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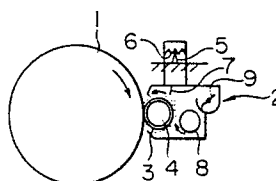
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54 Developing device for use in electrophotography.

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57 To provide a development process enabling the satisfactory and stable development of the image without relying on the conventional mechanism requiring high precision machined parts and highly accurate adjustment of the parts, an electrostatic latent image carrier and a magnetic brush supporter according to the present invention are disposed opposite to each other so as to be able to change their relative positions freely and the magnetic brush is brought so as to press against the electrostatic latent image carrier.

FIG. 1



DEVELOPING DEVICE FOR USE IN ELECTROPHOTOGRAPHY

BACKGROUND OF THE INVENTION

5 The present invention relates to the improvement of the magnetic brush development process applicable to the electrophotography and the electrostatic recording characterized by developing the electrostatic latent image formed on the image carrier into the visible image.

Conventionally, as far as the development process using the developer consisting of a single-component developer including the magnetic substance or a two-component developer consisting of the
 10 mixture of the toner and the carrier which is the magnetic substance is concerned, the development process using the magnetic brush developing device as shown in Fig. 10 is used. In said figure, numeral notation 71 denotes an electrostatic latent image carrier (hereinafter referred to simply as image carrier) that is to turn in the direction of an arrow and is also a photosensitive layer comprising, for example, ZnO, Se, OPC and so on, and 72 is a developer conveyance sleeve (hereinafter referred to simply as the sleeve)
 15 consisting of a non-magnetic cylindrical body that is to turn in the direction of an arrow to convey the developer D to the developing area E. 73 is a magnetic roll that is disposed inside the developing sleeve 72 and consists of the plural number of magnets having different polarities arranged radially and alternately so that said developer D is not only caused to be deposited on said sleeve 72 but also caused to form the brush due to the magnetic force. 74 is a brushformation controller that is provided on the upstream side of
 20 the development area E and controls the thickness of the developer layer to the predetermined value so that the electrostatic latent image can be developed with the brush formed at its best condition. 5 is a power source of the bias such as the DC bias to be applied to the developing sleeve 72 to prevent the scattering of the toner and the foggy development. 75a is a protective resistor.

The development process using the magnetic developing device can be divided into a process using a
 25 stationary magnetic roll 73 and rotary developing sleeve 72 and another process rotating the magnetic roll 73. In any of said processes, the layer of the developing agent controlled by the brush-formation controller 74 forms the flow of the developing agent, is adsorbed on the developing sleeve and conveyed to the development area E for the development.

Conventionally, the space, DSD, (hereinafter referred to as the space in development area) between the
 30 image carrier 71 and the developing sleeve 72 in the development area and the space, DH, (hereinafter referred to as the developing agent controlling space) between the brush-formation controller 74 and the developing sleeve 72 are kept constant in controlling the quantity of the developing agent to be conveyed for development. In this case, as one of the conditions necessary for accomplishing the development satisfactorily, there is the correlation between the DSD, the space in the development area, and the DH, the
 35 developing agent controlling space, and the accuracies of these spaces are required to be maintained at adequately high levels.

In the conventional system, the center of rotation of the image carrier 71 and the center of the rotation of the developing sleeve 72 are in a fixed relationship with each other as far as their relative positions are concerned. In such a fixed relationship, an example of the conditions for accomplishing satisfactory
 40 development including the values of DSD, the space in development area, and DH, the developing agent controlling space are as follows:

Value of DSD: 0.40 ± 0.04 mm

Value of DH : 0.40 ± 0.03 mm

Another condition to be satisfied simultaneously with the above condition is as follows:

45 Value of DSD - Value of DH = $-0.02 - +0.3$ mm

These conditions are required to be satisfied throughout the whole range wherein the image on the image carrier 71 is formed with the toner at the time the development. Both the image carrier 71 and the developing sleeve 72 are of cylindrical form. In the case of the ordinary electrophotographic duplicating machine, the image carrier and the developing sleeve take the form of a cylinder about 30 cm long in its
 50 axial direction in many instances. Thus, in order to maintain the developing agent controlling space DH within said range, it is essential for the axis of the developing sleeve 72 and the brush-formation controller 74 to be parallel to each other at highest possible accuracy. Also, in order to maintain the space DSD in the development area within said range, it is also essential not only that the axis of the developing sleeve 72 and the axis of the drum of the image carrier 71 are kept parallel to each other highest possible accuracy but also that the cross-sectional forms of said developing sleeve and said drum are completely circular.

Furthermore, the drum of the image carrier 71 and the developing sleeve are to be free from eccentricity, but it is difficult either from the machining technique or machine assembly technique to eliminate the eccentricity. For instance, where the axis of the developing sleeve 72 is fixed, said space DSD in the development area varies as the drum rotates, thereby causing the unevenness of the development.

5 According to the conventional way of solving this problem, the sleeve is pressed against the drum through a spacer in order to keep said space constant all times. In the case of such conventional system, however, said space varies when the foreign matter such as the developing agent is deposited on the surfaces of the drum, spacer or the sleeve, this causes the change in the space and the unevenness of the development as the result. Besides, as the surface of the spacer wears out, the space DSD cannot be maintained constant
10 as one of the disadvantages of the conventional system. In addition, the conventional system requiring the precision construction including the highly accurate spacer cause another disadvantage such as the high manufacturing cost.

