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(54) **Image forming method**

Bilderzeugungsverfahren

Méthode de formation d'images

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Description

[0001] The present invention relates to a method of forming an image, comprising the steps of:

- supplying developer onto the surface of a developing roller, the developer being formed at least of toner and magnetic carrier; and
- making color superposed images on a photoreceptor by repeating at least twice the step of non-contact-developing a latent image formed on the photoreceptor through an oscillating electric field formed between the developing roller and the photoreceptor,

wherein:

- the developing roller comprises a rotating sleeve and a magnet which is positioned in the sleeve at a position adjacent the line where the sleeve is closest to the photoreceptor, or which is positioned in the sleeve on the upstream side with respect to the sleeve rotation on a sleeve radial line which has an angle of not more than 35° to a radial line intersecting said line where the sleeve is closest to the photoreceptor; and
- an average particle size of the carrier particles is not more than $50\text{ }\mu\text{m}$, and the saturation magnetization amount σ_s of the carrier particles is not more than $50\text{ A}\cdot\text{m}^2/\text{kg}$ (50 emu/g).

[0002] A method of this kind is known from EP 0 616 269 A2. According this known method, the developing roller comprises a rotating sleeve and two magnets. The magnets are positioned in the sleeve on the upstream and the downstream side with respect to the sleeve rotation, respectively, of a developing region defined as that region of the surface of the sleeve which is adjacent the line where the sleeve is closest to the photoreceptor. Each of the two magnets forms a magnetic field of a magnetic induction between 400 and $800\cdot 10^{-4}\text{ T}$ (between 400 and 800 G) on the surface of the sleeve over the respective magnet.

[0003] As a dominating technology for image forming methods, there have so far been studied actively electrostatic image developing methods wherein those bringing a particle size of a developer into focus and those bringing non-contact developing into focus have been applied for a patent in large quantities.

[0004] For example, Japanese Patent Publication Open to Public Inspection No. JP 58 129437 A (hereinafter referred to as Japanese Patent O.P.I Publication) discloses a technology wherein an average particle size of toner and the toner content of a developer are doubly regulated, from the viewpoint of avoiding troubles in practical use, based on weight distribution and number distribution, with regard to an average particle size of toner in a two-component developer, and even a carrier is regulated based on weight distribution. Further, Japanese Patent O.P.I. Publication No. JP 57 147 652 A discloses a technology wherein a two-component developer is brought into a gap formed by plates facing each other as a frictional electrification method, and toner is charged with electricity by A.C. electric field given between the plates so that the toner may be used for non-contact developing. Further, Japanese Patent O.P.I. Publication No. JP 60 140 361 A discloses a developing method wherein an amount of toner whose particle size is not greater than one fourth of an average particle size of the total toner is $2\text{ wt}\%$ or less in a method in which the two-component developer is used for developing under an oscillating electric field.

[0005] On the other hand, Japanese Patent O.P.I. Publication No. JP 60 76766 A represents a typical technology as an image forming method wherein latent images formed on the same image carrier (photoreceptor) are subjected to non-contact developing repeatedly for making a multi-color image.

[0006] Further, Japanese Patent O.P.I. Publication No. JP 60 95456 A discloses that in an image forming method for making a color-superposed image by repeating twice or more the cycle of developing, on a non-contact basis, a latent image formed on an image carrier by oscillating electric field formed between a developing roller and the image carrier, better image quality can be obtained by making an electrostatic latent image through a dot exposure by means of a laser beam and by superposing each dot representing each color image of yellow, magenta and cyan.

[0007] It is described in Japanese Patent O.P.I. Publication No. JP 61 118 775 A that it is possible to form latent images of each color image with extremely high accuracy of superposing by using a photoreceptor drum of a rigid body such as one made of metal for enhancing accuracy of superposing latent images made repeatedly on an image carrier in the aforementioned method, and by affixing a drum index on a shaft of the drum to start each exposure based on signals generated from the drum index.

[0008] Incidentally, the color-superposed image means an image made by superposing on an image carrier a plurality of toner images each being different in color, wherein either an occasion where toner images are superposed on each other or an occasion where toner images are not superposed on each other is accepted.

[0009] As stated above, many studies have so far been made concerning the technology of a color image forming method employing an electrostatic image developing method and a system of superposing images on an image carrier. However, it has become clear that there still exist problems awaiting solution under the existing conditions that the

level of a technology and a degree of a user's demand for products have been enhanced.

[0010] The problem to be solved by the invention is an important one among the aforementioned problems awaiting solution, and its existence was not recognized clearly when many other problems existed and image quality was not as high as that in the present time.

[0011] Namely, it has been cleared that slight mixing of color is caused in a color image forming method by means of an image-superposing system, and further improvement of image quality is prevented by that mixing of color.

[0012] The mixing of color is a phenomenon that the second color toner sticks to an image portion on the first color toner in the course of superposing development in an image forming apparatus wherein a multi-color toner image is formed by superposing mono-color or multi-color toner images on an image carrier, then transferred onto a transfer material, and fixed. The mixing of color deteriorates color reproducibility and gradient and causes an increase of noise. The reason for this is that small particle components of toner of the second color enter the gap with a toner layer of the first color.

[0013] A developing apparatus, by which an electrostatic latent image on a photoreceptor, i.e., an image carrier, is developed, has a developing roller, composed of a sleeve rotating around a plurality of permanent magnets, in a developing tank. A two-component developer made of toner and carrier is adhered to the developing roller, and electrostatic developer brushes are formed thereon. The toner in the developer electrostatically flies onto the latent image on the photoreceptor surface so that a toner image is formed, without coming into contact with the latent image, in a developing area in which the developing roller is in close proximity to the photoreceptor. Carrier and surplus toner are returned into a developing tank for the next development.

[0014] Here, the developing area means an area on the developing sleeve in which toner in a developer layer on the sleeve flies to the electrostatic latent image.

[0015] One or two magnets are arranged in the sleeve just under or on both sides of the line closest to the photoreceptor, sandwiching the position, for forming a stationary magnetic field. In the case that two magnets are arranged, the space between the magnets is approximately the developing area. On the other hand, a magnet, arranged just under the line closest to the photoreceptor, the developing area in this case is in the vicinity of the developing magnet.

[0016] A brush regulation plate is provided on the upstream side of the developing area of the developing roller so that the thickness of the developer layer is appropriately leveled previously. Further, a stirring unit is provided in the developing tank so that toner and carrier are uniformly mixed and stirred and appropriately charged. Still further, an appropriate amount of toner, consumed during the development, is continuously replenished from a toner replenishing unit.

[0017] In the development in the above-described developing apparatus, the following processes are carried out. (a) The magnetic field is formed on the surface of the sleeve by magnetic bodies provided in the sleeve. (b) Developer brushes are formed on the surface of the sleeve along the magnetic field, while toner and carrier, charged by electrical charges generated when they are mixed, are loosely combined with each other. (c) These developer brushes are conveyed on the surface of the sleeve in the direction of its rotation. (d) The toner flies onto the photoreceptor in the developing area. Almost all carrier is returned to the developing tank while retained on the sleeve by the magnetic field.

[0018] In the conventional developing system the following disadvantages occur. The brush height in the developing area varies greatly. Accordingly, the difference of the amount of the developer conveyed to the minute spaces on the sleeve, that is, the difference of density of the developer layer is large, and the developer is not accurately adhered onto the latent image on the photoreceptor. The undesirable contrast conspicuously occurs in microscopic areas, and further, noise occurs, resulting in an image of low quality. In order to solve the above-described problem, a low magnetized carrier is used. However, carrier adheres on the photoreceptor, and a great increase of image quality can not be expected. Further, since the density of developer layer is not sufficiently large, the height of the developer layer is not decreased satisfactorily. Accordingly, the closest distance between the developing roller and the photoreceptor, (which will be referred to as D_{sd} , hereinafter), is limited.

[0019] An object of the present invention is to establish a means to solve such problems, and to provide an electrostatic image developing apparatus by which a high image quality can be accomplished.

[0020] This object is achieved by the method of forming an image of the kind mentioned at the beginning, which method is characterized in that the magnet forms a magnetic field of a magnetic induction not less than $1000 \cdot 10^{-4}$ T (1000 G) on the surface of the sleeve over the magnet.

[0021] This method of the invention comprises, supplying developer onto the surface of a developing roller, and making color superposed images on an image carrier by repeating twice or more the step of non-contact-developing a latent image formed on the image carrier through oscillating electric field formed between the developing roller and the image carrier.

[0022] The developing roller is composed of a rotating sleeve and one or two developing magnets arranged in the sleeve just under or on both sides of the line closest to the photoreceptor, sandwiching the position, for forming a stationary magnetic field and by which a latent image on a photoreceptor is developed. The magnetic induction or magnetic field intensity on the surface of the sleeve over the developing magnet(s) is not less than $1000 \cdot 10^{-4}$ T (1000

G) and preferably $1300 \cdot 10^{-4}$ T (1300 G). The first developing magnet of the developing roller is positioned in the sleeve just under the line closest to the photoreceptor or a position making an angle of not more than 35 degrees in the upstream side with respect to the sleeve rotation between the line closest to the photoreceptor in the developing roller. The other magnet, when existent, is positioned in the sleeve just under the line closest to the photoreceptor (when the first developing magnet is not there) or a position making an angle of not more than 35 degrees in the down stream direction between the line closest to the photoreceptor in the developing roller.

[0023] The developing roller may have another magnet other than the developing magnet mentioned above. The magnetic field intensity on the surface of the sleeve over the another magnet is not more than that of the developing magnet. The difference of the magnetic field by the developing magnet and the another magnet at each of the surface of the magnets is preferably not less than $1000 \cdot 10^{-4}$ T (1000 G), and preferably more than $1300 \cdot 10^{-4}$ T (1300 G).

