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Method for fixing a toner image.

In a method for fixing a toner image formed on a transfer member by applying heat and pressure to the toner image using a fixing roller unit, the toner has melt viscosities of 1×10^5 to 3×10^6 poises at 90°C and 1×10^4 to 1×10^5 poises at 100°C, and the fixing roller unit comprises a heater and a press roller having a mirror-like elastic surface.

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METHOD FOR FIXING A TONER IMAGE

The present invention relates to a method for fixing a toner image on a transfer material by means of a fixing roller unit, and more particularly to a method for fixing a toner image on a transfer material with the reproduction of the original density of a solid image and the original intricacy of fine, delicate lines and patterns.

In an electrophotography or electrostatic printing process, a toner image transferred onto a transfer material is fixed thereto by means of a fixing roller unit that comprises a roller and a press roller. The toner image fixed on the transfer material must be reproduced without losing the original density of a solid toner image and the original intricacy of fine, delicate line and pattern image. The density of a toner image to be transferred to a copy paper can be adjusted by controlling the amount of toner to be transferred thereto, but since the amount of toner to be transferred depends on the amount of toner developer to be carried on an image bearer, it is difficult to reproduce a solid toner image and a fine toner image with the original density and delicacy. More specifically, if the amount of a toner developer is increased so as to reproduce the original density of a solid image, the toner deposit equally increases on fine, delicate lines and patterns owing to edge effect. The excessive deposit of toner blurs fine, delicate lines and patterns. As a result, the original density of a solid toner image may be satisfactorily attained but the fine, delicate lines and patterns will be blackened or spoiled. On the contrary, if the amount of a toner developer is reduced so as to reproduce the original intricacy of fine, delicate lines and patterns, the scarcity of toner will unfavourably affect the density of a solid image.

The recent common practice to attain a full-colour image is to use cyan toner, yellow toner, magenta toner, and if necessary, black toner, which are consecutively applied so as to develop respective colour images which are then superimposed one after another on a transfer material so as to form a full-colour image. The full-colour image formation unavoidably increases the deposit of toner on the transfer material. As a result, some portion of the toner is likely to remain unfused in the fixing process, which causes unevenness on the surface of the toner image transferred to the transfer material. The uneven surface of the toner image on the transfer material spoils the transparency, spectral characteristics, colouring characteristics, and other desirable characteristics, thereby failing to produce a dense, definitive and clear image.

According to this invention, there is provided a method for fixing a toner image formed on a trans-

fer member by applying heat and pressure to a toner image using a fixing roller unit, wherein the toner has melt viscosities of 1×10^5 to 3×10^5 poises at 90°C and 1×10^4 to 1×10^5 poises at 100°C , and wherein the fixing roller unit comprises a heater and a press roller having a mirror-like elastic surface.

In a preferred embodiment, the elastic surface is provided by an elastic rubber layer coated with tetrafluoroethylene-perfluoroalkyl vinyl ether copolymer resin (PFA).

In another preferred embodiment, the toner contains a colouring agent dispersed in a resinous binder and the resinous binder has a weight-average molecular weight (M_w) of 10,000 to 80,000 and a ratio of the weight-average molecular weight (M_w) to the number-average molecular weight (M_n) of 2 to 15.

Thus, the invention described herein makes possible singly or in combination the objectives of (1) providing a method for fixing a toner image on a transfer material with the original density of a solid image and the original intricacy of fine line image, (2) providing a method for fixing a dense, definitive colour image on a transfer material thereby ensuring that the color image has an even surface, and (3) providing a method of fixing a toner image on a transfer material with an economical amount of toner.

For a better understanding of the invention and to show how the same can be carried into effect, reference will now be made, by way of example only, to the accompanying drawings as follows:

Figure 1 is a diagrammatic view exemplifying the fixing method according to the present invention;

Figure 2 is a diagrammatic view showing a prefixed toner image on a transfer material and a post-fixed toner image thereon, respectively;

Figures 3 are diagrammatic views showing a conventional method for fixing a toner image on a transfer material, wherein Figure 3(a) shows a prefixed and post-fixed toner solid image, and Figure 3(b) shows a prefixed and post-fixed toner line image;

Figure 4 is a schematic cross sectional view showing a fixing roller unit used for carrying out the method of the present invention; and

Figure 5 is a graph showing how the melting viscosities of toner change with temperatures in the examples of this invention and comparative examples.

