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(54) Image recording apparatus and printing method

(57) An electrostatic printer comprises a toner supply for providing charged toner particles, a particle-flow modulating electrode member (120;220), which includes an aperture portion (113;213) that has a plurality of apertures and a back electrode (130;230) disposed in opposed relation with a surface of the modulating electrode member (120;220). A control circuit applies controlled electric signals to the modulating electrode member (120;220) and the back electrode (130;230), so as to cause streams of the charged toner particles to flow through selected ones of the apertures, toward the back electrode (130;230). A pressure member (140;240), such as a roller, is disposed in proximate opposed relation with a surface of the back electrode (130;230), so that a recording medium, such as a sheet of paper, interposed between the back electrode (130;230) and the pressure member (140;240) is pressed between the pressure member (140;240) and the surface of the back electrode (130;230) at directly opposing surface locations of the recording medium. A heating circuit is coupled with the back electrode or the pressure member for fusing the charged toner particles.

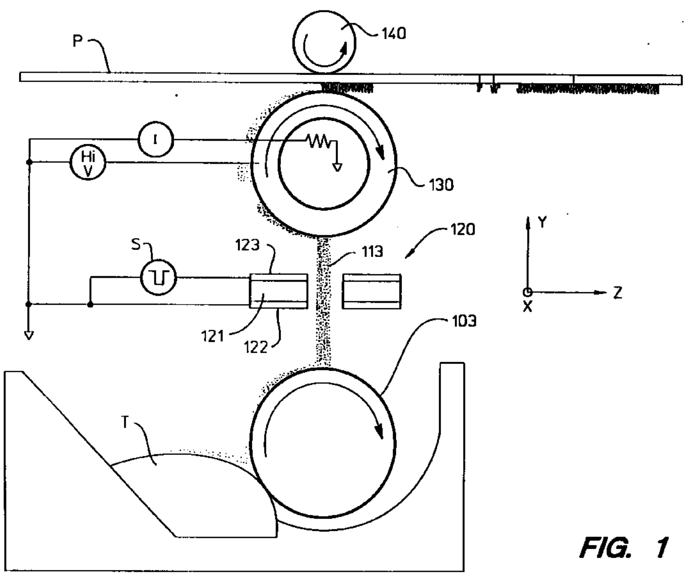

FIG. 1

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Description

The invention is generally directed to image recording apparatus and in particular to the field of printers and more specifically directed to the field of electrostatic printers.

Printers are common in both offices and homes. Printers employing an electro-photographic print process, for example laser printers, are particularly popular because they are provide high print quality at an affordable price. Unfortunately, the electro-photographic print process is relatively complex and requires a bulky apparatus. In accordance with teachings of the prior art, an electro-photographic print cycle includes the following six steps.

In a first step, a photo conductor such as a Selenium drum or an organic photo conductor drum is electrically charged. In a second step the photo conductor is selectively discharged using a scanning laser beam to produce a latent image. Laser beam scanning optics and space needed for an optical scanning path greatly contribute to both size and complexity of electrophotographic printers.

In a third step, the latent image is developed using electrically charged toner particles that are electrostatically attracted to the latent image of the photo conductor so as to produce a toner image. It should be particularly noted that imaging in the electro-photographic printer is indirect, since toner image is not formed until after the latent image is formed. Accordingly, there is no direct toner imaging practiced in electro-photographic printing.

In a fourth step, the toner image is transferred to paper. In a fifth step a pair of fusing rollers apply heat to fix the toner image to the paper. In a sixth step the photo conductor is cleaned so that the cycle can be repeated.

Although these six steps have been greatly refined in recent years, much of the complexity and bulkiness of electro-photographic printers still remains. One way of reducing complexity and bulkiness of the prior art is to simplify printing by eliminate steps. For example, by eliminating the photo conductor, steps are eliminated. However the fact that most electro-photographic printers today retain the full six step cycle attests to the difficulty of eliminating any of the steps.

Another limitation of electro-photographic printers of the prior art is that the fusing rollers are positioned remotely from the photo conductor to provide thermal isolation therefrom. Thermal isolation is employed in the prior art because the photo conductor could be damaged by heat, and because design of the photo conductor is optimized for its photo conducting function without accepting heat from any fusing rollers.