[0024] In this method, a toner having a narrow particle size distribution is used preferably. An accumulated volume up to 0.8D is not more than 15% of whole volume of the toner particles and an accumulated volume up to 0.7D is not more than 8% of whole volume of the toner particles, wherein D is a volume average particle size of toner particles in developer.

[0025] Two-component developer composed at least of magnetic carrier particles and toner particles is used. The volume average particle size of the carrier is not more than $50 \mu\text{m}$, preferably not more than $35 \mu\text{m}$, and more preferably not more than $25 \mu\text{m}$. The saturation magnetization value σ_s of carrier is not more than $50 \text{ A} \cdot \text{m}^2/\text{kg}$ (50 emu/g), and preferably not more than $40 \text{ A} \cdot \text{m}^2/\text{kg}$ (40 emu/g), and more preferably not more than $30 \text{ A} \cdot \text{m}^2/\text{kg}$ (30 emu/g).

Brief Description of the Drawings

[0026] Fig. 1 is a sectional view showing an example of an image forming apparatus of the invention.

[0027] Fig. 2 is a structural diagram showing an example of a developing unit in the invention.

[0028] Fig. 3 is a diagram illustrating toner particle size distribution of the invention.

[0029] Figs. 4(A), 5(A) and 6(A) are each a partially side sectional view showing the relationship of a developing roller and an image carrier, of an example of an electrostatic image developing apparatus of the present invention.

[0030] Figs. 4(B), 5(B), 6(B) and 6(C) are each a partially side sectional view showing the behavior of brushes of the developer in a developing area in an example of the present invention.

[0031] Fig. 7 is a perspective view showing the difference between the maximum and minimum height of developer brushes in the developing area in the conventional developing apparatus.

[0032] Fig. 8 is a perspective view showing the difference between the maximum and minimum height of developer brushes in the developing area in an example of the developing apparatus of the present invention.

[0033] Fig. 9 is a graph showing the relationship between the height of the brushes of the developer and the conveyance amount of the developer.

[EXPLANATION OF SYMBOLS]

[0034]

- 1. Photoreceptor drum
- 10: Developing roller
- 11: Sleeve
- 12: Magnet body
- 13, 14: Developing magnet
- 13A: Developing magnet
- 15, 16: Adjoining magnets
- 18: Brush regulation plate
- 19, 19A: Brush developer layer
- 20. Scorotron charging unit
- 21: Developing tank
- 25. Image reading portion
- 30. Image writing portion
- 31: Developer
- 41, 41A: Smoothing member
- 45. Supply roller
- 46. Regulating bar
- 47. Scraper
- 48. Stirring roller

- 49. Casing
- 50. Two-component developer
- 51, 52. Power supply
- 60. Sheet-feeding section
- 5 61. First sheet-feeding roller
- 62. Second sheet-feeding roller
- 70. Transfer-use corona charging unit
- 75. Separation-use corona charging unit
- 80. Conveyance section
- 10 85. Fixing section
- 90. Cleaning unit
- 91. Cleaning blade
- 95. Pre-charging lamp
- 101. Conductive base member
- 15 102. Light-sensitive layer
- 140A, 140B, 140C, 140D. Developing units
- 141. Developing roller
- 142. Magnet member
- 143. Plate-shaped member
- 20 144. Auxiliary electrode portion

Detailed Disclosure of the Invention

[0035] Fig. 1 is a sectional view showing an example of a developing unit used in an image forming method of the invention, and Fig. 2 is an enlarged sectional view of main portions of the developing unit. In these figures, the numeral 141 is a developing roller which is a developer conveyer having therein fixed magnetic body 142, the numeral 143 is a plate-shaped member having an auxiliary electrode portion 144, the numeral 45 is a supply roller which is a developer supply member, 46 is a regulating bar which is a member for regulating an amount of developer to be conveyed, 47 is a scraper which is a member for scraping a developer, 48 is a stirring roller which is a member for stirring a developer, 49 is a casing of a developing unit, 50 is a two-component developer composed of toner T and carrier C, each of 51 and 52 is a power supply as a bias impressing means, 1 is a photoreceptor drum which is an image forming body wherein light-sensitive layer 102 is formed on conductive base substance 101, D_{sd} is a minimum clearance between the photoreceptor drum 1 and the developing roller 141, D_2 is a minimum clearance between the electrode portion 44 and the developing roller 141, and D_3 is a minimum clearance between an end portion of the plate-shaped member 43 and the developing roller 141. In the figures the photoreceptor drum 1 goes around in the clockwise direction and the developing roller counter clockwise direction.

[0036] The developing roller 141 is a cylinder of 0.5 - 3 cm in diameter made of non-magnetic and conductive metal such as aluminum and stainless steel, for example, and it is processed so that its surface roughness (Rz) is 1 - 30 μm . Inside the developing roller 141, there is affixed magnetic body 142 that is of a cylinder shape or a pillar-shaped aggregate having 4 - 12 magnetic poles magnetized to N pole or S pole so that the magnetic field on the surface of the developing roller 141 may show $500\text{--}1200 \cdot 10^{-4} \text{ T}$ (500 - 1200 gauss), and the developing roller 41 can rotate around the magnetic body 142.

[0037] The plate-shaped member 143 is a monolayer or multi-layer plate-shaped member of 0.05 - 0.5 mm in thickness made of insulating organic substrate material or inorganic substrate material such as polyimide resin, epoxy resin, glass-fiber-reinforced epoxy resin and ceramics, for example, and auxiliary electrode portion 144 made of conductive material such as a copper foil, for example, having a thickness of 0.005 - 0.1 mm and a width of 0.1 - 1 mm is formed on the top surface or inside of the plate-shaped member 143.

[0038] The casing 49 is a casing made of insulating resins such as acryl or polycarbonate, for example, and inside the casing 49, there are arranged developing roller 141 wherein the fixed magnetic body 142 is housed, supply roller 45, scraper 47 and stirring roller 48. On the outlet of the casing 49, there is arranged regulating bar 46, and on the upper end portion of the casing 49, there is arranged the plate-shaped member 143 having the auxiliary electrode portion 144 with its end affixed.

[0039] Inside the casing 49, there is stored two-component developer 50 composed of toner T and carrier C. The two-component developer 50 is supplied by the supply roller 45 while it is being stirred and mixed by the stirring roller 48, and it sticks on the developing roller 141 to form a magnetic brush. The magnetic brush is conveyed by rotation of the developing roller 141 while being regulated in terms of an amount of conveyance by the regulating bar 46.

[0040] On the developing roller 141, there is impressed A.C. voltage containing D.C. components from the power supply 51, and on the auxiliary electrode portion 144 of the plate-shaped member 143, there is impressed D.C. voltage

from the power supply 52, and thereby a strong oscillating electric field and a weak oscillating electric field are formed respectively in a clearance between the developing roller 141 and the auxiliary electrode portion 144 and in a clearance between the developing roller 141 and the photoreceptor drum 1. Owing to the strong oscillating electric field, toner T leaves carrier C to fly to form a toner cloud. The toner cloud is helped with its fly to a latent image on the photoreceptor drum 1 by the weak oscillating electric field, thus, a toner image is formed on the photoreceptor drum 1.

[0041] Fig. 1 is a structural diagram showing an example of an image forming apparatus using the image forming method of the invention. In the figure, the numeral 1 is a photoreceptor drum which is an image forming body, 120 is a scorotron charging unit which is a charging means, 25 is an image reading section, 30 is an image writing section employing a laser beam representing an exposure means, 140A, 140B, 140C and 140D are developing units containing respectively two-component developers which are different in color each other, 60 is a sheet-feeding portion equipped with first sheet-feed roller 61 and second sheet-feed roller 62, the numeral 70 is a transfer corona charging unit which is a transfer means, 75 is a separation corona charging unit which is a separation means, 85 is a fixing portion, 90 is a cleaning unit equipped with cleaning blade 91, and 95 is a pre-charging lamp. An arrow mark in the figure shows the direction of rotation of the photoreceptor drum 1.

[0042] In basic operations of a multi-color image forming process according to the present example, a command to start copying is sent first from an unillustrated operation section to an unillustrated controlling section, and thereby photoreceptor drum 1 starts rotating. As the photoreceptor drum 1 rotates, its circumferential surface is charged uniformly by scorotron charging unit 120. At the image reading section 25, light information from an original is converted to electrical signals, and the electrical signals are inputted in image writing section 30 after being subjected to image processing. On the photoreceptor drum 1 charged as stated above, there is projected a laser beam by the image writing section 30 and thereby a latent image is formed on the photoreceptor drum 1. The latent image on the photoreceptor drum 1 is developed by either one of the aforementioned developing units 140A, 140B, 140C and 140D, and thus, a toner image is formed on the photoreceptor drum 1.

[0043] The photoreceptor drum 1 on which the toner image has been formed is charged again uniformly by the scorotron charging unit 120, and is irradiated by the image writing section 30 with a laser beam, thus, a following latent image is formed. The latent image on the photoreceptor drum 1 is developed by either one of the aforesaid developing units 140A, 140B, 140C and 140D, thus a following toner image is superposed on the photoreceptor drum 1.

[0044] In the present invention, a cycle of a latent image forming step and a developing step is repeated 2 times or more, and 2 or more toner images each being different in color from others are superposed on the photoreceptor drum 1 accordingly.

[0045] In the present example, a cycle of a latent image forming step and a developing step is repeated 4 times, and 4 toner images are superposed on the photoreceptor drum 1 accordingly.