Main features of the present invention reside in (1) the use of toners whose melt viscosities are in a relatively small range and which melt quickly, and

(2) the use of a fixing roller which has a mirror-like elastic surface capable of fixing a toner image to a transfer material with the original density and intricacy of the image.

As shown in Figure 1, a toner image 11 is transferred to a transfer material 15 and then passed between a press roller 14 and a fixing roller, more specifically, a mirror-like surface 12 on an elastic layer 13 of the fixing roller. The mirror-like surface 12 keeps contact with the toner portion of the toner image 11. Owing to the elastic layer 13, the toner image 11 is protected from becoming deformed when it is passed through the fixing roller unit. While the toner image 11 keeps its shape, the toner is heated. The toner quickly melts and is bonded to the transfer material 15. Then, the transfer material 15 is separated from the mirror-like surface 12 of the fixing roller. This prevents offset and secures an even surface of the toner image 11 so that the toner image 11 is fixed to the transfer material 15.

Referring to Figure 3(a), which shows an example in which an excessive amount of toner is supplied so as to form a dense solid image area 31. The problem in this case is that surplus toner 32 tends to remain unmelted in the solid image area on the transfer material after the toner image is fixed thereto. The same problem occurs in a fine line image area 33, that is, surplus toner also remains unmelted. In this way, the surplus toner causes a resulting image to extend more widely than the toner image initially transferred onto the transfer material. In addition, the respective surface 34 of the dense solid image area 31 and the fine line image area 33 are uneven. In contrast, Figure 3(b) shows a case in which a controlled amount of toner is supplied so as to prevent the resulting toner image from extending to a larger image than the original one. In this case, the problem is that the toner on the dense solid image area 35 is lacking, and the apparent image density decreases because of irregular reflection due to the uneven surface 36 of the toner image. In the fine line image area 37, no problem of thickened lines occurs but the surface 38 is still uneven.

Figure 2 shows a case in which an adequate amount of toner is supplied so as not to thicken the fine line image. In this case, the toner in the dense solid image area 21 is safe from disturbance and keeps its initial even surface 22, thereby preventing a reflecting light on the dense solid image area 21 from scattering. Thus, its apparent density is enhanced. In the fine line image area 23 the initial smooth surface is maintained and the toner is melted in this state, thereby preventing the fine line image from becoming thick or squashed.

Figure 4 shows an example of a fixing unit used for fixing method of the present invention.

The fixing unit 5 comprises a fixing roller 51 and a press roller 52. The fixing roller 51 comprises a core 42 of a cylindrical metal (e.g., aluminum) including a heat source 41 therein, an elastic rubber layer 43 such as silicone rubber laminated on the outer surface of the core 42, and a mirror finish fluorocarbon resin (PFA) tube 44 covering the elastic rubber layer 43, so that the fixing roller 51 has a mirror-like outer surface. A discharger roller 45 of metal is disposed in such a manner as to contact the PFA tube 44 that covers the outer surface of the elastic rubber layer 43 provided along the circumference of the fixing roller 51. The discharger roller 45 rotates together with the rotation of the fixing roller 51. The discharger roller 45 is made of aluminum, for example, and is grounded through an image forming apparatus (not shown). An oil-impregnated felt roller 46 and a blade 47 are disposed in such a manner as to contact the outer surface of the discharger roller 45, the oil-impregnated felt roller 46 rotating together with the rotation of the discharger roller 45. The blade 47 is disposed downstream of the oil-impregnated felt roller 46 in the rotating direction of the discharger roller 45. The discharger roller 45 and the oil-impregnated felt roller 46 are provided to prevent offset, coiling of a transfer material, and so on.