The remote positioning of fusing components disadvantageously adds to printer size and also has some potentially detrimental effects on print quality. In particular, before the toner image is fused by the fusing rollers, charged toner particles of the toner image have opportunity to repel each other, possibly increasing toner dot size and decreasing print resolution. As positioning distance of the remote positioning of fusing components is increased, chances of degrading print quality are also increased.

While the prior art provides many advantages, size and complexity difficulties still remain. Because of the difficulties associated with the photo conductor discussed previously herein, it is desirable to somehow eliminate the photo conductor, in favor of a simplified, more direct way of producing the toner image. Furthermore, because of the difficulties associated with remote location of fusing components, a more compact arrangement is desirable.

What is needed is simplified, efficient, and compact electrostatic printing using proximately located fusing components and using direct toner imaging.

The present invention provides simplified, efficient and compact electrostatic printing using proximately located fusing components and using direct toner imaging. Accordingly, the present invention is not burdened by a photo conductor, laser beam scanning optics and space requirements of an optical scanning path, which greatly contribute to both size and complexity of electrophotographic printers of the prior art. Furthermore, the present invention is not burdened by remote positioning of fusing components as in the prior art, which disadvantageously adds to printer size and affects print quality.

Briefly, and in general terms, the present invention includes a toner supply for providing charged toner particles, and a particle-flow modulating electrode member, which includes an aperture portion that has a plurality of apertures. The invention further includes a back electrode disposed in opposed relation with a surface of the modulating electrode member. A control circuit applies controlled electric signals to the modulating electrode member and the back electrode, so as to cause streams of the charged toner particles to flow through selected ones of the apertures, toward the back electrode.

A pressure member, such as a roller, is disposed in proximate opposed relation with a surface of the back electrode, so that a recording medium, such as a sheet of paper, interposed between the back electrode and the pressure member is pressed between the pressure member and the surface of the back electrode at directly opposing surface locations of the recording medium. In the preferred embodiment, a heating circuit is coupled with the back electrode for heating the back electrode to a temperature sufficiently high for fusing the charged toner particles. In an alternative embodiment, the heating circuit is coupled with the pressure member for heating the pressure member.

Such proximate arrangements of components for fusing the toner greatly contributes to desired the compactness of the present invention. Furthermore, in accordance with principles of the invention, print quality is improved by the proximate positioning of fusing components because charged toner particles have little opportunity to repel each other before being fused.

Other aspects and advantages of the present invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention

FIG. 1 shows a side view of a partial schematic diagram of a preferred embodiment of the invention.

FIG. 2 shows a side view of a partial schematic diagram of an alternative embodiment of the invention.

As shown in FIG. 1 and discussed in detail subsequently herein, the invention provides efficient and compact electrostatic printing using proximately located fusing components and using direct toner imaging. FIG. 1 shows a cross-sectional side view of a partial schematic diagram of a preferred embodiment of the invention. For illustrative purposes, a notional set of mutually perpendicular x, y, and z axes are drawn in FIG. 1, with it being understood that the x-axis extends outwardly from the page of the two dimensional side view of FIG. 1.

A toner supply provides charged toner particles. For example, as shown in FIG. 1, a mass of toner particles T is stored proximate to a rotatable toner roller 103 so that a surface of the toner roller engages toner particles as the toner roller rotates. Due to frictional contact with the toner roller, the toner particles collect a static electric charge. Some of the charged toner particles disengage from the toner roller to flow in a y-axis direction towards an aperture portion 113 of a particle-flow modulating electrode member 120.

The aperture portion 113 of the particle-flow modulating electrode member 120 has a plurality of apertures. FIG. 1 shows a cross-sectional side view of one of the apertures. The electrode member is generally a plate like member having a preferred rectangular shape, and including an insulating layer 121, a reference electrode layer 122, and an array of control electrodes 123. The reference electrode 122 is formed on a first one of two opposing major surfaces of the insulating layer 121, which is located on the side of the toner roller 103, while the array of control electrodes 123 is formed on another one of the two opposing major surfaces of the insulating layer, such that the control electrodes takes the preferred form of elongated parallel strips which extend in a z-axis direction and are spaced apart from each other in an x-axis direction. The x-axis and z-axis directions define an x-z plane parallel to the plane of the insulating layer 106.