[0046] In the sheet-feeding section 60, there are loaded recording sheets each being fed out by first sheet-feeding roller 61 and second sheet-feeding roller 62 to transfer-use corona charging unit 70 while being synchronized with toner images superposed on the photoreceptor drum 1. The toner images superposed on the photoreceptor drum 1 are transferred onto a recording sheet by the transfer-use corona charging unit 70, and that recording sheet is separated from the photoreceptor drum 1 by separation-use corona charging unit 75. The recording sheet onto which toner images have been transferred is conveyed to fixing section 85 through conveyance section 80, then is subjected to melting pressure fixing, and is ejected out of the apparatus.

[0047] On the other hand, the toner remaining on the photoreceptor drum 1 without being transferred onto the recording sheet is scraped off by cleaning unit 90 that is equipped with cleaning blade 91 which is brought into pressure contact with the photoreceptor drum 1 on a timely basis, then, the photoreceptor drum 1 enters a following image forming process after residual potential on the photoreceptor drum 1 is removed by precharging exposure lamp 95.

[0048] In the step of developing in the invention, there is performed non-contact development in which A.C. voltage is impressed, and a frequency of 50 - 50,000 Hz is preferable in this case, and developing electric field at a developing area of not less than 0.5 MV/m and not more than 20 MV/m is preferable. Incidentally, the developing electric field represents the following value.

$$\text{Developing electric field} = \{V_{DC} + (V_{AC})_{MAX}/2 - V_H\} D_{sd}$$

V_{DC} : D.C. voltage (V)

V_{AC} : A.C. voltage (V)

V_H : Photoreceptor charging voltage (V)

D_{sd} : Minimum clearance between photoreceptor and developing roller

[0049] In this case, any order for superposing yellow, magenta, cyan and black images on the surface of a photoreceptor is acceptable, but the thickness of a developer layer on the developing roller needs to be smaller than D_{sd} for

the reason of non-contact developing.

[0050] A developing roller of the electrostatic image developing apparatus is composed of a rotating sleeve provided around magnetic bodies forming a magnetic field by a plurality of magnets. The latent image on a photoreceptor is developed by using a two-component developer. The magnetic field intensity of the surface of the sleeve at a developing area is not less than $1000 \cdot 10^{-4}$ T (1000 G).

[0051] The developing area is an area in the vicinity where the sleeve is closest to the photoreceptor and the development is carried out, and is regulated mainly due to one or two highly magnetized magnets in the magnetic bodies provided in the sleeve.

[0052] A difference between the intensity of the magnetic field of the sleeve surface in the case where the highly magnetized magnets are arranged, and that of the magnetic field of the sleeve surface in the case where other magnets are arranged adjoining the highly magnetized magnet bodies in the magnetic bodies, is not more than $1000 \cdot 10^{-4}$ T (1000 G).

[0053] The preferable embodiment of the developing apparatus has a leading edge of an elastic smoothing member which comes into contact with a sleeve located slightly upstream of the developing area.

[0054] In the non-contact type electrostatic image developing apparatus of the present invention, the intensity of the magnetic field generated from the magnet bodies in the developing roller is greatly increased. Specifically, when the intensity of the magnetic field on the surface of the sleeve, generated by the developing magnet or the developing magnet, is not less than $1000 \cdot 10^{-4}$ T (1000 G), the distribution of the developer brushes (dispersion of the height of the developer layer) is reduced, and the density of the developer layer is increased and the height of the developer layer is reduced. As a result, a gap formed between the photoreceptor and the developing roller can be reduced, and the fidelity of contrast, due to developer density, in the microscopic area is increased, (noise is decreased), resulting in an image of high quality. In this connection, when the difference of intensities of the magnetic fields on the surface of the sleeve, in the case where highly magnetized magnets are arranged in the sleeve and in the case where magnets adjoining the highly magnetized magnets are arranged in the sleeve, is not more than $1000 \cdot 10^{-4}$ T (1000 G), the developing apparatus is able to convey greater amounts of developer.

[0055] Further, when the leading edge portion of the smoothing member comes into contact with the developer layer slightly upstream of the developing area in this type of developing apparatus, the density of the developer is increased and the dispersion of the height of the developer layer is reduced. Accordingly, noise is also reduced, and the image quality is enhanced.

[0056] Still further, when the carrier particle size in the developer is reduced, or the magnetic intensity of the carrier particle is reduced, the dispersion of the height of the developer layer or the noise caused by the above dispersion is further reduced, and a higher image quality can be obtained.

[0057] Figs. 4A, 5A and 6A are each a partially side sectional view showing the position relationship of a developing roller of a developing apparatus to an image carrier.

[0058] A developing roller 10 is provided in a developing tank 21 of a developing apparatus 20. Inside the developing roller 10, a plurality of magnets such as two developing magnets 13 and 14, and their adjoining magnets 15 and 16, etc., are provided on the inner peripheral surface. Numeral 12 is a magnet body attached to the peripheral surface on which above-described magnets are arranged. A sleeve 11, made of a non-magnetic material, is rotatably provided around the outer peripheral surface of the magnet body 12. That is, the developing roller 10 comprises the inner magnet body 12 and the outer sleeve 11. As shown by the partially side sectional view in Fig. 6B, on the upstream side of the developing area, the leading edge portion of the smoothing member 41 is brought into contact with the upper layer of the developer located slightly upstream of the point closest to the photoreceptor. This smoothing member 41 may be a high polymer material or a metallic plate. The smoothing member 41 is affixed to an inside fixing position 42 in the developer tank 21. Although an image of high quality, to some extent, is obtained even when this smoothing member 41 is removed, an image of still higher quality can be obtained when this smoothing member is attached to the developing apparatus.

[0059] An appropriate amount of developer 31 is accommodated in the developing tank 21. Toner and carrier are uniformly mixed by a stirring roller, not shown in the drawing, and are supplied to the peripheral surface of the sleeve 11 of the developing roller 10. The layer thickness of developer brush is kept almost uniform by a brush regulation plate 18. The developer, brushed by the rotation of the sleeve 11, is continually conveyed to the developing area. Toner in the developer 31 is separated from the carrier, flies to a latent image on the photoreceptor 1, and a toner image is formed on the photoreceptor 1. Carrier and surplus toner are returned again into the developing tank 21. An amount of toner, corresponding to the consumed amount, is replenished from the replenishing unit, and toner is again uniformly mixed with carrier. The triboelectric charging of toner and carrier is carried out by the mixing operation.

[0060] In the present invention, the magnetic intensity on the sleeve surface due to the developing magnets 13 and 14 is not less than $1000 \cdot 10^{-4}$ T (1000 G), and more preferably, not less than $1500 \cdot 10^{-4}$ T (1500 G). In this connection, conventionally, the intensity of the magnetic field on the sleeve 11 surface due to the developing magnets of the developing apparatus is about $700 \cdot 10^{-4}$ T (700 G). Further, when the difference between the intensity of the magnetic

field on the sleeve surface due to adjoining magnets 15 and 16, and that of the magnetic field on the sleeve surface due to the developing magnets, is not more than $1000 \cdot 10^{-4}$ T (1000 G), the conveyance amount of developer is increased, and the desired conveyance amount can be assured.

[0061] The first effect in the case where the highly magnetized magnets are used, is that D_{sd} can be reduced. The brush of developer in the developing area is formed as shown in partially side sectional views in Figs. 4(A) and 4(B). The height of the brush developer layer 19 located between the two developing magnets 13 and 14 is lowered and the height of the developer layer located on the developing magnets 13 and 14 is not as high. As a result, the closest distance between the developing roller 10 and the photoreceptor 1, (hereinafter, called D_{sd}), can be reduced as compared to conventional apparatus. In Fig. 8, since the height (thickness) of the developing layer 19 is considerably lower than D_{sd} , the D_{sd} can be further reduced by a gap distance C. Conventionally, in contrast to this, the height of the developer layer is considerably high even between the developing magnets, and even on the developing magnets. Accordingly, D_{sd} can not be reduced enough.

[0062] The second effect, in the case where the highly magnetized magnets are used, is that the image quality is increased. The reason for this is as follows. The developer density on the sleeve 11 is higher than conventional, and dispersion of the difference of the height between the highest portion and the lowest portion of the developer layer, that is, the dispersion of the height of the brushes, is smaller in the present invention.

[0063] Fig. 6 shows the maximum and the minimum height of the developer layer 19 when the conveyance amount of the developer layer 19, (hereinafter, called D_{WS} , with a unit of mg/cm^2) is changed, in the developing roller 10 in which the developing magnets are used. Here, the following carrier is used: the diameter of carrier particles is $50 \mu\text{m}$, and the saturation magnetization amount is $35 \text{ A} \cdot \text{m}^2/\text{kg}$ (35 emu/g).

[0064] As shown by the schematic illustration showing a model of brushes of developer in Fig. 4, in the developing roller having the intensity of the surface magnetic field of about $700 \cdot 10^{-4}$ T (700 G), the difference between the maximum height and the minimum height of the developer layer is $250 \mu\text{m}$. As shown by the schematic illustration showing a model of brushes of developer, the difference between the maximum height and the minimum height of the developer layer is $150 \mu\text{m}$, and the height of the developer layer is leveled. As a result, the noise in the microscopic image density area is reduced, resulting in an increase of image quality.

[0065] Further, Fig. 6 shows that the difference between the maximum and the minimum height of the developer layer can be reduced further when the smoothing member, made of PET or the like, is brought into contact with the developer layer. Accordingly, D_{sd} can be further reduced thereby, and the noise in the microscopic image density can be reduced further, resulting in a further increase of the image quality.