The press roller 52 includes a cylindrical metal body 53 covered with a PFA tube 54 so that the press roller 52 has a hard surface. The press roller 52 includes a heat source 55. An oil-impregnated felt 56 is disposed in contact with the surface of the PFA tube 54. A blade 57 is disposed downstream of the oil-impregnated felt 56 in the rotating direction of the press roller 52.

The fixing device of the present invention is not limited to the above-described embodiment. For example, the elastic rubber layer 43 can be made of fluorine-contained rubber, urethane, etc. Instead of covering the elastic rubber layer 43 with the PFA tube 44, it may be covered with a mirror finish silicone rubber or a sintered layer of polytetrafluoroethylene (PTFE) so as to make the surface of the fixing roller 51 glossy.

The toner used in the fixing method of the present invention has such a melting viscosity as to soften immediately upon the start of the melting process. For example, it consists of plastic particles having an average diameter of 5 to 20 μm having a coloring agent dispersed in a binder. In the toner melting viscosity characteristics shown in Figure 5, the melt viscosity of the toner at 90°C (η_{90}) is within the range of 1×10^5 to 3×10^6 poises, and the melt viscosity thereof at 100°C (η_{100}) is higher than 1×10^4 poises and lower than 1×10^5 poises. As compared with the known toner, the above-described toner has a low melt viscosity but at a relatively early stage the toner stops be-

coming fluid. The advantage of the above-described toner softens immediately upon the start of the melting process and become adequately fluid. If the toner becomes excessively fluid, it causes an offset and stains the roller. If a toner image is formed with such an excessively fluid toner, and is fixed by means of a known fixing unit, a fatal offset or a poor fixing may occur. Such problems can be overcome by using a fixing unit equipped with a fixing roller having an elastic and mirror-like surface that is kept in contact with the toner, no problems of offset and poor fixing will occur, and a fixed image has a smooth surface, being free from any troubles, such as thickened line images and squashed image, due to the overdose of toner.

If the above-mentioned melt viscosity at 90 °C (η_{90}) is lower than 1×10^5 poises, an offset is likely to occur at the start of melting. Conversely, if it is higher than 3×10^5 poises, the fixed toner image may not have a surface smoothness, thereby spoiling the transparency thereof, and preventing the dense reproduction of dense solid toner image. If the melt viscosity at 100 °C (η_{100}) is lower than 1×10^4 poises, a fatal offset is more likely to occur, and its durability decreases. If it is higher than 1×10^5 poises, the fixed image will have an uneven surface, thus spoiling the transparency, the coloring characteristics, and the density preservation characteristics of the image. In view of the coloring characteristics of color toner mixtures, when fixing a plurality of color toners, and the surface smoothness of the fixed toner image, it is desirable that the ratio of the melt viscosity at 100 °C (η_{100}) to that at 90 °C (η_{90}), (η_{100}/η_{90}), be maintained at least 0.5 or less preferably 0.3 or less. If the ratio is greater than 0.5, the coloring characteristics of color toner mixtures and the surface smoothness of the fixed toner image will decrease.

Of a number of measuring methods for the melt viscosity of toner, one is now set out as follows:

The toner whose melt viscosity is to be measured may be passed through a sieve of 60 mesh, and about 1.5 g of the sieved particles are charged in a mold. The flow rate of this sample is measured using a flow meter, for example, Model FT-500 manufactured by Shimadzu Corporation, under the following conditions.

Rise in temperature: 6.0 D/M (°C/minute)

Initial temperature: 70.0 DEG (°C)

Maximum temperature: 200.0 DEG (°C)

Interval: 3.0 DEG

Preheating time: 300.0 SEC

Load: 20.0 KG

Capillary diameter: 1.0 MM

Plunger bottom area: 1.0 CM²

For a binder contained in the toner a known resin can be used, such as polystyrene,

polyacrylic, polyamide, or polyether resins which are most preferable. Hereinafter, these binders are referred to as "resinous binders".