Furthermore, the conventional system also causes what is called the blocking phenomenon characterized by the oversupply of the developing agent for the space DSD in the development area due to the
15 variation of the developing agent controlling space DH. This phenomenon is especially conspicuous where the single-component developing agent is used, and this phenomenon causes the extreme deterioration of the image quality. On this understanding, a system wherein the space DSD in the development area is set so that it can be enlarged when the development agent is supplied exceeding the predetermined quantity has been proposed in the specification of Japanese Patent Publication No. 61-28989. Such proposal,
20 however, cannot be the solution to said problem of the conventional system, since the proposed system also relies on the stop member in setting the space DSD in the development area at the time of the development like the case of the conventional system.

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SUMMARY OF THE INVENTION

The present invention relates to a development process for developing the electrostatic latent image on the image carrier using the single-component or the two-component developing agent and is intended to
30 provide a development process enabling the satisfactory and stable development of the image without relying on the conventional mechanism requiring the high-precision machined parts and highly accurate adjustment of the parts.

Said object of the present invention can be accomplished by the development process characterized in that the electrostatic latent image carrier and the magnetic brush supporter are disposed opposite to each
35 other so as to be able to change their relative positions freely and that the development of the image is accomplished by bringing the magnetic brush and said electrostatic latent image carrier to be pressed against each other.

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BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1 through 5 are respectively the partial side views showing the outline of the image-forming system using the developing system embodying the development process according to the present
45 invention.

Fig. 6 shows the composition of the developing system as one of the embodiments of the present invention.

Fig. 7 is a cross-sectional view of the magnetic roll.

Fig. 8 is a graphical illustration of the relationship between the developing agent controlling space DH
50 and the space DSD in the development area.

Fig. 9 is a diagram showing the relationship between the line pressure and the space in the development area and the range of the line pressure wherein the satisfactory development can be accomplished.

Fig. 10 is a drawing showing the composition of the conventional developing system.

55 Figs. 11 through 18 are respectively the cross-sectional views of the improved developing systems as the embodiments of the present invention.

Fig. 19 is a cross-sectional view of another embodiment of the present invention.

Fig. 20 is a cross-sectional view of the developing roller shown in the above Fig. 19.

Fig. 21 is a cross-sectional view of further another embodiment of the present invention.

Fig. 22 is an oblique view of the developing roller according to the present invention.

Fig. 23 is a lateral cross-sectional view of said developing roller including the view of its axis.

Fig. 24 shows the driving system and power transmission gear system provided to the aforementioned system.

Fig. 25 is a diagram showing the relationship between the depressing load and the space in the development area in the aforementioned system.

Fig. 26 the gear system for the transmission of driving force provided to the aforementioned system.

Fig. 27 shows the relationship between the depressing load and the space in the development area in the aforementioned system shown in Fig. 26.

DETAILED DESCRIPTION OF THE INVENTION

The photosensitive material as the image carrier to be used in the developing process according to the present invention can be, for example, the selenium-based photosensitive material (selenium photosensitive material, selenium-tellurium photosensitive material, selenium-arsenic photosensitive material), or the photoconductive inorganic pigment dispersed type photosensitive material (zinc oxide photosensitive material, cadmium sulfide photosensitive material), or the amorphous silicon type photosensitive material (function separation type, single-layer type), or the organic photoconductive photosensitive material (single-layer type, function separation type), or the composite type photosensitive material (photosensitive material consisting of the upper layer of selenium-based material and the lower layer of organic photosensitive material or photosensitive material consisting of the selenium and polyvinyl carbazole). The image carrier can be of non-photosensitive material. For the non-photosensitive image carrier, the synthetic resin film such as the polyester film may be used.

Any of the aforementioned image carriers is adaptable to the developing process according to the present invention, but the organic photoconductive photosensitive material and the amorphous silicon are especially preferable. Said photosensitive materials can preferably be used in the developing process according to the present invention, wherein the development takes place at a relatively low electric potential, to provide stable and high-quality developed image.

The organic pigments usable as the charge-generating materials to constitute the organic photosensitive material are as follows:

Monoazo pigment, polyazo pigment, metal complex salt pigment, pyrazolone azo pigment and azo-based pigments such as stilbene azo pigment and thiazole azo pigment.

(2) Perylene pigments such as the perylenic acid anhydride and perylenic acid imide.

(3) Anthraquinone or polycyclic quinone pigments such as the anthraquinone derivative, anthanthrone derivative, diben divenzpyrenequinone derivative, pyranethoron derivative, violanthoron derivative and isobiolanthrone derivative.

(4) Indigoid pigments such as the indigo derivative and thioindigo derivative.

(5) Phthalocyanine pigments such as the metal phthalocyanine and non-metal phthalocyanine.

(6) Carbonium pigments such as the diphenylmethane pigment, triphenylmethane pigment, xanthene pigment and acridine pigment.

(7) Quinoline pigments such as azine pigment, oxazine pigment and thiazine pigment.

(8) Methine pigments such as cyanine pigment and azomethine pigment.

(9) Quinoline pigments.

(10) Nitro pigments.

(11) Nitroso pigments.

(12) Benzoquinone and naphthoquinone pigments.

(13) Naphthal-imide pigments.

(14) Perinone pigments such as bis benzimidazole derivative.

The polycyclic quinone pigments and azo pigments are preferable. As the charge transport materials, the triphenylamine compounds or the hydrazone compounds are preferable.

As for the developing agents to be used in the developing process according to the present invention, any generally available one-component or two-component developing agent may be used and they are not limited to any specified ones. As the one-component developing agent, the magnetic toner may be used.