The particle flow modulating electrode member 120 has a multiplicity of the apertures arranged in a row in a middle portion thereof as viewed from the z-axis direction. Each of the apertures is formed through the insulating layer 121, the reference electrode layer 122, and a respective one of the control electrodes 123.

As shown in FIG. 1, the invention further includes a back electrode 130 disposed in opposed relation with the major surface of the modulating electrode member and the toner roller 103. In the preferred embodiment, the back electrode comprises a rotatable conducting drum, such as an Aluminum drum, having an outer surface and further having a thin layer, for example approximately twenty five microns thick, of a toner release promoting plastic such as silicone rubber or such as polyvinylflouridine, alternatively known as Teflon, substantially covering the outer surface of the drum. For the sake of simplicity, the toner release promoting plastic layer is not shown in FIG. 1.

A control circuit applies controlled electric signals to the modulating electrode member and the back electrode, so as to cause streams of the charged particles to flow through selected ones of the apertures, in a y-axis direction toward the back electrode. For example, as shown in FIG. 1, the reference electrode layer 122 is connected to ground, while each one of the control electrodes 123 is electrically connected to a modulating signal source indicated at S in FIG. 1. The back electrode is electrically connected to a high voltage source, Hi V, so that streams of the charged toner particles that are first selected by the modulating signal source to flow through the apertures are then electrostatically attracted to the back electrode 130 to deposit the charged toner particles onto the drum surface of the back electrode as the drum rotates. Accordingly, in the preferred embodiment shown in FIG. 1, a toner image is directly applied to the drum surface of the back electrode 130 as the drum rotates. It should be understood that although FIG. 1 shows toner particles from a single toner supply deposited onto the back electrode, the invention is not strictly limited to a single toner supply, since a plurality of different colored toner supplies may alternatively be used so that a color toner image is directly applied to the back electrode.

A pressure member 140, such as a roller, is disposed in proximate opposed relation with a surface of the back electrode 130, so that a recording medium P, such as a sheet of paper, moving in a z-axis direction is interposed between the back electrode 130 and the pressure member 140 and is pressed between the pressure member 140 and the surface of the back electrode 130 at directly opposing surface locations of the recording medium. As the recording medium moves in the z-axis direction, the toner image is transferred from the drum surface of the back electrode onto a surface of the recording medium and is fused onto the recording medium by heat flowing through the back electrode.

In the preferred embodiment, a heating circuit is thermally coupled with the back electrode for heating the back electrode to an appropriate temperature sufficiently high for fusing the charged toner particles. For example, in the preferred embodiment shown in FIG. 1, the heating circuit includes a thin film resistor 150 thermally coupled with the back electrode. A thermally controlled current source, I, is electrically coupled with the thin film resistor 150 for maintaining the resistor and the back electrode at the appropriate temperature. However, it should be understood that the present invention is not strictly limited to a heating circuit using the thin film resistor, since alternative heating circuits thermally coupled with the back electrode may be used with beneficial results. For example, in some alternative embodiments, a quartz heating lamp is used in place of the thin film resistor. In other alternative embodiments, the heating circuit is coupled with the pressure member for heating the pressure member. Such proximate arrangements of components for fusing the toner greatly contributes to the desired compactness of the present invention.

FIG. 2 shows a cross-sectional side view of a partial schematic diagram of an alternative embodiment of the invention. For illustrative purposes, a notional set of mutually perpendicular x, y, and z axes are drawn in FIG. 2. In the alternative embodiment, a plurality of different toner supplies provide charged toner particles of different colors. For example, as shown in FIG. 2, a mass of yellow toner particles T_Y, a mass of magenta toner particles T_M, and a mass of cyan toner particles, T_C, are each stored proximate to a respective rotatable toner roller 203 so that the toner rollers engage toner particles as the toner rollers rotate. Due to frictional contact with the toner rollers, the toner particles collect a static electric charge. Some of the charged toner particles disengage from the toner rollers to flow in a y-axis direction towards an aperture portion 213 of a respective one of a plurality of particle-flow modulating electrode members 220.

The aperture portion 213 of each particle-flow modulating electrode member 220 has a plurality of apertures. FIG. 2 shows a cross-sectional side view of a respective one of the apertures of each electrode member 220. Each electrode member is generally a plate like member including a respective insulating layer 221, a respective reference electrode layer 222, and respective array of control electrodes 223, similar to that which is discussed in detail previously herein with respect to the preferred embodiment of FIG. 1.