Polyester resins are formed by condensation of polyols and polycarboxylic acids, the polyols including aliphatic polyols, aromatic polyols, heterocyclic polyols, etc., aromatic polyols being most desirable. Polycarboxylic acids include aliphatic carboxylic acids, aromatic polycarboxylic acids, etc. More specifically, the acids include terephthalic acid, isophthalic acid, naphthalenedicarboxylic acid, maleic acid, fumaric acid, succinic acid, adipic acid, sebacic acid, cyclohexane dicarboxylic acid, etc., among which terephthalic acid is preferably used.

In addition, the polyols include ethylene glycol, propylene glycol, diethylene glycol, butane-diol, cyclohexanedimethanol, hexylene glycol, triethylene glycol or glycerol, mannitol, pentaerythritol, bisphenol A, 2,2'-bis(4-oxypropoxyphenyl) propane, 2,2'-bis(oxyethoxyphenyl) propane, etc. Any combination of these substances which can be used is determined by taking into consideration the compatibility with the used electric charge prohibitor, and the desired transparency.

The above-mentioned resins should have a weight-average molecular weight (Mw) within the range of 10,000 to 80,000, and preferably within the range of 30,000 to 70,000. The degree of dispersion (Mw/Mn) expressed by the ratio of the weight-average molecular weight (Mw) to the number-average molecular weight (Mn) should be within the range of 2 to 15, and preferably within the range of 3 to 10. The resinous binder having a molecular weight within the above range has dispersed therein a coloring agent and other constituents described below.

The degree of dispersion within the above range facilitates the softening of the toner so as to soften immediately without causing an offset. A degree of dispersion greater than the above range tends to retard the progress of melting, and a degree of dispersion smaller than the above range is likely to cause a blocking problem and reduces heat resistance.

The coloring agent to be dispersed in the resinous binder includes: carbon black; aniline black; lamp black; magenta dyes and pigments such as C.I. pigment red 81, C.I. pigment red 122, C.I. pigment red 57, C.I. solvent red 49, C.I. solvent red 19, C.I. solvent red 52, C.I. basic red 10, C.I. disperse red 15, etc.; cyan dyes and pigments such as C.I. pigment blue 16, C.I. pigment blue 25, C.I. pigment blue 55, C.I. pigment blue 70, C.I. direct blue 25, C.I. pigment blue 86, etc.; and yellow dyes and pigments such as C.I. pigment yellow 17, C.I. pigment yellow 12, C.I. pigment yellow 1, C.I. pigment yellow 97, C.I. pigment yel-

low 138, C.I. solvent yellow 29, C.I. solvent yellow 162, C.I. pigment yellow 93, etc.

These coloring agents are blended within the range of 0.3 to 15 weight parts, and preferably within the range of 1 to 7 parts, for every 100 weight parts of the above resinous binder. When making up a magnetic toner, known magnetic substances such as ferrite, magnetites can be added. These magnetic substance are added within the range of 5 to 200 weight parts for every 100 weight parts of the resinous binder.

Besides the above coloring agents, electric charge prohibiting substances may be added. They include known substances such as metal complex monoazo dyes, metallic salts or metallic complex salts such as salicylic acid, alkyl salicylic acid, naphthoic acid, etc., and nigrosine dyes. Sulphonic acids, phosphonic acids, carboxylic acids, and polymers having these metallic salts as side chains may also be used. These charge control substances are added within the range of 0.1 to 10 weight parts, and preferably within the range of 0.5 to 5 weight parts, for every 100 weight parts of the resinous binder.

The toner can be produced by known methods. A common method consists of the steps of melting the above-mentioned substances, kneading them, cooling the dough and crushing the mass and classifying the particles. Another is a method in which various orientation agents are added to the polymerized monomers forming the resinous binder and the toner is produced in a single step during the polymerization process of the resinous binder.

It is desirable that the toner produced in this way is treated on its surface with powder, e.g. hydrophobic silica or alumina, or with fine powder of acrylic, styrene, silicone or other polymers.