The two-component developing agent consists of the toner and the carrier. The resins as the binders of the one-component developing agents and the two-component developing agents may be any publicly

known resins and are not limited to any specified ones. As the resins suitable for the fixing process by heating, there are, for example, the styrene resin, styrene-acrylic resin,, styrene-butadiene resin, polyester resin, epoxy resin, polyimide resin and polyurethane resin. As the resins suitable for the pressure fixing process, there are the polyolefin compounds such as the polyethylene, polypropylene and polytetrafluoride-ethylene; polyethylene copolymers such as the ethylene-vinyl acetate copolymer, ethylene-ester acrylate copolymer and polyethylene-ester methacrylate copolymer; polyester; styrene-butadiene copolymer; the waxes such as the beeswax, carnauba wax and microcrystalline wax; the higher fatty acids such as the stearic acid and palmitic acid and their chlorides and esters; epoxy resin; the rubbers such as the isobutylene rubber, cyclized rubber and nitrile rubber; polyamide; chloro-indene resin; maleic acid modified resin; phenol modified terpene resin; silicon resin and so on.

The polyester resin preferred as the binder of the toner is obtained through the condensation polymerization of the alcohol monomer and the carboxylic acid monomer. As the alcohol monomers to be used for this purpose, there are, for example, the diol compounds such as the ethylene glycol, diethylene glycol, triethylene glycol, 1, 2-propylene glycol, 1, 3-propylene glycol, 1, 4-butanediol, enopentyl glycol and 1, 4-butanediol and the etherified bisphenols such as the 1,4-bis (hydroxymethyl) cyclohexane, bisphenol-A, hydrogenated bisphenol-A and polyoxyethylene bisphenol-A; and other bivalent alcohol monomers. As the preferred carboxylic acid type monomers, there are, for example, the maleic acid, fumaric acid, mesaconic acid, citraconic acid, itaconic acid, glutaconic acid, phthalic acid, cyclohexane dicarbonic acid, succinic acid, adipic acid, sebacic acid, malonic acid and the anhydrides of these acids; the dimer of lower alkylester and linolenic acid; and other bivalent organic acid monomers.

Besides said bivalent monomers, the polymonomers higher than the trivalent monomers may be used when necessary. As the preferred polyalcohol monomers higher than trivalent monomers, there are, for example, the sorbitol, 1, 2, 3, 6-hexane-tetrol, 1, 4-sorbitan, pentaerythritol, dipentaerythritol, tripentaerythritol, cane sugar, 1, 2, 4-butanetriol, 1, 2, 5-pentanetriol, glycol, 1, 2-methylpropanetriol, 2-methyl-1, 2, 4-butanetriol, trimethylethane, trimethylpropane, 1, 3, 5-trihydroxymethylbenzene and others. Also, as the preferred polycarboxylic acid monomers higher than the trivalent monomers, there are, for example, 1, 2, 4-benzenetricarboxylic acid, 1, 3, 5-benzenetricarboxylic acid, 1, 2, 4-cyclohexanetricarboxylic acid, 2, 5, 7-naphalenetricarboxylic acid, 1, 2, 4-naphthalenetricarboxylic acid, 1, 2, 4-butanetricarboxylic acid, 1, 2, 5-hexanetricarboxylic acid, 1, 3-dicarboxyl-2-methylenecarboxy-propane, tetra (methylenecarboxy) methane, 1, 2, 7, 8-octanetetracarboxylic acid, empol trimer acid, their anhydrides and others.

The styrene-acrylic resin preferred as the binder of the toner can be obtained through the copolymerization of the styrene monomer and acrylic monomer. As the styrene monomers, there are, for example, the styrene, O-methylstyrene, m-methylstyrene, p-methylstyrene, α -methylstyrene, p-ethylstyrene, 2, 4-dimethylstyrene, p-n-butylstyrene, p-tert-butylstyrene, p-n-hexylstyrene, p-n-octylstyrene, p-n-nonylstyrene, p-n-decylstyrene, p-methoxystyrene, p-phenylstyrene, p-chlorstyrene and 3, 4-dichlorstyrene. These monomers may be used either singly or in combination of plural kinds. As the preferred acrylic monomers, there are, for example, the acrylic acid compounds such as the acrylic acid, methyl acrylate, ethyl acrylate, n-butyl acrylate, isobutyl acrylate, propyl acrylate, n-octyl acrylate, dodecyl acrylate, lauryl acrylate, 2-ethylhexyl acrylate, stearyl acrylate, 2-chloroethyl acrylate, phenyl acrylate, α -chlor acrylate methyl or ester acrylate; the methacrylic acid compounds such as the methacrylic acid, methyl methacrylate, ethyl methacrylate, propyl methacrylate, n-butyl methacrylate, isobutyl methacrylate, n-octyl methacrylate, dodecyl methacrylate, lauryl methacrylate, 2-ethylhexyl methacrylate, stearyl methacrylate, phenyl methacrylate, dimethylaminoethyl methacrylate and diethyl diethyl aminoethyl methacrylate or ester methacrylates and others. These monomers may be used either singly or in combination of plural kinds.

In obtaining the resin particle powder, besides said binder resins, as the additives to be used whenever necessary, there are, for example, coloring agents, charge controlling agents and mold releasing agents.

As the preferred coloring agents, there are, for example, the carbon black, nigrosine dye (C.I.No. 50415B), aniline blue (C.I. No. 50405), chalcocyanine blue (C.I.No. 50405), chrome yellow (C.I. No. 14090), ultramarine blue (C.I.No. 77103), Du Pont oil red (C.I.No. 26105), quinoline yellow (C.I.No. 47005), methyleneblue chloride (C.I.No. 52015), phthalocyanine blue (C.I.No. 74160), malachite green oxalate (C.I.No. 42000), lamp black (C.I.No. 77266), Rose bengal (C.I.No. 45435), their mixtures and others. The content of the coloring agent should preferably range 0.1 - 20% in weight to 100% of binder resin in weight, most preferably 0.5 - 10% in weight.

