second transfer roller conducting to the paper, the interface between the paper and the first transfer roller is increased to about 80°C. At this higher temperature, the adhesion between the toner and the first transfer roller is reduced, and the toner is peeled off from the first transfer roller surface and bonded on to the paper, thus completing the image transfer process. To further encourage the film-forming process, a source of heat, like a heat lamp, for example, may also be made available between the developing station and the indirect transfer system.

While there is shown and described the present preferred embodiment of the invention, it is to be distinctly understood that this invention is not limited thereto but may be variously embodied to practice within the scope of the following claims.

Claims

1. In an electrophotographic apparatus, having a member (OPC) provided with a photoconductor surface adapted to receive a latent electrostatic image and a developer system adapted to supply liquid developer to said photoconductor surface at a developer station and means for moving said photoconductor surface past said developer station, apparatus including a film-forming roller (FR), means mounting said film-forming roller (FR) for rotational movement in engagement with said photoconductor surface at a location spaced beyond said developer station, said film-forming roller (FR) being relatively soft, compared to said photoconductor surface, being heated above the temperature of said liquid developer, and being engaged under pressure onto said photoconductor surface.

2. The apparatus of Claim 1 wherein the film-forming roller is conductive.

3. The apparatus of Claim 2 wherein the film-forming roller has an electrical resistivity of about 1E6 Ohm-cm.

4. The apparatus of Claim 2 wherein the film-forming roller is electrically biased at between about 500-1000(+)V.

5. The apparatus of Claims 1, 2, 3 or 4 wherein the film-forming roller (FR) has a durometer index of about 40 Shore A.

6. The apparatus of Claims 1, 2, 3 or 4 wherein the film-forming roller (FR) is internally heated to a surface temperature of approximately 40°C.

7. The apparatus of Claims 1, 2, 3 or 4 wherein the film-forming roller (FR) is applied to the photoconductor (OPC) at a pressure of approximately 1/2 lb/linear inch.

8. The apparatus of Claims 1, 2, 3 or 4 which also includes an intermediate, indirect transfer system (T1,T2).

9. The apparatus of Claim 9 wherein the indirect transfer system (T1,T2) comprises a first transfer roller (T1) in contact with the photoconductor surface downstream of the film-forming roller (FR), which first transfer roller (T1) is also in contact with a second transfer roller (T2).

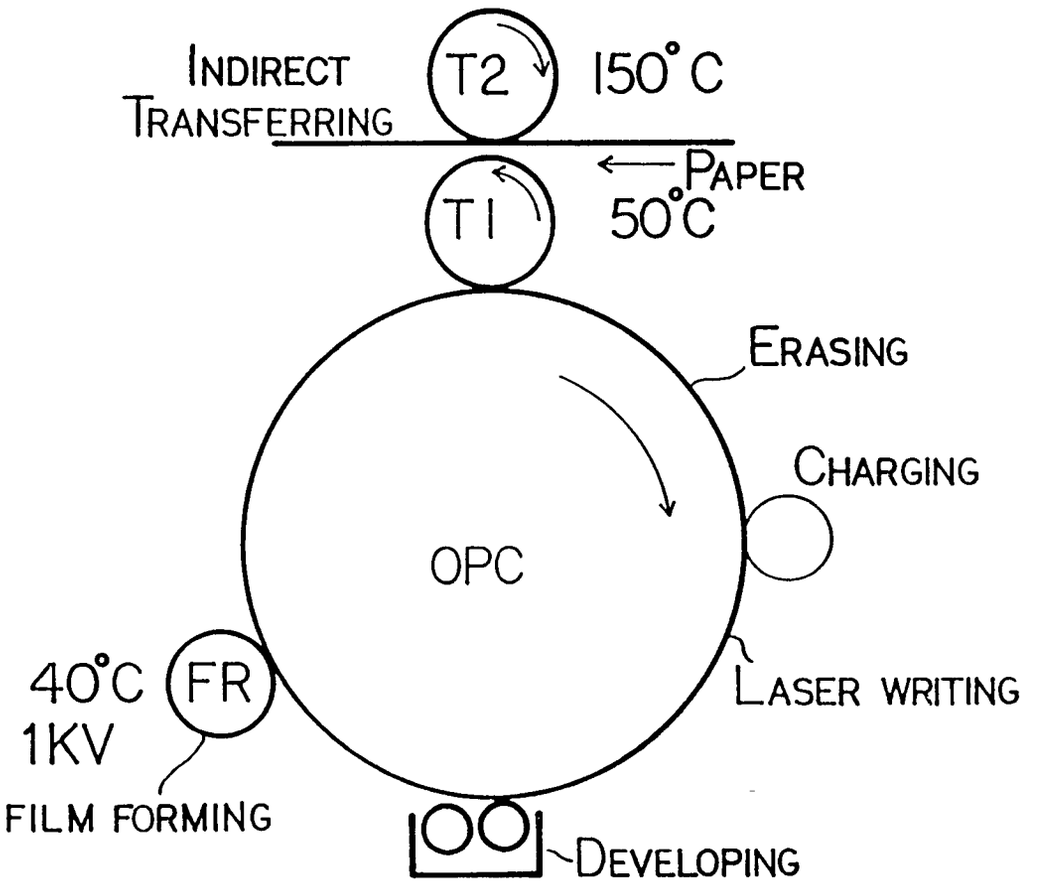
INDIRECT
TRANSFERRING
T2
150°C
PAPER
50°C
T1
ERASING
CHARGING
OPC
40°C
FR
1KV
FILM FORMING
LASER WRITING
DEVELOPING

FIG. 1

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EUROPEAN SEARCH REPORT

Application Number
EP 95 30 1249

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.6)
A	US-A-5 136 334 (CAMIS THOMAS ET AL) 4 August 1992 * column 5, line 9 - column 6, line 43; figures 1,2 *	1-7	G03G15/11 G03G15/16
D,A	US-A-4 286 039 (LANDA BENZION ET AL) 25 August 1981 * column 3, line 46 - column 4, line 47; figures 1,3 *	1-5	
A	US-A-3 689 147 (SUZUKI SHIGERU) 5 September 1972 * column 2, line 48 - column 3, line 33; figure 1 *	1	
D,A	US-A-5 028 964 (LANDA BENZION ET AL) 2 July 1991 * abstract; figure 1 *	1,2,4,8,9	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

G03G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	20 June 1995	Cigoj, P

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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