When using the above described toner in an image fixing unit, the previously noted conditions should be satisfied, and it is desirable that the surface temperature of the fixing roller be controlled within the range of 120 to 190°C so that the deposit of toner on the transfer material is maintained within the range of 30 to 200 mg, preferably within the range of 60 to 120 mg for an image which occupies 40% of an A4 size paper. The fixing roller is preferably operated at a surface speed of 30 to 300 mm/sec.

As described above, the fixing method of the present invention prevents undulations occurring in the fixed toner image surface and unevenness in melting of the toner so as to provide the fixed toner image with a smooth, uniform surface, thus enabling all-toned areas to be produced in high density while faithfully reproducing fine line areas. Therefore, a monochromatic image can be produced in high density, while in the case of a color image, a high-density, clear and definitive image

having good transparency and spectral characteristics can be produced.

Example 1

Five weight parts of carbon black and 1.5 weight parts of a metallic complex salt of alkyl salicylic acid used as charge control agent were mixed with 100 weight parts of polyester resin, used as resinous binder, having a weight average molecular weight of 40,000 and a degree of dispersion (Mw/Mn) of 5, and the steps of melting, kneading, crushing, and classifying were sequentially performed to obtain toner having an average particle size of 8.5 μm. Hydrophobic silica and ferrite carrier having an average particle size of 80 μm were mixed in a weight ratio of 5:95 with respect to 100 weight parts of the thus obtained toner, to prepare a developer. Using the thus prepared developer, a toner image was fixed to a transfer material using an image forming apparatus equipped with a fixing unit providing the fixing conditions shown in Table 1. After that, the toner image fixed to the transfer material was evaluated. The results of the evaluation are shown in Table 1. Also, the melting viscosity characteristic of the toner is shown in Figure 5.

Examples 2 to 4 and Comparative Examples 1 to 4

The procedure of Example 1 was repeated but using different resinous binders and coloring agents, as shown in Table 1, to prepare toners of Examples 2 to 4 and Comparative Examples 1 to 4. When using carbon black, 5 weight parts were used for every 100 weight parts of the resin, while in the case of copper phthalocyanine or benzidine pigments, 3.5 weight parts were used for every 100 weight parts of the resin. In each of Examples 2 to 4 and Comparative Examples 1 to 4, a fixed toner image was produced using the fixing conditions shown in Table 1, and the fixed toner image was evaluated. The results are shown in Table 1. Also, the melting viscosity characteristics of these toners are shown in Figure 5.

As is apparent from Table 1, since, according to the present invention, an image formed with toner having a low viscosity and a prescribed melting viscosity characteristic is fixed using a fixing roller provided with a toner contact surface having elasticity and a mirror-like finish, a fixed image superior both in fine line reproducibility and transparency can be obtained, with all-toned areas produced in high density without dislocation. In particular, the image density can be enhanced with a relatively small amount of toner deposition.

Further, when the present invention is applied to the production of a full-color image formed by

superposing different color toner images, since the melting of the toners progresses quickly, good coloring by mixing respective molten toners is achieved, thus assuring production of a clear image.