For the charge controlling agent, various pigments or dyes may be used. More specifically, the nigrosine, azo, quaternary ammonium salt, thiourea pigments or dyes may be used. These charge controlling agents may be used in combination. The content of the charge controlling agent should preferably range 0.1% - 10% in weight to 100% of the binder resin in weight, most preferably 0.5% - 5% in weight.

As the preferred mold releasing agents, there are, for example, the polyolefin, fatty acid metallic salt, fatty acid ester, partially saponified fatty acid ester, higher fatty acid, higher alcohol, fluid or solid paraffin wax, amide wax, polyhydric alcohol ester, silicon varnish, aliphatic fluorocarbon, etc. Especially, the polyolefin such as the polyethylene and polypropylene whose softening points range 80 - 180°C is preferable, 70 - 160°C most preferably when measured by the ring and ball method. These mold releasing agents may be used in combination. The content of the mold releasing agent is preferred to range 1 - 10% in weight to 100% of the binder resin in weight.

The toner to constitute the two-component developing agent to be used according to the present invention may be one consisting of the resin particle powder formed into spheres and mixed with the external additive such as one for improving the adaptability to cleaning.

As the preferred agents for improving the adaptability to the cleaning, there are, for example, the fatty acid metallic salts such as the stearate and calcium stearate. For example, the fine grains of the polymers such as the polymethyl methacrylate, the fine grains of polystyrene and polyvinylidene fluoride may be used.

The toner to constitute the two-component developing agent may be manufactured, for example, by the following process. That is, the binder resin and the additive, which is to be used whenever necessary, are kneaded, for example, with the extruder as the mixture is being melted. Then, the mixture is cooled, crushed into rough pieces, for example, with the hammer mill or wiley type crusher, further crushed into fine grains using, for example, the jet mill and sorted into the resin grains of desired size.

Then, said resin grains are subjected to the repetitive impact of the mechanical energy in the gaseous phase so that the grains are shaped into spherical grains to obtain the desired toner without being crushed further.

The spherizing treatment of the resin grains may be conducted either at the room temperature or at the heated condition for some softening. Too much heating, however, causes the increase in the viscosity of the binder resin, which further causes the aggregation of the resin grains leading to the formation of the lumps and the serious hindrance to the production of the toner with ideal distribution of grain sizes.

The carrier to constitute the two-component developing agent according to the present invention is not limited to special one but it may be preferred to use the carrier of magnetic particles, the resins-coated carrier consisting of the magnetic particles whose surfaces are coated with the resin and the magnetic substance dispersion type carrier consisting of the binder resin containing dispersed magnetic substance.

As the preferred magnetic substances to be used in the carrier may be, for example, the substances which are conspicuously magnetized in the direction of the magnetic field such as the iron, ferrite and magnetite; the metals such as the iron, nickel and cobalt which are highly magnetizable or the alloys and chemical compounds containing these metals; and the alloys not containing the highly magnetic elements but highly magnetizable when subjected to the appropriate heat treatment such as the kinds of the alloys called the Heusler alloys including the manganese-copper-aluminum alloy, manganese-copper-tin alloy and chromium dioxide.

The preferred resins usable in obtaining the resin-coated carrier or the magnetic substance dispersion type carrier are not specified but may be, for example, the styrene resin, acrylic resin, styrene-acrylic resin, vinyl resin, ethylene resin, rosin modified resin, polyamide resin, polyester resin and so on. These resins may be used in combination.

The present invention relates to the development process characterized by that the magnetic brush whereon said single-component or two-component developing agent is deposited is made to contact said image carrier for the development of the image, and said image carrier and the magnetic brush are disposed opposite to each other so that said magnetic brush and said image carrier are able to change their relative positions freely when said magnetic brush comes to contact the image carrier for the development of the image.

As described previously, the development using the magnetic brush is accomplished when the developing agent is conveyed to the development area for the purpose of the development by the developing sleeve and its built-in roller. The development using the magnetic brush according to the present invention is accomplished by causing both or either one of the developing sleeve and the magnetic roll to rotate.

Changing the relative positions of the image carrier and the magnetic brush according to the present invention may be accomplished either by changing both the position of the drum axis of the image carrier and the position of developing sleeve axis to cause said DSD in the development area to change or by fixing the position of the axis of the image carrier drum whereas the position of the developing sleeve axis is left changeable to enable the DSD in the development area to change.

The means for enabling the developing agent to be pressed against the image carrier between the

magnetic brush supporter and the image carrier according to the present invention may be either the pressure of the loaded spring or the gravitational pressure or the pressure deriving from the combination of the both. Besides, the pressurizing means driven by the solenoid may equally be used. As described here, according to the present invention, the image carrier and the magnetic brush supporter are disposed
 5 opposite to each other but so as to be able to change their relative positions when they come into contact under pressure for accomplishing the desired development, and thus the magnetic brush can always be pressed against the image carrier under a constant pressure to ensure the development of the uniform and high-quality visible images.

Furthermore, the development process according to the present invention is applicable to both the
 10 normal development and the reversed development.

The present inventor has conducted the study on the relationship between the pressure to cause both said magnetic brush and the image carrier to be pressed against each other and the space DSD in the development area and on the range of the appropriate compressive pressure, and then reached the conclusions discussed in the following.

15 In said study, in considering the compressive pressure, the total compressive pressure should be considered in terms of the pressure (gf/cm²) divided by the area of the developing agent present in the development area between the drum with the photosensitive material as the image carrier and the developing sleeve as the magnetic brush supporter, but, actually, the value (gf/cm) (hereinafter referred to as the "linear pressure") obtained by dividing the total compressive pressure by the lateral length of the
 20 development area is considered, since it is difficult to measure the area of the development area.

When the total compressive pressure is considered in terms of the linear pressure, however, it seems to vary depending on the diameter D(PH) of the drum with the photosensitive material and the diameter D(DV) of the developing sleeve.