[0066] In the developing apparatus the highly magnetized magnets are composed of developing magnets 13 and 14 which are respectively arranged upstream and downstream of the closest point between the photoreceptor and the developing sleeve. However, the developing apparatus may be comprised of the developing magnet 13A in which the highly magnetized magnet is located at the closest point between the photoreceptor and the developing sleeve, as shown by the partially side sectional view in Fig. 5(A) or 6(C). In addition to this, a smoothing member 41A may be fixed at positions of 1 through 3 mm just upstream of the upper portion of the developing magnet. Although a considerably high image quality is obtained even when the smoothing member 41A is not provided, a higher image quality can be obtained when the smoothing member 41A is provided, which is the same as in the case of the above-described developing magnet.

[0067] In this connection, material for the highly magnetized magnet is an alloy of neodymium, iron, and boron in the present invention, however, it should be understood that the component material is not limited to this example. Other material such as samarium, iron, nitrogen, or the like, can also be used in the present invention, and the material may be any which satisfies the intensity of the magnetic field of the sleeve surface, regulated by the present invention.

[0068] Next, results of experiments are shown in Table 2, in which the experiments were carried out in the case where the particle size of carrier was changed from $60 \mu\text{m}$ to $30 \mu\text{m}$, the magnetic intensity of the carrier was changed, and the smoothing member was provided, and was not provided.

[0069] The volume average particle size of the carrier is not more than $50 \mu\text{m}$, preferably not more than $35 \mu\text{m}$, and more preferably not more than $25 \mu\text{m}$. The saturation magnetization value σ_s of carrier is not more than $50 \text{ A} \cdot \text{m}^2/\text{kg}$ (50 emu/g), and preferably not more than $40 \text{ A} \cdot \text{m}^2/\text{kg}$ (40 emu/g), and more preferably not more than $30 \text{ A} \cdot \text{m}^2/\text{kg}$ (30 emu/g).

[0070] As stated above, it is disclosed that it is necessary to use toner having narrow distribution of particle sizes for forming images through non-contact developing and obtaining excellent image quality. However, under the conditions of the conventional level of technology, no one has known that careful removal of small particle components of toner is necessary because the small particle components of toner of the second color enter the gap of toner layers of the first color, resulting in deterioration of color reproducibility, lightness and chroma, in a toner image area for the first color (a non-image area is not affected in this case) in the course of superposing development, and nothing has naturally been carried out. According to the studies of the inventors of the invention, when D represents a volume average particle size of toner particles, an accumulated value up to 0.8D is at least 15% or less and that up to 0.7D is

8% or less of whole volume of the toner particles. Toner wherein an accumulated value at 0.8D is 15% or less and that at 0.7D is 8% or less is more preferable and it has good characteristics.

[0071] With regard to volume average particle size D, 0.8D and 0.7D, in this case, the volume average particle size D means a particle size wherein an accumulated value in which volumes starting with a small particle size are accumulated is 50%, and 0.8D represents a particle size being 0.8 times that of D and 0.7D represents a particle size being 0.7 times that of D. For measurement of a volume average particle size, a Coulter counter (Coulter TA-II made by Coulter Co.; Coulter is a registered trademark.) is usually used. For the measurement, toner was dissolved in an electrolytic solution ISOTONE-II (made by Nikkaki Co.), then dispersed and the aforesaid Coulter counter was used. For raising accuracy of measurement, it is recommended to make measurement two times or three times.

[0072] A volume average particle size of toner is about 5 - 20 μm usually, and 4 - 10 μm is especially preferable on the point of obtaining high image quality. As an additive other than coloring agents and mold releasing agents, it is possible to use, for example, charge control agents, cleaning property improving agents and fluidity improving agents.

[0073] There is no limitation, in particular, for binding resins constituting toner, and resins having been used for application of this kind can be employed. To be concrete, styrene resin, styrene/acryl resin, styrene/butadiene resin, ester resin and epoxy resin, for example, can be used. Among them, ester resin and styrene/acryl resin may be used preferably, in particular, as one having stable frictional electrification property for toner. These resins are used either independently or in combination as a mixture of two kinds or more.

[0074] As a coloring agent, there is no limitation in particular, and many dyes and pigment such as carbon black, phthalocyanine blue, pigment green B and solvent red 49 can be used. As a mold releasing agent, low molecular weight polyolefin, aliphatic ester and aliphatic ester wax and carnaba wax, for example, can be used. As a charge control agent, Nigrosine dye and metal chelate dye, for example, can be used. As a cleaning property improving agent, zinc stearate, aliphatic metal salt such as lithium stearate, and polymer fine particles, for example, can be used. As a fluidity improving agent, inorganic fine particles, for example, are used and inorganic oxide fine particles such as silica, alumina and titania are preferably used. It is preferable that these inorganic oxide fine particles have been processed by silan coupling agent to be hydrophobic.

[0075] In a manufacturing method for toner, binding resins, coloring agents and mold releasing agents are mixed by a Henschel mixer, then the coloring agents and mold releasing agents are mixed and kneaded while they are dispersed under various conditions to a predetermined dispersed diameter, and after that, they are crushed and classified. In some cases, cleaning property improving agents and fluidity improving agents can be subjected to external addition to be mixed.

[0076] For preventing an increase of an average particle size caused by cutting (classification) of small particles, it is preferable to cut the large particle side also so that an average particle size does not vary in a period before and after classification.

[0077] It is possible to make a toner particle to be spherical through a spray dry method wherein resins such as styrene resin, vinyl resin, ethyl resin and acryl resin, coloring components such as carbon, charging control agent added in case of need, and other additives are melted, mixed and kneaded, then are dissolved in a solvent, the liquid thus obtained is jetted from a nozzle into hot air in a form of spray, and a solvent in the jetted drop of spray is evaporated to obtain a spherical particle. It is also possible to make a toner particle to be spherical through a curtain flow coater method wherein those melted, mixed and kneaded mentioned above are solidified and then crushed, thus, the particle obtained is jetted into hot air so that resins in the particle are made to be in the melted state to obtain a spherical particle, or through a granulation polymerization method wherein resins are subjected to polymerization and crystallization in a solution of prepolymer in which coloring components are dispersed, or through a method wherein resins are stirred in boiling water to be softened, in place of the aforementioned curtain flow coater method, for making a particle to be spherical, which is then subjected to filtration and drying.

[0078] Further, those cooled and crushed after being melted, mixed and kneaded mentioned above can also be used as monolithic toner.

[0079] The toner having particle size distribution suitable for the method of the invention can be obtained by adjusting various conditions such as a condition for the aforesaid spray dry method, a condition for crushing those mixed, kneaded and cooled, and a condition for granulation and polymerization, or by classifying pulverulent bodies obtained through various known methods in Table 1 and thereby removing unnecessary small particle components (and large particle components).

Table 1
Classification of dry classifiers

Principle and classification		Detailed classification	Classifier names and other items
I. Screen	Supersonic waves Air jet		Wire sieve for sizes up to about 20 mm Electric forming screen for sizes up to 3 mm
II. Gravity field classification	1. Horizontal flow 2. Vertical flow		(Sedimentation tank)
III. Inertia force classification	1. Lower type 2. Impacting type 3. Cross flow type 4. Coanda effect utilizing type	a) Air duct type b) Fluid bed type c) Multi-step bent type	(Sir screen) For cement (Multi-step fluid tank classifier) (Zigzag classifier)
IV. Centrifugation field classification	1. Spiral air flow (Helical) 2. Airedy (helical) (i) Free airedy type (ii) Forced airedy type	a) Without guide blade b) With guide blade a) Rotary classification chamber type b) Rotary blade type c) Particle centrifugation type	(Variable impacting means) Submicron classification Combination with a particle centrifugation type (Elbow jet and others) Multi-step cyclone (Classicon of a Iitani type) (Microplex, dispersion separator) (Acou-cut, turboclassifier) (Micron-separator, super-separator) (Staterpart type, O-Sepa)

[0080] Classification methods classified as II, III and IV in Table 1 are especially preferable among those listed in

Table 1.

[0081] In the two-component developer, a carrier is naturally needed. As a core particle for the carrier for a developer, it is possible to use known materials including metals such as iron, ferrite, magnetite, alloys of those metals and other metals such as aluminum and lead, and those of a binder type wherein the aforesaid magnetic powder is dispersed in resins.

[0082] Further, it is preferable that a core particle of a carrier is the so-called coating carrier whose surface is covered with resins or the like.

[0083] As a resin for covering a carrier, there may be given olefin resin such as styrene resin, acryl resin, styrene/acryl resin, ester resin, urethane resin and polyethylene, fluorine resin such as phenol resin, carbonate resin, ketone resin, fluorinated methacrylate and fluorinated vinylidene, silicone resin and its denatured product.

[0084] In an example of manufacturing of a carrier, magnetic substance particles and fine resin particles for covering are stirred and mixed uniformly by a stirring and mixing device equipped with a horizontal rotary member, and the mixture thus obtained is further stirred and is given mechanical shocks repeatedly, and thereby a covering resin layer composed of fine particles of covering resins is formed on the surface of the magnetic substance particle. It is also possible to manufacture through a dipping method which is a wet method.

[0085] Incidentally, a rate of mixing with toner that makes the toner density to be 1 - 15 wt% is preferable.

Example

[0086] The invention will be explained in detail as follows, referring to examples. Incidentally, the expression of "parts" in the description represents "parts by weight".

[Preparation of toner for developing]

[0087] Some 100 parts of polyester resins and 8 parts of carbon black were mixed and dissolved, and were subjected to kneading, crushing and classification to obtain non-magnetic and colored particles having a volume average particle size of 8.5 μm .

[0088] To these particles, there was added 0.4 wt% of hydrophobic silica, and Toners 1 - 6 of the invention and Comparative Toners 1 - 4 were prepared. Incidentally, an extruder was used for kneading, a jet crushing machine was used for crushing and a zigzag classifier of a vertical flow multi-step bending type was used for classification.

[Preparation of developer]

[0089] Some 100 parts of resin-coated carrier wherein a ferrite particle having a volume average particle size of 50 μm is covered by styrene/acryl resins and 5 parts of each toner mentioned above were mixed, and two-component developers were prepared.