As shown in FIG. 2, the invention further includes a back electrode 230 disposed in opposed relation with the major surface of each of the modulating electrode members and the toner rollers. In the alternative embodiment shown in FIG. 2, the back electrode comprises a flexible rotatable conducting belt of stainless steel, or alternatively of polyimide coated with an aluminum layer approximately three hundred to five hundred nanometers thick. The belt of the back electrode 230 is positioned proximate to the particle-flow modulating electrode members 220, but is positioned a sufficient distance away from the modulating electrode members so as to provide a space therebetween through which a recording medium P, such as a sheet of paper, is fed along a feed path as the belt rotates.

A control circuit applies controlled electric signals to the modulating electrode members and the back electrode, so as to cause streams of the charged toner particles to flow through selected ones of the apertures, in a y-axis direction toward the back electrode. For example, as shown in FIG. 2, the reference electrode layer of each member is connected to ground, while each one of the control electrodes is electrically connected to a respective modulating signal source for controlling yellow toner indicated at S_Y, for controlling magenta toner indicated at S_M, and for controlling Cyan toner indicated at S_C. The back electrode is electrically connected to a high voltage source, Hi V, so that streams of the charged toner particles that are first selected by the modulating signal sources to flow through the apertures of each modulating member are then electrostatically attracted by the back electrode so as to deposit the charged toner particles onto a surface of the recording medium as the recording medium moves along the feed path. Accordingly, in the alternative embodiment shown in FIG. 2, a color toner image is directly applied to the surface of the recording medium P as the recording medium moves along the feed path. It should be understood that although FIG. 2 shows toner particles deposited directly onto the recording medium, the invention is not to be strictly limited by this embodiment, since in other alternative embodiments the belt of the back electrode is substantially coated with a toner release promoting plastic and toner particles are first deposited onto the belt of the back electrode before being transferred to the recording medium.

In the embodiment shown in FIG. 2, a pressure member 240, such as a roller is disposed in proximate opposed relation with a surface of the back electrode, so that the recording medium moving in a z-axis direction is interposed between the back electrode and the pressure member and is pressed between the pressure member 240 and the surface of the back electrode 230 at directly opposing surface locations of the recording medium. As the recording medium moves in the z-axis direction, the toner image is fused onto the recording medium by heat flowing through the pressure member 240.

In the alternative embodiment, a heating circuit is thermally coupled with the back electrode for heating the pressure member to an appropriate temperature sufficiently high for fusing the charged toner particles. For example, in the alternative embodiment shown in FIG. 2, the heating circuit includes a thin film resistor 250 thermally coupled with the pressure member 240. A thermally controlled current source, I, is electrically coupled with the thin film resistor for maintaining the resistor and the pressure member at the appropriate temperature. In another alternative embodiment, the heating circuit is coupled with the belt of the back electrode for heating the a region of the belt of the back electrode.

The present invention provides simplified, efficient and compact electrostatic printing using proximately located fusing components and using direct toner imaging. Although specific embodiments of the invention have been described and illustrated, the invention is not to be limited to the specific forms or arrangements of parts so described and illustrated, and various modifications and changes can be made without departing from the scope of the invention. Within the scope of the appended claims, therefore, the invention may be practiced otherwise than as specifically described and illustrated.

Claims

1. An image recording apparatus, comprising:

a toner supply for providing electrostatically charged toner particles;
a particle-flow modulating electrode member (120; 220) including an aperture portion (113; 213) that has a plurality of apertures;
a back electrode (130; 230) disposed in opposed relation with a surface of said modulating electrode member (120; 220) which is remote from said toner supply;
a control circuit for applying controlled electric signals to said modulating electrode member (120; 220) and said back electrode (130; 230), for causing streams of said charged toner particles to flow through selected ones of said apertures toward said back electrode (130; 230); and
a pressure member (140; 240) disposed in proximate opposed relation with a surface of the back electrode (130; 230), so that a recording medium interposed between the back electrode (130; 230) and the pressure member (140; 240) is pressed between the pressure member (140; 240) and the surface of the back electrode (130; 230) at directly opposing surface locations of the recording medium.