Thus, as for the D(PH), four different diameters were prepared, that is 50 mm, 80 mm, 150 mm and 200
 25 mm and as for the D(DV), three different were prepared, that is 20 mm, 30 mm and 40 mm, then the experiment was conducted as to various combinations of PH and DV.

The result of the experiment concerning the relationship between the space DSD in the development area and the linear pressure (gf/cm), however, indicates that there is no significant difference depending on the difference in said diameters. Thus, in said experiments, the diameter of 80 mm is used for the D(PH),
 30 and the diameter of 30 mm for the D (DV).

Fig. 9 shows the relationship between the linear pressure and the space in the development area, and the range within which the high-quality development can be accomplished.

In the experiment, a drum of 80 mm in diameter whose surface was covered with a layer of OPC photosensitive material was used as the image carrier; a developing sleeve of 30 mm in diameter with a
 35 magnetic roll fixed inside said sleeve was used as the magnetic brush supporter; the magnetic flux density in the development area was set within 800 to 900 Gauss; and the toner of within 9 to 13 μ m in average grain size was used.

The space DSD in the development area varies depending on the developing agent controlling space DH. Said Fig. 9 shows the cases under two different conditions, that is, DH = 0.5 mm and DH = 0.40 mm.

40 As shown in said diagram, the space DSD in the development area is almost equal to the developing agent controlling space DH where the linear pressure is 5 gf/cm or less but the space DSD decreases as the linear pressure increases where the linear pressure is above 5 gf/cm.

In any of the cases where DH = 0.05 mm or DH = 0.40 mm, fairly satisfactory development can be accomplished when the linear pressure is within the range (A) of 5 - 200 gf/cm, but the poor development
 45 almost close to the whitening can occur when the linear pressure is less than 5 gf/cm, and the uneven development occurs when the linear pressure is higher than 200 gf/cm. Thus, the latter two linear pressure ranges are ranges of poor development.

Besides, when the linear pressure is within the range (C1) of 5 - 15 gf/cm and the range (C2) of 80 - 200 gf/cm, the frequency of the poor development tends to increase depending on the environmental
 50 condition, especially when the temperature is relatively high, and so these ranges would be considered to be unstable ranges.

Thus, it has been clarified that the desirable linear pressure range (B) is within 15 - 80 gf/cm.

The preferred embodiments of the present invention will be explained in the following.

55 Figs. 1 through 3 are respectively the partial side views of the image forming units using the developing units embodying the development process according to the present invention, each representing the case where the position of the image carrier drum is fixed, whereas the position of the developing sleeve axis is left movable to keep the space DSD in the development area variable.

In these figures, 1 denotes a photosensitive drum using the photosensitive material such as the OPC as

the image carrier, and 2 a developing unit with the magnetic brush using the two-component developing agent consisting of the mixture of the toner and the carrier. The photosensitive drum 1 rotates in the direction indicated with an arrow and forms the electrostatic latent image thereon by the latent image forming device, which is not shown in the drawing, provided on the upstream side of the developing unit 2.

5 Then, said photosensitive drum is brushed with the magnetic brush of the two-component developing agent D that is conveyed on the developing sleeve 3 of the developing unit 2. The developing sleeve 3 of the developing unit 2 shown in the drawing may be either fixed or left to be able to rotate counterclockwise so that the magnetic brush can be conveyed towards the direction indicated by an arrow as is shown in Fig. 1 as the internal magnetic roll 4 having the N and S magnetic poles rotates clockwise (the roll may be fixed

10 where the developing sleeve 3 is set to rotate).

In Fig. 1, the developing unit 2 indicates an embodiment using the component of the gravity as the means for pressing. Said developing unit 2 is supported, like a pendulum, at a supporting point 5 provided on the frame of the image forming unit. The center of gravity of said developing unit 2 locates at right side of the vertical line passing the supporting point 5 so that said developing unit comes to contact the

15 photosensitive drum 1 when the magnetic brush is not on the developing sleeve 3. Then, said contact pressure can be adjusted by changing the engaging position of the engaging base 6 of the developing unit 2 engaging with the supporting point 5. By using this contact pressure adjusting system, the contact pressure can be controlled and stabilized; furthermore, the space DSD in the development area can be determined automatically corresponding to the clearance between the developing sleeve 3 and the brush

20 formation controller 7, that is, the value of the controlling space for the developing agent D, so that the toner image with adequate density and free of vertical and lateral unevenness can be formed not only when the photosensitive material such as Se is used for the photosensitive drum 1 but also even when the photosensitive materials which form the low-potential electrostatic image such as the OPC is used. The contact pressure can be varied continuously by adjustably setting the position of the supporting point 5 or

25 the engaging base 6. Note that 8 denotes a stirrer for agitating developing agent, and 9 a toner feeder for the toner hopper.

Figs. 2 and 3 show the embodiments using a spring as the contact pressure provider. In the embodiment shown in Fig. 2, the developing unit 2 is supported with the supporting point 5 and a spring 10 and differs from the developing unit 2 described in Fig. 1 in that the contact pressure of the developing

30 sleeve 3 against the photosensitive drum 1 can be adjusted by adjusting the pressing force of the spring 10. This embodiment is also capable of accomplishing desired development as well as the developing unit 2 shown in Fig. 1.

In the embodiment shown in Fig. 3, the developing unit 2 moves on the frame of the image formation unit by means of wheels 11, and the contact pressure of the developing sleeve 3 against the photosensitive

35 drum 1 is adjustable by the spring 10, thereby differentiating from the developing units shown in Figs. 1 and 2, but this embodiment is capable of accomplishing the desired development as well as the development unit shown in Figs. 1 and 2.