[Image forming conditions]

[0090] Image forming was conducted under the following conditions on the modified color copying machine, Konica 9028 (Konica is a registered trademark.) of a non-contact two-component developing system made by Konica Corporation.

[0091] Photoreceptor surface charging voltage: -850 V using an organic photoreceptor of titanylphthalocyanine multi-layer type

D.C. bias voltage: -750 V

A.C. bias voltage: 2.2 kV_{p-p}, 8 kHz

Developing area clearance: 500 μm

Developer layer thickness: 250 μm obtained by bringing a magnetic stainless steel regulating bar (SUS416) having a diameter of 3 mm into contact with a developing roller.

[Evaluation method]

[0092] Each developer was used for developing a test chart, and reproducibility of character images (character reproducibility) and mixing of color were evaluated.

Character reproducibility:

[0093] Images obtained by developing test charts and then copying the developed test charts were evaluated visually. In this case, character images mean all images discriminated as characters, including not only characters but also fine line images.

[0094] Mixing of color: The number of black toner particles mixed in 100 cm² of solid yellow image (black is non-image portion) was counted.

[Evaluation results]

[0095] Results of the evaluation are shown in Table 2. For all samples characters were copied clearly.

Table 2

Sample No.	Toner particle distribution accumulated volume (%)			Developing condition				(Image quality)	
	0,7D	0,8D	D	Magnetic Intensity (10 ⁻⁴ T)	Pressure Member*	Carrier size (μm)	Carrier σ_s (A·m ² /kg)	Noise	Color mixing (number)
1	5	10	50	2000	YES	30	30	AA	2
2	7	16	50	2000	NO	30	30	A	41
3	5	10	50	2000	NO	50	30	B	3
4	7	16	50	2000	NO	30	50	C	38
5	7	16	50	1300	NO	30	30	C	4
6	5	10	50	700	NO	30	30	D	5
7	5	10	50	700	NO	50	30	D	5
8	7	16	50	700	NO	30	50	D	40
9	5	10	50	700	NO	50	50	D	8
10	5	10	50	2000	NO	60	30	D	5
11	7	16	50	700	NO	60	30	D	43
12	5	10	50	2000	NO	30	60	D	5
13	7	16	50	700	NO	30	60	D	46

* In Pressure Member, YES denotes the pressure member is provided and No not.

AA : extremely good

A : very good

B : good

C : fairly good

D : unacceptable

[0096] It has become apparent that developer and toner in the invention are extremely excellent in terms of mixing of color characteristics. In the case that, components of small particles are less, and mixing of color characteristics and character reproducibility are excellent because classified toner is used. It is understood that Examples wherein particle size distribution is leveled show high characteristics. To the contrary, it is understood that Comparative examples show good character reproducibility, but they show high degree of mixing of color of black toner in non-image area in yellow because of a broad distribution of particle size and of much components of small particles.

[0097] No. 9 is a conventional developing apparatus in which the intensity of the magnetic field on the surface of the magnet for regulating a developing area is 700·10⁻⁴ T (700 G), and no smoothing member is provided, and in which carrier, having normal particle size of 50 μm, is used. Considerable noise is generated, resulting in unsatisfactory image quality.

[0098] The invention makes it possible to prevent mixing of color without deteriorating character reproducibility in a color image forming method of a type to superpose multi-color toners on an image carrier. Due to this, it is possible to obtain images with high image quality which are excellent in character reproducibility and are free from mixing of color.

Claims

1. Method of forming an image, comprising the steps of:

- supplying developer (31) onto the surface of a developing roller (10), the developer (31) being formed at least of toner and magnetic carrier; and
- making color superposed images on a photoreceptor (1) by repeating at least twice the step of non-contact-developing a latent image formed on the photoreceptor (1) through an oscillating electric field formed between the developing roller (10) and the photoreceptor (1),

wherein:

- the developing roller (10) comprises a rotating sleeve (11) and a magnet (13A; 13) which is positioned in the sleeve (11) at a position adjacent the line where the sleeve (11) is closest to the photoreceptor (1), or which is positioned in the sleeve (11) on the upstream side with respect to the sleeve rotation on a sleeve radial line which has an angle of not more than 35° to a radial line intersecting said line where the sleeve (11) is closest to the photoreceptor (1); and
- an average particle size of the carrier particles is not more than $50\text{ }\mu\text{m}$, and the saturation magnetization amount σ_s of the carrier particles is not more than $50\text{ A}\cdot\text{m}^2/\text{kg}$ (50 emu/g),

characterized in that the magnet (13A; 13) forms a magnetic field of a magnetic induction not less than $1000\cdot 10^{-4}\text{ T}$ (1000 G) on the surface of the sleeve (11) over the magnet (13A; 13).

2. Method according to claim 1, **characterized in that** the toner in the developer (31) has such a particle size distribution that the accumulated volume of those toner particles having a size up to $0,8D$, is not more than 15% of the whole volume of the toner particles, and that the accumulated volume of those toner particles having a size up to $0,7D$, is not more than 8% of the whole volume of the toner particles, wherein D is a volume average particle size of the toner particles in the developer (31).

3. Method according to claim 1 or 2, **characterized in that** the developer (31) is supplied to a position adjacent the line where the sleeve (11) is closest to the photoreceptor (1), through a smoothing member (41, 41A).

4. Method according to one of the preceding claims, **characterized in that** the magnetic induction on the surface of the sleeve (11) over the magnet (13A; 13) is more than $1300\cdot 10^{-4}\text{ T}$ (1300 G).

5. Method according to one of the preceding claims, **characterized in that** the developing roller (10) comprises a second magnet (13; 14); **in that** both magnets (13; 14) are positioned as sandwiching said line where the sleeve (11) is closest to the photoreceptor (1); and **in that** the second magnet (13; 14) forms a magnetic field of a magnetic induction not less than $1000\cdot 10^{-4}\text{ T}$ (1000 G) on the surface of the sleeve (11) over the second magnet (13; 14).

6. Method according to one of the preceding claims, **characterized in that** the average particle size of the carrier particles is not more than $35\text{ }\mu\text{m}$.

7. Method according to claim 4, **characterized in that** the saturation magnetization amount σ_s of the carrier particles is not more than $40\text{ A}\cdot\text{m}^2/\text{kg}$ (40 emu/g).

Patentansprüche

1. Verfahren zur Erzeugung eines Bildes mit den Schritten:

Auftragen von Entwickler (31) auf die Oberfläche einer Entwicklungsrolle (10), wobei der Entwickler (31) aus wenigstens Toner und Magnetträger besteht; und
Erzeugen von Bildern mit übereinandergelegten Farben auf einem Photorezeptor (1), indem mindestens zweimal der Schritt der kontaktlosen Entwicklung eines latenten Bildes wiederholt wird, das durch ein zwischen der Entwicklungsrolle (10) und dem Photorezeptor (1) ausgebildetes schwingendes, elektrisches Feld auf dem Photorezeptor (1) erzeugt wird,
wobei:

die Entwicklungsrolle (10) ein drehendes Rohr und einen Magneten (13A; 13) aufweist, der in dem Rohr (11) an einer Stelle positioniert ist, die an die Linie angrenzt, wo das Rohr (11) dem Photorezeptor (1) am nächsten ist, oder der in dem Rohr (11) auf der oberstromigen Seite bezüglich der Rohrdrehung auf einer radialen Linie des Rohrs positioniert ist, welche einen Winkel von nicht mehr als 35° mit einer radialen Linie bildet, welche die Linie schneidet, wo sich das Rohr (11) dem Photorezeptor (1) am nächsten befindet; und

eine durchschnittliche Partikelgröße der Trägerteilchen nicht mehr als $50\text{ }\mu\text{m}$ und die Sättigungsmagnetisierungsmenge σ_s der Trägerteilchen nicht mehr als $50\text{ A m}^2/\text{kg}$ (50 emu/g) beträgt,

dadurch gekennzeichnet, daß der Magnet (13A; 13) ein Magnetfeld mit einer Magnetinduktion von nicht weniger als $1000 \cdot 10^{-4}\text{ T}$ (1000 G) auf der Oberfläche des Rohrs (11) über dem Magneten (13; 13A) bildet.

2. Verfahren gemäß Anspruch 1, **dadurch gekennzeichnet, daß** der Toner in dem Entwickler (31) eine solche Partikelgrößenverteilung aufweist, **daß** das akkumulierte Volumen derjenigen Tonerpartikel mit einer Größe von bis zu $0,8D$ nicht mehr als 15% des Gesamtvolumens der Tonerpartikel beträgt, und **daß** das akkumulierte Volumen derjenigen Tonerpartikel mit einer Größe von bis zu $0,7D$ nicht mehr als 8% des Gesamtvolumens der Tonerpartikel beträgt, wobei D ein durchschnittliches Partikelgrößenvolumen der Tonerpartikel in dem Entwickler (31) darstellt.

3. Verfahren gemäß Anspruch 1 oder 2, **dadurch gekennzeichnet, daß** der Entwickler (31) durch ein Glättelement (41, 41A) einer Stelle zugeführt wird, welche an die Linie angrenzt, wo das Rohr (11) sich am nächsten zu dem Photorezeptor (1) befindet.

4. Verfahren gemäß einem der vorherigen Ansprüche, **dadurch gekennzeichnet, daß** die Magnetinduktion an der Oberfläche des Rohrs (11) über dem Magneten (13A; 13) mehr als $1300 \cdot 10^{-4}\text{ T}$ (1300 G) beträgt.