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Table 1

Fixing conditions	fixing roller	Substance (Elastic layer) Surface temperature (°C) Surface Mirror-finish	Example 1	Example 2	Example 3	Example 4	Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4
			Silicone rubber 130 PFA Provided	Silicone rubber 140 Silicone rubber Provided	Silicone rubber 120 PFA Provided	Silicone rubber 140 Silicone rubber Provided	140 PTFE Provided	Silicone rubber 140 Silicone rubber Provided	Silicone rubber 130 PFA Provided	150 PTFE Provided
Toner	Press Roller	Substance	PTFE	PTFE	PTFE	PTFE	Silicone rubber Nil	PTFE	PTFE	Silicone rubber Nil
		Heat source	Provided	Provided	Provided	Provided	Nil	Provided	Provided	Nil
		Circumferential velocity (mm/sec)	120	130	110	130	130	130	120	130
Image assessment		Resinous binder Colouring Agent	Polyester carbon black	Polyester Copper phthalocyanine	Polyester Benzidine	MMA-EA Copper phthalocyanine	Polyester carbon black	Polyester Copper phthalocyanine	Polyester Copper phthalocyanine	Polyester Benzidine
		η_{90} (poise)	2×10^5	3×10^5	4×10^5	6×10^5	2×10^5	8×10^5	1×10^5	4×10^5
		η_{100} (poise)	3×10^4	5×10^4	8×10^4	9×10^4	3×10^4	3×10^5	9×10^3	8×10^4
		η_{100} / η_{90}	0.15	0.16	0.2	0.15	0.15	0.38	0.09	0.2
		Weight-average	40000	35000	50000	50000	40000	70000	20000	50000
		Molecular weight (Mw)	5	6	6	7	5	6	7	6
		Dispersion (Mw/Mn)	70	80	80	85	120	70	80	70
		Deposit (mg/A4:40% paper)								
		Density of solid image	1.85	1.85	1.84	1.87	1.79	1.63	1.73	1.62
		Resolution (lines/mm)	6.3	6.3	6.3	5.6	4.0	5.6	4.0	4.0
Image assessment		Smoothness	Excellent	Excellent	Excellent	Good	Poor	Poor	Good	Poor
		Offset	Nil	Nil	Nil	Nil	Nil	Nil	Occurred	Occurred
		Transparency	----	Excellent	Excellent	Good	----	Poor	Good	Poor

(Note) The image density was measured by a densitometer "PDA" manufactured by Sakura Inc. A range of 1.8 to 2.0 for black, and a range of 1.7 to 1.9 for cyan and yellow were set as optimum ranges. The smoothness of the fixed surface and the anti-offset were judged by a sample image and the fixing roller. The transparency was measured by visually observing the transmissibility of light passing through a sample image (OHP) having predetermined wavelengths (600 nm and 400 nm).

Claims

1. A method for fixing a toner image formed on a transfer member by applying heat and pressure to the toner image using a fixing roller unit, wherein the toner has melt viscosities of 1×10^5 to 3×10^6 poises at 90°C and 1×10^4 to 1×10^5 poises at 100°C , and wherein the fixing roller unit comprises a heater and a press roller having a mirror-like elastic surface. 5
2. A method as claimed in claim 1, wherein the ratio of the melt viscosity at 100°C to that at 90°C is 0.5 or less. 10
3. A method according to claim 1 or 2, wherein the elastic surface is provided by an elastic rubber layer coated with tetrafluoroethylene-perfluoroalkyl vinyl ether copolymer resin (PFA). 15
4. A method according to claim 1, 2 or 3, wherein the toner contains a coloring agent dispersed in a resinous binder and the resinous binder has a weight-average molecular weight (Mw) of 10,000 to 80,000 and a ratio of the weight-average molecular weight (Mw) to the number-average molecular weight (Mn) of 2 to 15. 20