Figs. 4 and 5 respectively show the partial side views of the image formation unit embodying the development process according to the present invention. In each of these cases, the developing sleeve axis

40 is fixed whereas the position of the image carrier is left movable so that the space DSD in the development area can be kept variable.

In the embodiment shown in Fig. 4, the developing unit 2 is fixed to the frame 12 of the main unit, and the toner supplied from the toner feeder 9 is mixed with other developing agent with the stirrer 8 in order to prepare the developing agent of appropriate mixing ratio, which is to be supplied as the developing agent D

45 to the internally located developing sleeve 3. The brush formation controller 7 controls the layer thickness of the magnetic brush. On the other hand, the drum axis 1a of the photosensitive drum 1 is disposed so as to be able to move along a long groove 14 provided on the frame 13 of the main unit, and thus the space DSD in the development area can be changed depending on the position of said drum axis. The spring 10 is a compression-loaded spring disposed between the frame 13 of the main unit and the drum axis 1a and

50 exerts the pressing force to cause the surface of the photosensitive drum to press against the magnetic brush to effect the desired development of the image.

In contrast with the embodiment shown in Fig. 4 characterized by making only the photosensitive drum to be movable, the embodiment shown in Fig. 5 is characterized by making the whole body of the image carrier in the form of the drum unit to be movable. More particularly, in the embodiment shown in Fig. 5, the

55 photosensitive drum 1 and the peripherally located cleaning member 16 and the charged electrode 17 are arranged so as to constitute the drum unit 15; the wheels 11 permit said drum unit to move along the long groove 14; and the space DSD in the development area can be varied depending on the position of said drum unit. The spring 10 compressed between the frame 13 of the main unit and the drum unit 15 is loaded

with the force to cause the surface of the photosensitive drum to be pressed against the magnetic brush for accomplishing desired development of the image.

The details of the embodiments of the present invention will be explained in the following.

5

(Embodiment 1)

In the unit shown in Fig. 3, the photosensitive drum 1, 80 mm ϕ in diameter and 330 mm long, has a layer of OPC photosensitive material on its surface and is designed to be charged with the surface potential of -600 V (black part potential) as the drum rotates at a peripheral speed of 150 mm/sec. The developing sleeve 3, 30 mm in diameter and 320 mm long, of the developing unit 2 is designed so as to be able to rotate at a peripheral speed faster 2.9 times that of the photosensitive drum, in the direction indicated with an arrow in Fig. 1, wherein the internal magnetic body 4 is fixed. The layer thickness controlling gap between the sleeve 3 and the brush formation controller 7 is set to 0.4 mm. In preparing the developing agent, the toner with the average size ranging 9 - 13 μ m is prepared by adding the coloring agent into polyester resin, the carrier consisting of the ferrite cores coated with the fluororesin of 2 μ m thick is made to form the particles with the average particle size of 70 μ m, and the toner and the carrier are then mixed with the silica, titanium oxide and stearic acid to prepare the two-component developing agent. The developing unit 2 is pressed towards the photosensitive drum 1 by means of the two spring exerting the spring pressure of 575 gf, equivalent to 35.9 gf/cm in terms of the linear pressure.

The result of the experiment conducted under the above-mentioned conditions indicates that the toner image with adequate stability and density can be developed without unevenness.

In the above embodiment, a series of experiments for the development were conducted under varied conditions such as the peripheral speed of the photosensitive drum varied within 105 - 150 mm/sec., the surface potential varies within -500 V to -700 V, the rotating speed (peripheral speed) of the sleeve varied within 2 to 3.5 times that of the photosensitive drum, the layer thickness controlling gas varied within 0.25 to 1.0 mm, the thickness of resin coating for the carrier particles varies within 1 to 4 μ m, the average particle size of the carrier particles varied with 70 to 100 μ m, the average particle size of the toner varied within 9 to 13 μ m, the spring pressure varied within 400 to 700 g or the liner pressure varied within 25 to 43.8 gf/cm, and it has been clarified that the stable image with adequate density can be developed even under these conditions.

(Embodiment 2)

35

More detailed study was conducted as to the embodiment shown in Fig. 3, and the result of this study will be discussed in the following in reference to Fig. 6.

In Fig. 6, 21 denotes the image carrier of 80 mm in diameter and 320 mm in length whose circumferential surface is coated with the OPC photosensitive material, which rotates in the direction (clockwise direction) indicated with an arrow at a peripheral speed v_P of 110 mm/sec. Said image carrier is negatively charged with a corona charger not shown in the drawing; said negative charge potential decreases depending the degree of the exposure that takes place following said negative charging process; and the electrostatic latent image is formed on said image carrier 21. The relationship between the density of original image and the surface potentiality of the photosensitive material exposed to the original image according to the results of the actual measurements are as follows:

$V_{1.3}$ (Density of original image: 1.3) = -590 to -700 V

$V_{0.2}$ (Density of original image: 0.2) = -200 to -240 V

$V_{0.0}$ (Density of original image: 0.0) = -50 to -80 V

As for this embodiment, the development process concerned with the development of the electrostatic latent image and developing unit will be explained, but the image carrier need not be limited to the OPC photosensitive material nor is the charging to the negative charging. The surface potential of the image carrier also need not be limited within said range. Thus, in applying this embodiment, said development bias may be adjusted depending on the surface potential.

The developing agents applicable to the development process according to the present invention are as described in the foregoing, but the following developing agents are used in this embodiment.

The toner used in this embodiment is of the particle size of 11 μ m (by average weight) and prepared by replacing the polyester of the toner used in the embodiment 1 with the atyrene-acrylic resin and by addings 3 weight % of the polypropylene to the total weight of the toner. The magnetic carrier is of the

spherical carriers with particle size of 70 μm whose surfaces are coated with the fluororesin, and the toner can be positively charged when stirred together with the magnetic carrier. The toner consumed during the development process is replenished in the developing unit which will be explained later, and the toner density is controlled within 3 to 6 w%. The developing agent controlled within said condition maintains desirable fluidity.