5. Verfahren gemäß einem der vorherigen Ansprüche, **dadurch gekennzeichnet, daß** die Entwicklungsrolle (10) einen zweiten Magneten (13; 14) umfaßt; **daß** beide Magneten (13; 14) derart angeordnet sind, **daß** sie die Linie, wo das Rohr (11) sich am nächsten zu dem Photorezeptor (1) befindet, einschließen; und **daß** der zweite Magnet (13; 14) ein Magnetfeld mit einer Magnetinduktion von nicht weniger als $1000 \cdot 10^{-4}\text{ T}$ (1000 G) an der Oberfläche des Rohrs (11) über dem zweiten Magneten (13; 14) ausbildet.

6. Verfahren gemäß einem der vorherigen Ansprüche, **dadurch gekennzeichnet, daß** die durchschnittliche Partikelgröße der Trägerpartikel nicht mehr als $35\text{ }\mu\text{m}$ beträgt.

7. Verfahren gemäß Anspruch 4, **dadurch gekennzeichnet, daß** die Sättigungsmagnetisierungsmenge σ_s der Trägerteilchen nicht mehr als $40\text{ A m}^2/\text{kg}$ (40 emu/g) beträgt.

Revendications

1. Procédé de formation d'images comprenant les étapes de:

- amener un développeur (31) sur la surface d'un rouleau de développement (10), le développeur (31) étant composé au moins de touer et de porteur magnétique; et
- former des images de couleurs superposées sur un photorécepteur (1) en répétant au moins deux fois l'étape du développement sans contact d'une image latente formée sur le photorécepteur (1) par un champ électrique oscillant formé entre le rouleau de développement (10) et le photorécepteur (1),

dans lequel:

- le rouleau de développement (10) comprend une tubulure rotative (11) et un aimant (13A ; 13) qui est positionné dans la tubulure (11) à une position adjacente à la ligne, où la tubulure (11) est le plus proche du photorécepteur (1), ou qui est positionné dans la tubulure (11) du côté amont par rapport à la rotation de la tubulure sur une ligne radiale de tubulure, qui forme un angle de pas plus de 35° avec une ligne radiale intersectant la dite ligne, où la tubulure (11) est le plus proche du photorécepteur (1); et
- une taille moyenne de particule des particules de porteur n'est plus que $50\text{ }\mu\text{m}$, et la quantité de magnétisation de saturation σ_s des particules de porteur n'est pas plus que $50\text{ A m}^2/\text{kg}$ (50 emu/g),

caractérisé en ce que l'aimant (13A; 13) forme un champ magnétique d'une induction magnétique de pas moins de $1000 \cdot 10^{-4}$ T (1000 G) sur la surface de la tubulure (11) au-dessus de l'aimant (13A; 13).

2. Procédé selon la revendication 1, **caractérisé en ce que** le touer dans le développeur (31) a une telle distribution de taille de particule que le volume accumulé de tels particules de toner comprenant une taille de jusqu'à 0,8D n'est pas plus que 15% du volume total des particules de toner, et que le volume accumulé de tels particules de toner comprenant une taille de jusqu'à 0,7D n'est pas plus que 8% du volume total des particules de toner, dans lequel D est un volume moyen de taille de particule des particules de toner dans le développeur (31).

3. Procédé selon la revendication 1 ou 2, **caractérisé en ce qu'on** amène le développeur (31) à une position adjacente à la ligne, où la tubulure (11) est le plus proche du photorécepteur (1), par un élément à lisser (41, 41A).

4. Procédé selon l'une des revendications précédentes, **caractérisé en ce que** l'induction magnétique sur la surface de la tubulure (11) au-dessus de l'aimant (13A; 13) n'est pas plus que $1300 \cdot 10^{-4}$ T (1300 G).

5. Procédé selon l'une des revendications précédentes, **caractérisé en ce que** le rouleau de développement (10) comprend un deuxième aimant (13; 14); **en ce que** les deux aimants (13; 14) sont positionnés d'une telle façon qu'ils enferment entre eux la dite ligne, où la tubulure (11) est le plus proche du photorécepteur (1); et **en ce que** le deuxième aimant (13; 14) forme un champ magnétique d'une induction magnétique de pas moins de $1000 \cdot 10^{-4}$ T (1000 G) sur la surface de la tubulure (11) au-dessus de l'aimant (13; 14).

6. Procédé selon l'une des revendications précédentes, **caractérisé en ce que** la taille moyenne de particule des particules de porteur n'est pas plus que 35 μm .

7. Procédé selon la revendication 4, **caractérisé en ce que** la quantité de magnétisation de saturation σ_s des particules de porteur n'est pas plus que 40 A $\cdot$ m²/kg (40 emu/g).