2. An image recording apparatus as in claim 1 further comprising a heating circuit coupled with the back electrode for heating the back electrode to a temperature sufficiently high for fusing the charged toner particles.

3. An image recording apparatus as in claim 1 further comprising a heating circuit coupled with the pressure member for heating the pressure member to a temperature sufficiently high for fusing the charged toner particles.

4. An apparatus as in claim 1 wherein the back electrode includes a substantially drum shaped surface.

5. An apparatus as in claim 1 wherein the back electrode includes a flexible belt.

6. A printing method comprising the steps of:

providing a toner supply of electrostatically charged toner particles, a particle-flow modulating electrode member (120; 220) having a surface and apertures therein, and a back electrode disposed in opposed relation with a surface of said modulating electrode member (120; 220), which is remote from said toner supply;

applying controlled electric signals to said modulating electrode member (120; 220) and said back electrode, so as to causing streams of said charged toner particles to flow through selected ones of said apertures toward said back electrode; and

heating the back electrode to a temperature sufficiently high for fusing the charged toner particles.

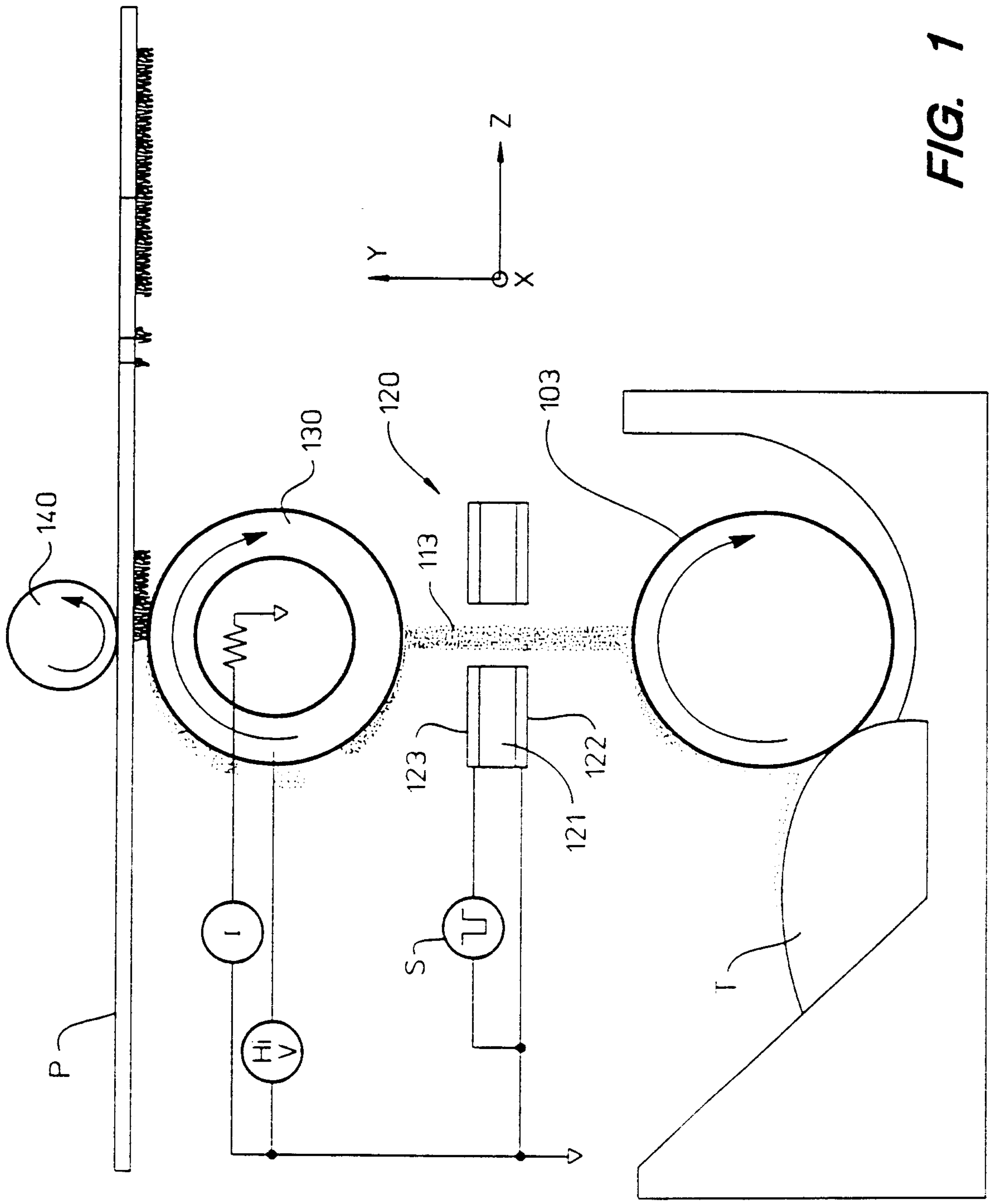

FIG. 1

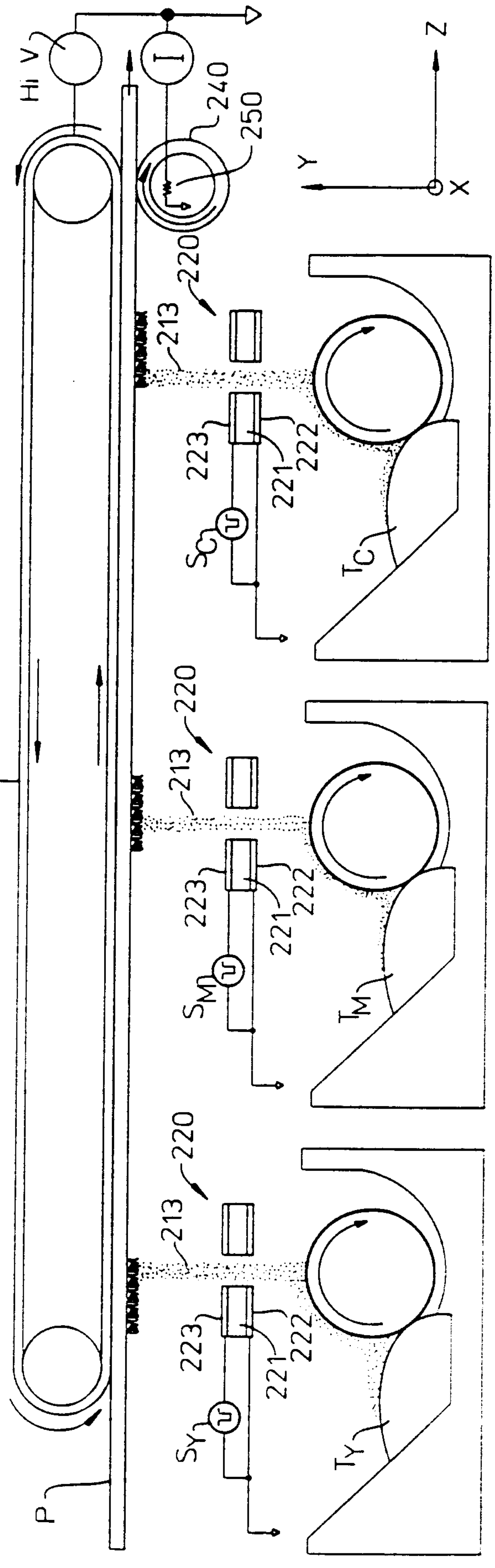

FIG. 2

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 30 3137

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)
X	US-A-5 305 026 (KAZUO SANGYOJI ET AL) 19 April 1994 * column 1, paragraph 1; figures 1,3,4 *	1,3-5	G03G15/34
A	* column 3, line 17 - line 57 * * column 4, line 60 - column 5, line 68 * * column 8, line 27 - line 52 * ---	2,6	
X	US-A-3 413 654 (STRONG ROGER K) 26 November 1968 * column 1, line 21 - line 24; figures 1,2 *	6	
A	* column 1, line 67 - column 3, line 71 * ---	1,2	
X	PATENT ABSTRACTS OF JAPAN vol. 008, no. 160 (M-312), 25 July 1984 & JP-A-59 055763 (CANON KK), 30 March 1984,	1	
A	* abstract * ---	4,6	
A	US-A-5 296 879 (KAGAYAMA SHIGERU) 22 March 1994 * claim 1; figure 1 * * column 3, line 38 - line 46 * -----	1,6	

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	8 August 1996	Greiser, N

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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