In Fig. 6, 30 denotes the developing unit, which is contained in a development casing 31 of polycarbonate and the like, and the following members are contained in said casing. That is the developing sleeve 32, which contains the magnetic roll 33 consisting of a group of magnets installed stationarily inside said sleeve. The magnetic roll 33 comprises a main magnet N1 disposed opposite to the image carrier 21 and the six pieces of auxiliary magnets S4, N3, S3, S2, N2 and S1 arranged on the internal circumferential surface of said sleeve in the counterclockwise order so that said auxiliary magnets maintain their anular positions as are shown in Fig. 7 and exert the magnetic flux densities as are listed in Table 1 on the circumferential surface of the developing sleeve 32.

Table 1

Magnetic pole	Magnetic flux density (Gauss)
N1	900 ± 50
S1	550 ± 50
N2	430 ± 50
S2	340 ± 40
S3	340 ± 40
N3	350 ± 50
S4	550 ± 50

The main magnet N1 disposed opposite to the image carrier 21 is slightly (5°) inclined against the line drawn between the drum axis of the image carrier 21 and the axis of the developing sleeve 32 so that its maximum magnetic flux density is present in the upstream direction (clockwise direction.) All the auxiliary magnets their magnetic forces so as to cause the developing agent to be adsorbed on the developing sleeve 32. The auxiliary magnets S3 and S2, which are of the same polarity, are disposed adjacent to each other and thus the repulsive magnetic field is formed between them, and the developing agent which has been deposited on the circumferential surface of the developing sleeve 32, conveyed to the development area and used for the development is changed with the newly stirred developing agent in this repulsive magnetic field. In this embodiment, the magnetic roll 33 is of the stationary type, but the present invention is applicable to the rotary type magnetic roll too.

The developing sleeve 32 consists of a aluminium or a stainless steel cylinder with relatively small wall thickness having the outside diameter of 30 mm and the length of 300 mm. The external circumferential surface of said developing sleeve is of sandblast-finish (using #30 sand), and the roughness of the surface after the sandblasting treatment range within $R_a = 3 - 8 \mu\text{m}$. Said developing sleeve 32 rotates counterclockwise (in following direction in the development area) at a peripheral speed v_s of 336 mm/sec. (Number of revolution: 214 rpm) in the development process. Thus, the development in the case of this embodiment is accomplished in the following relationship of the speeds:
Speed ratio (v_s/v_p) = 3.05

As one of the conditions for the satisfactory development of the image, it is considered that the speed ratio (v_s/v_p) should be at least 2 though it is dependent on the quantity of the developing agent to be conveyed, but the value in this embodiment is not necessarily limited.

The brush formation controller 34 is disposed parallel to the axis of the developing sleeve 32 and fixed to the point on the upstream side at about 140° from the position of the main magnetic pole in the

development area E leaving the developing agent controlling space D to the developing sleeve 32. The space DH is not required to be maintained so accurately as the space in the case of the conventional developing unit or the development process. The space DH should be set to about 0.5 mm though the reason for this will be explained in details. 35A is a main stirring blade. 35B is an auxiliary stirring blade. 36 is a toner replenishing roller. 37 is a toner stirring plate. 38 is a remainder quantity detection sensor. 39 is a toner cartridge holder. When the toner cartridge containing the toner which is cylindrical in form is set in the toner cartridge holder 39, a port of the cartridge is opened by the port opening mechanism not shown in the drawing to cause the toner to drop due to the gravity, and the toner accumulates on the toner replenishing roller 36. The toner stirring plate 37 turns slowly to prevent the accumulated toner from hardening.

When the toner accumulated on the toner replenishing roller 36 is consumed, the remainder quantity detection sensor 38 detects the quantity of the remainder and gives an alarm requiring the toner cartridge to be refilled. Also, when the density of the toner in the developing unit 30 is found to be not enough through the separately installed toner density detector, this causes the toner replenishing roller 36 to rotate to replenish the developing agent pool with the toner.

The developing agent remaining in the developing agent pool is stirred together with the newly replenished toner by the auxiliary stirring blade 35B and the main stirring blade 35A in order to prepare the developing agent in which the toner is distributed uniformly, and, simultaneously, the toner is charged by the friction occurring while being stirred.

The stirred developing agent is deposited on the developing sleeve 32, and its quantity to be conveyed to the development area E is controlled by the brush formation controller 34. Then, the toner is electrostatically deposited on the electrostatically charged latent image on the image carrier 21 to accomplish the development of the image.

The developing unit incorporating the aforementioned system and capable of operating in the aforementioned manner is designed so as to be movable and has its weight of 3.5 kgf including the weight of the developing agent. Said developing unit is pressed by the spring so as to come close to the drum of image carrier 21. On the side of the recording unit, two rails 51 are installed parallelly to each other on both the near side and the far side, viewing Fig. 6 from front side. Said rails 51 are made from the material with relatively small coefficient of friction and provide the smooth surfaces with adequate rigidity.

On the other hand, the developing unit 30 is provided with two pairs of the rollers 41A and 41B for the movement of said unit, each located on both the near side and the far side. Said two pairs of rollers 41A and 41B for the movement are designed to move on the rails 51, but, in this embodiment, said rollers are provided with the ball bearings for minimising the resistances at the time of the movement. Of course, the roller bearings may be used instead of the ball bearings.