FIG. 1

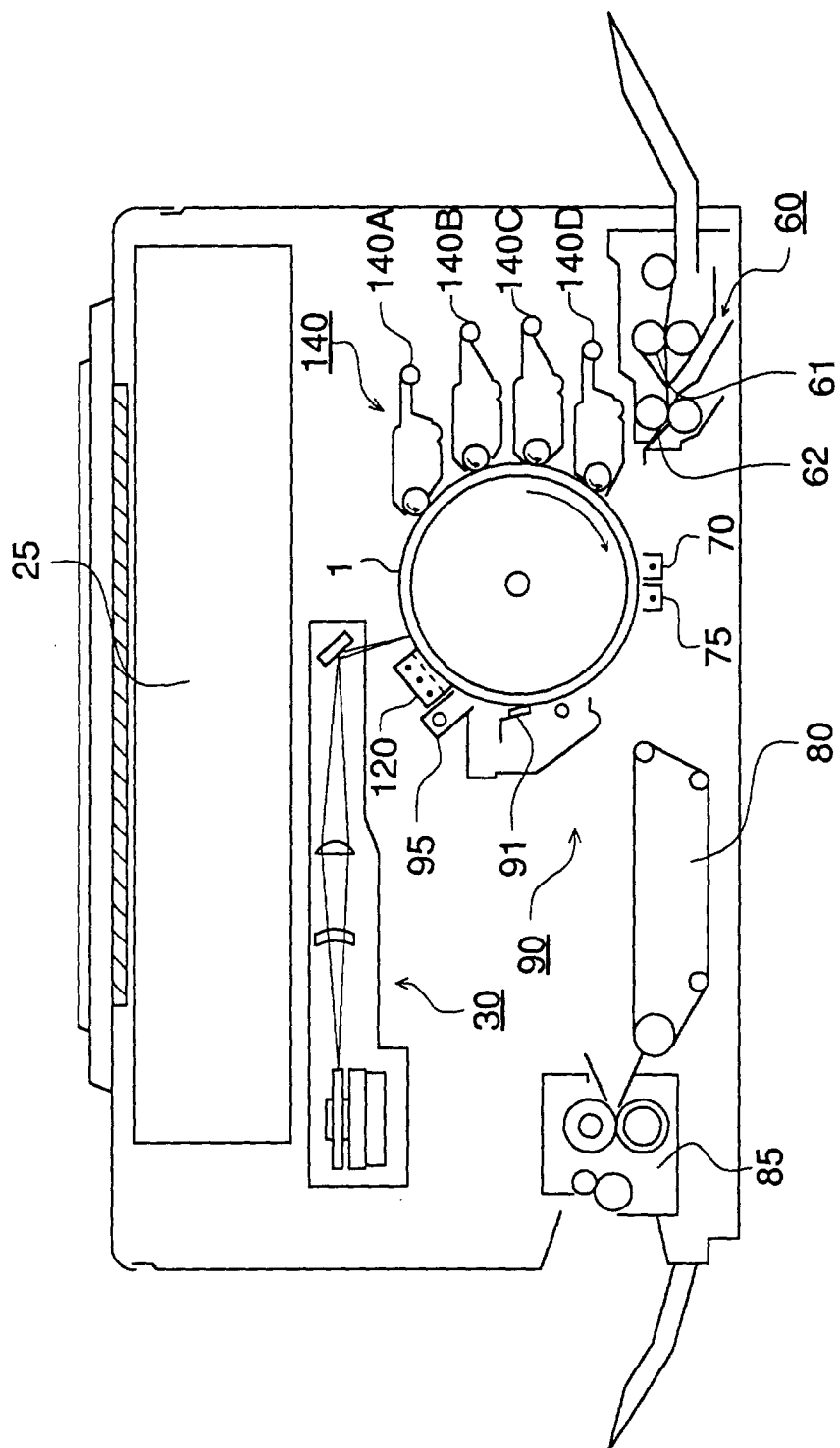


FIG. 2

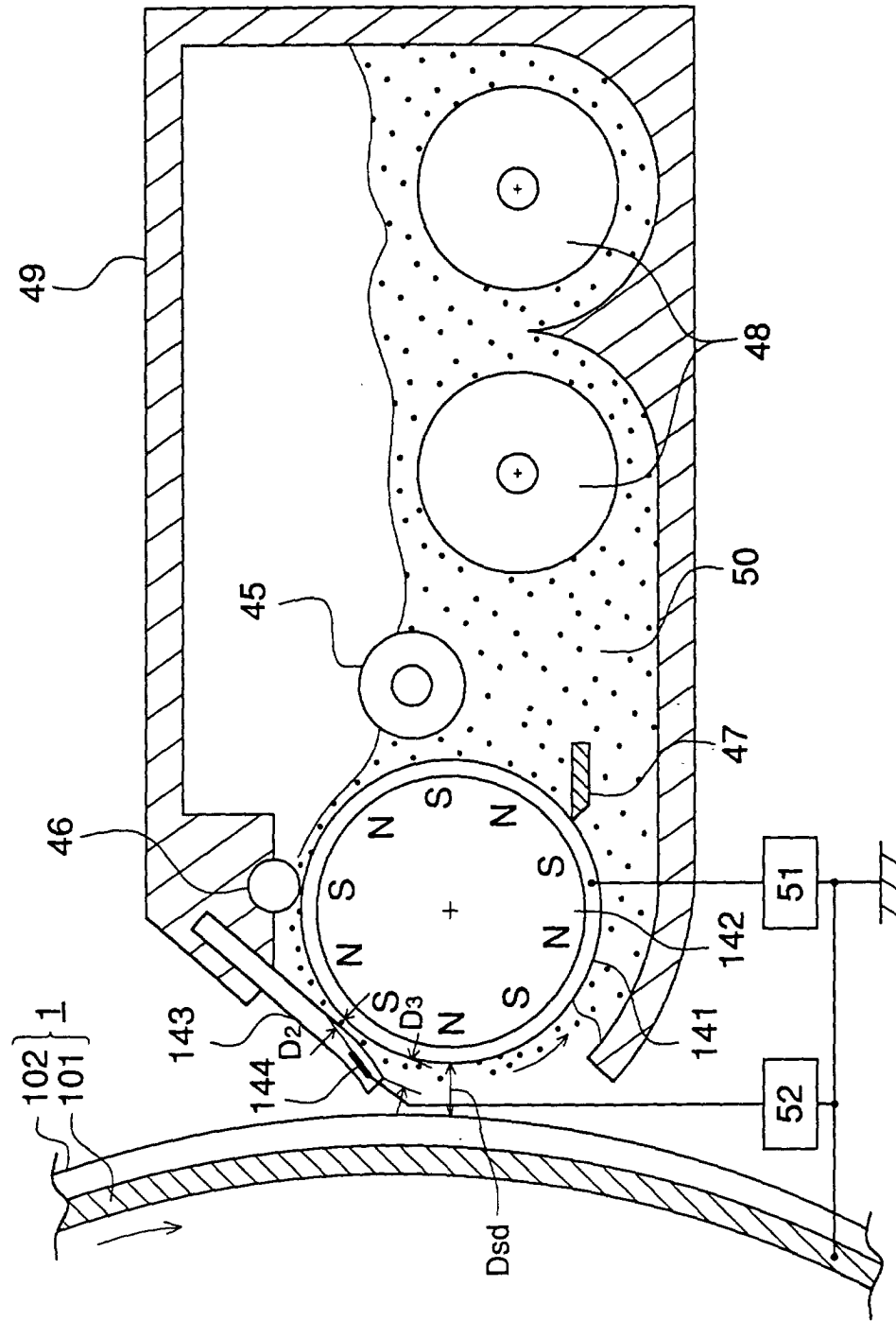


FIG. 3

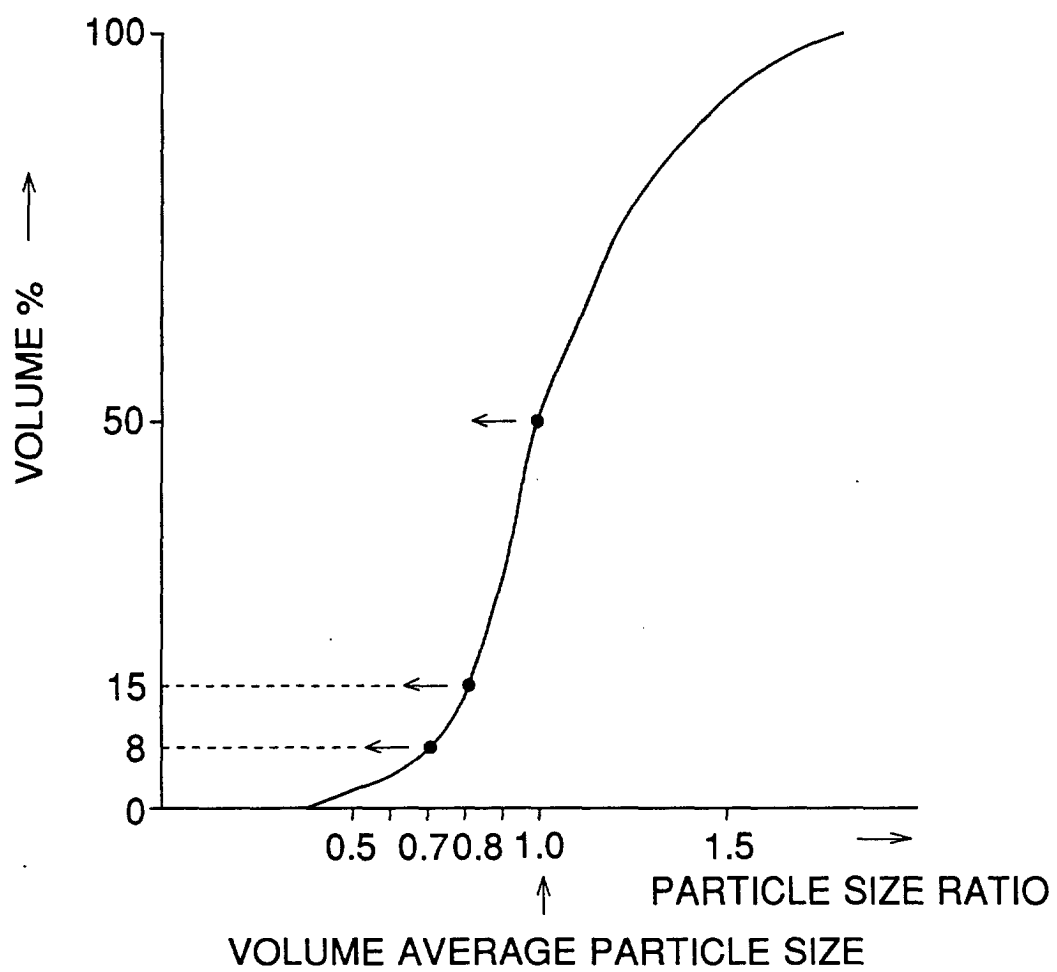


FIG. 4 (A)

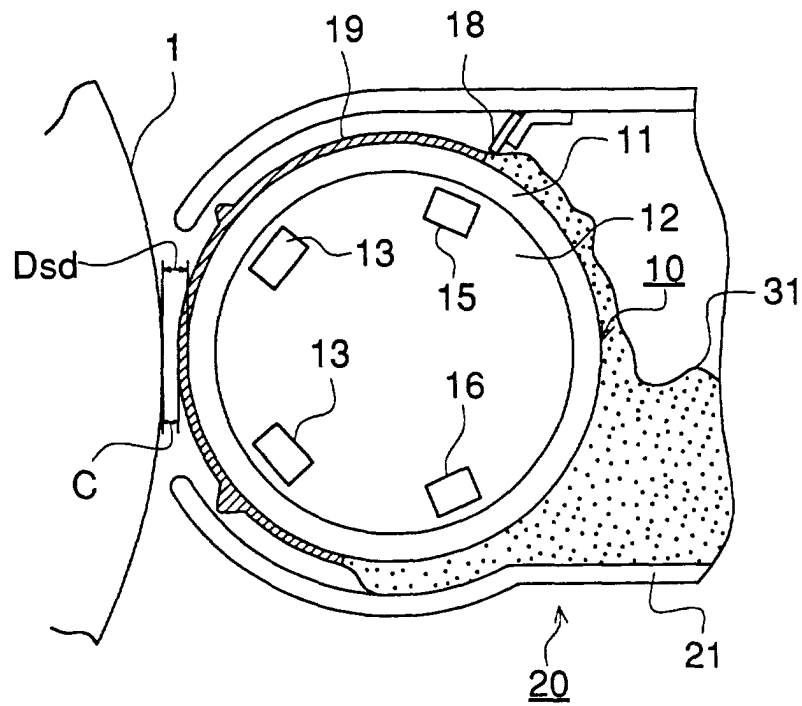


FIG. 4 (B)

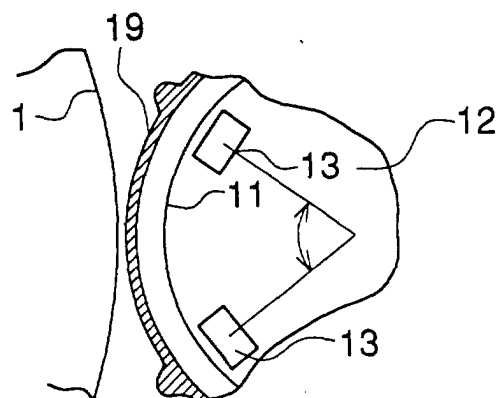


FIG. 5 (A)

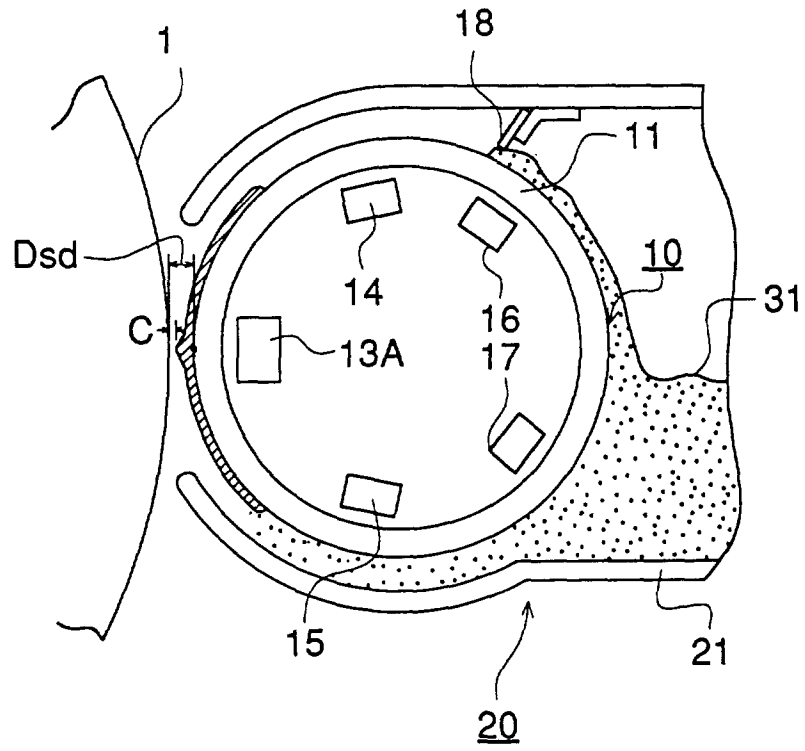


FIG. 5 (B)