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Fig. 1

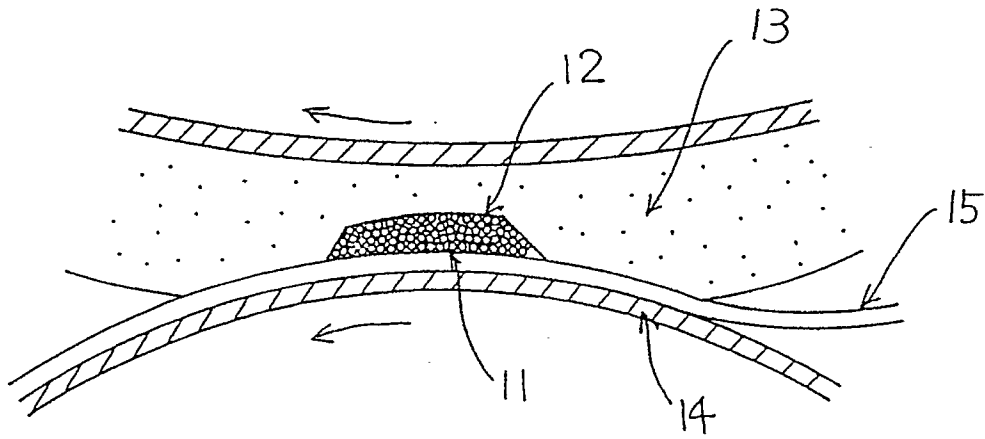


Fig. 2

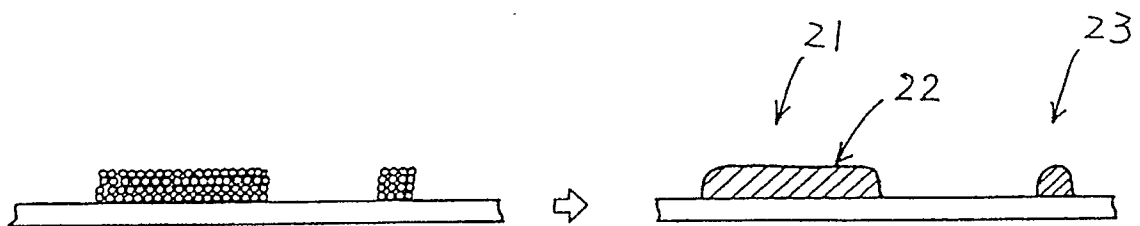


Fig. 3(a)



Fig. 3(b)



Fig. 4

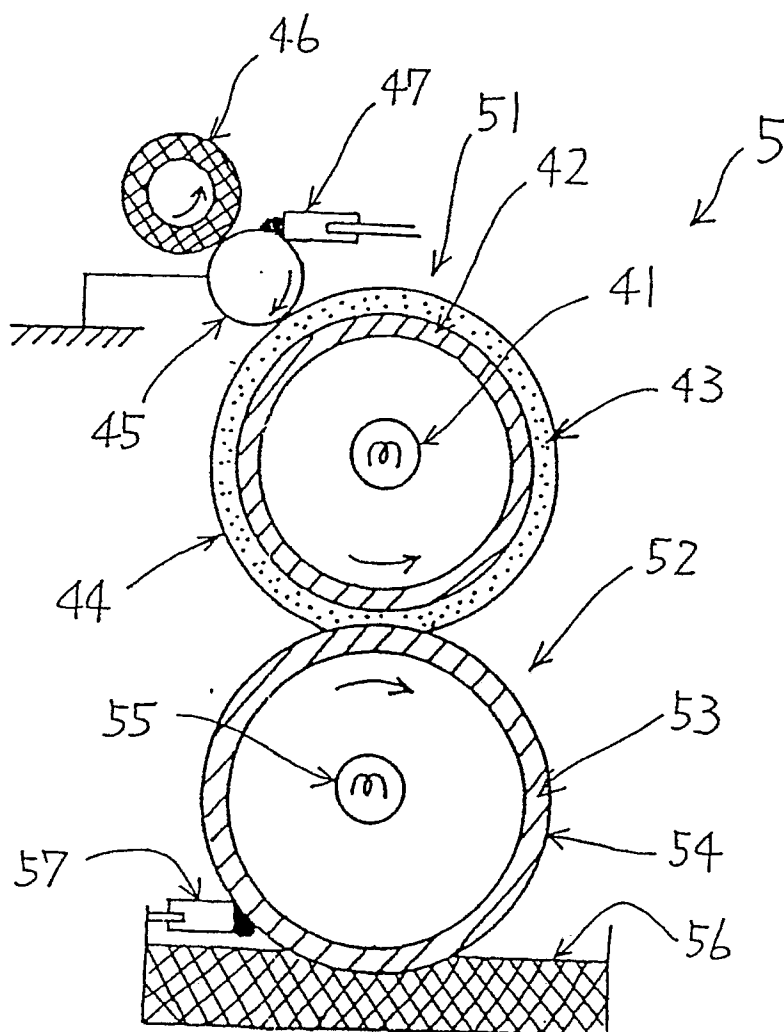


Fig. 5