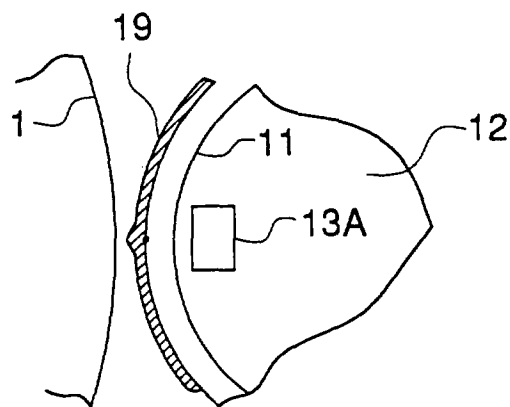


FIG. 6 (A)

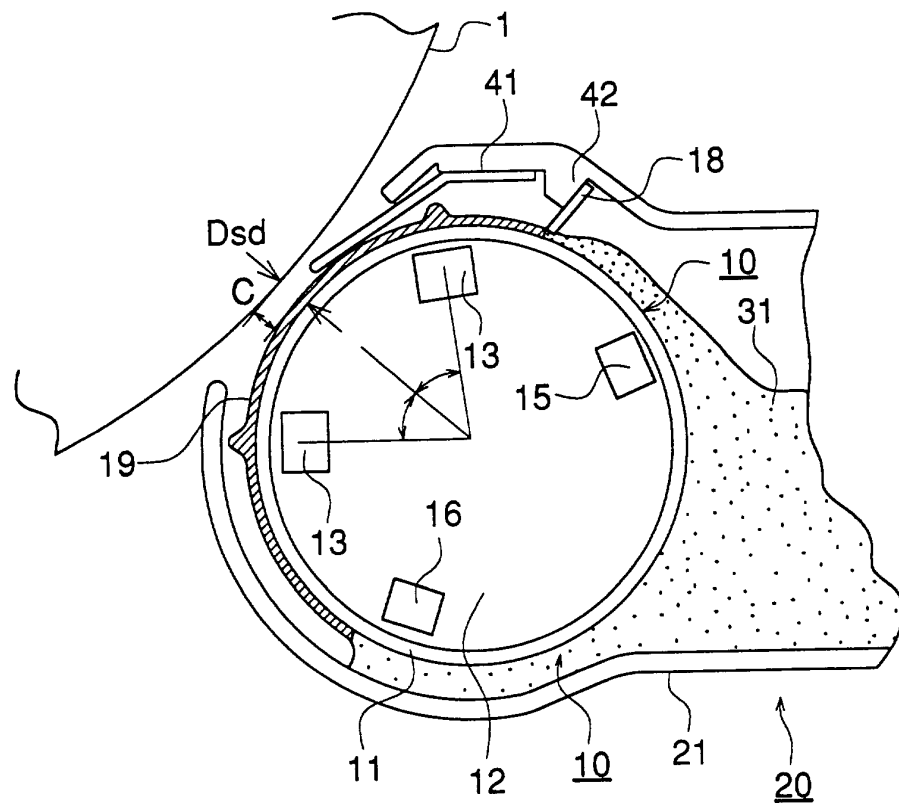


FIG. 6 (B)

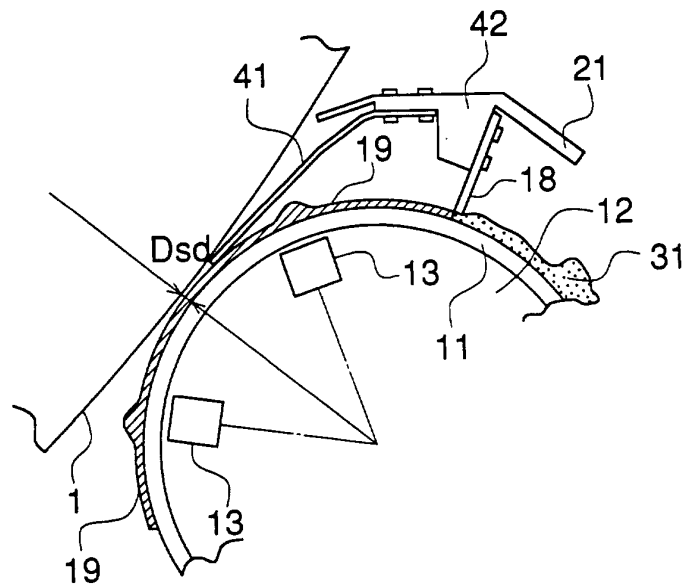


FIG. 6 (C)

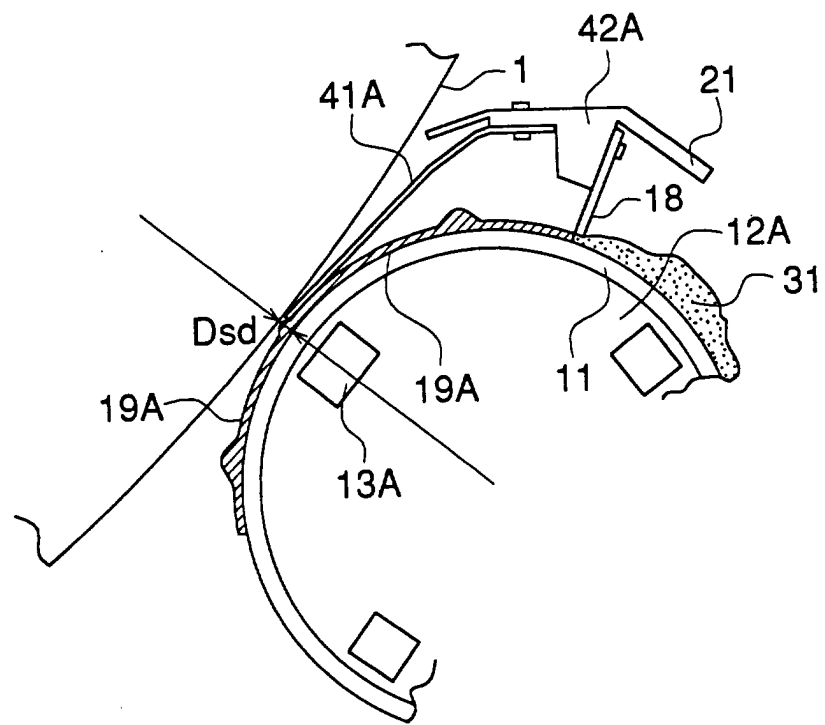
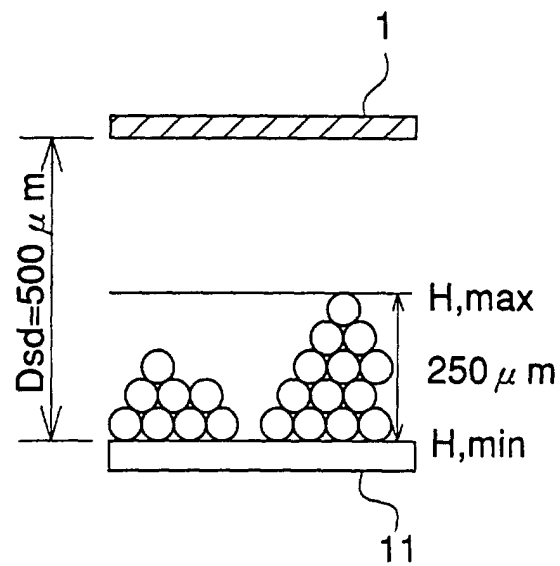


FIG. 7



SURFACE MAGNETIC FIELD INTENSITY
700G

FIG. 8

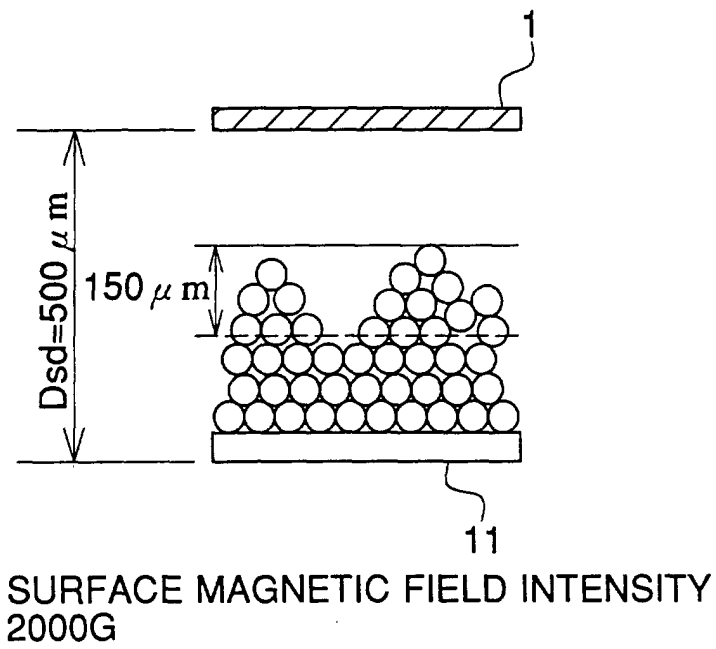


FIG. 9