On the side of the recording unit, a compression supporting shafts 52 are provided on both the near side and the far side. The two pressure springs 53 with one end supported by the compression supporting shaft 52 are incorporated so that the compressed and forced two pressure springs 53 press the side wall 31A through a pressure shoe 54, thereby causing the developing unit 30 to be pressed against the circumferential surface of the drum of the image carrier 21. As a result, the developing agent deposited and held on the surface of the developing sleeve 32 causes the electrostatic latent image on the image carrier to be developed. In this embodiment, for the pressure springs 53, the two pressure springs with the pressure load F ranging 200 gf to 600 gf are used to provide the linear pressure ranging 13.3 gf/cm to 40 gf/cm. Consequently, the poor development having the whitening condition was observed in a few cases where the linear pressure was 13.3 gf/cm, but the satisfactory development was obtained where the linear pressure was 16 gf/cm or more.

The present invention is represented by the foregoing embodiments. The result of the study on the developing unit shown in Fig. 6 will be explained in the following.

Fig. 8 is a graphical illustration indicating the change in the space DSD in the development area where the developing agent controlling space DH is changed within about 0.4 mm to 0.6 mm. For the pressing force, an experiment was conducted using the two pressure springs 53 whose pressing forces F are set to 575 gf respectively to produce the linear pressure of 38.3 gf/cm and using a same reference image as an original image to be copied.

According to the result of the experiment, satisfactory developments can be obtained in all the cases as far as the DSD and DH are within the graphically shown ranges. This means that the system, according to the present invention characterized by that the space DSD in the development area is variable depending on the quantity of the developing agent to be supplied during the development process, automatically corrects the space DSD even when the set value of the space DH has varied or deviated for desirable development.

More strictly, however, the space DSD in the development area is primarily not dependent only on the

above-mentioned two conditions but also dependent on many other conditions to some extent. For example, the DSD is also dependent to some extent on the surface potential and line speed of image carrier, the fluidity of developing agent, the density and electric charge intensity of the toner and the density of the original image (the potential of electrostatic latent image). The result of the study by the present inventor indicates that there is the following relationship between the condition of the original image (Black solid printed matter or blank white paper) and the space DSD in the development:

$$\text{DSD (Black solid printed matter)} = \text{DSD (Blank paper)} + 0.02 \text{ mm.}$$

In the foregoing, the content of the present invention is explained in reference to its embodiments. The content of the present invention, however, is not limited to that represented by above embodiments. For example, in said embodiment, the pressure spring 53 are used as the means for providing the pressing force that cause the circumferential surface of the developing sleeve 32 to be pressed against the surface of the image carrier 21. Instead of said kind of pressure-producing means, however, the means for obtaining the necessary pressing force from the component of the weight of the developing unit 30 by inclining the rails 51 for the movement of said developing unit 30 may be employed. Besides, the direction of the movement of the developing unit 30 may be converted into the pressing force by means of the dead weight. Furthermore, in the embodiment described in the foregoing, the surface position of the image carrier 21 is fixed, and the developing unit 30 is pressed so as to be brought close to said developing unit, but the development process according to the present invention permits the developing unit 30 to be fixed while the image carrier 11 is pressed so as to be brought close to said developing unit 30, and such development process is also included in the concept of the present invention.

The development process according to the present invention is characterized by the variable space in the development area that permits the image carrier and the magnetic brush to be pressed against each other during the development process, so that a stable brushing force is produced between the image carrier and the developing agent to develop the high-quality image stably.

Furthermore, the space in the development area can be varied depending on the quantity of the developing agent deposited on the developing sleeve for conveyance, so that the developing agent can flow smoothly without causing the scattering of the developing agent.

Also, according to the development process of the present invention, it is not necessary to rise up the toner concentration in the two-component type developing agent even when the OPC is used for the photosensitive material of the photosensitive drum, so that the toner of adequate concentration which will not cause uneven development can be obtained stably, and this one of the outstanding features of this development process.

Further, the development process and the developing unit according to the present invention is provided with the function to enable the automatic control of the space in the development area, and this permits the accuracy and the allowance of the brush formation controlling member and the allowances of the deflections of the image carrier drum and the developing sleeve due to their eccentricities to be set broader than those of the conventional developing unit, so that the manufacturing costs of the parts and the number of steps of assembly work can be reduced.

The improvement of the conventional developing unit through the introduction of the aforementioned development process will be explained in the following.

With respect to the aforementioned development process, as the means for keeping the developing sleeve pressed against the image carrier at a constant intensity, the means for pressing the whole developing unit elastically by the separately provided spring member and the system for pressing the developing unit by utilizing its own weight as the dead weight have been explained.

Said systems, however, may cause the hardening of the developing agent that ends up with the formation the depressed marks on the surface of the image carrier or the crystallization of the photosensitive material such as one containing Se, since, with said systems, the developing sleeve is left pressed against the image carrier even after the developing unit comes to rest, thereby causing the developing agent layer to be left compressed for a long period of time to promote the packing and the hardening of the developing agent.

The packing of the developing agent can cause the scattering of the image carrier or cause unnecessary developing agent to be deposited on the image carrier when the developing unit is started, thereby causing deterioration of the developed image.

The present inventors have taken into account said short-comings of aforementioned systems and improved said systems to prevent the packing of the developing agent layer that occurs when the developing agent layer is left compressed for a long period of time.

More specifically, the developing unit comprising the electrostatic latent image carrier and the magnetic brush supporter which are disposed opposite to each other and to be able to change their realative positions freely so that the magnetic brush can be pressed against said electrostatic latent image carrier to accomplish the desired development is improved by providing the means for separating said magnetic
 5 brush and said electrostatic latent image carrier from each while the development process is not in progress.

The embodiment of the present invention comprising the above-mentioned improved system is shown in Figs. 1 through 18.

10 Figs. 11 and 12 show the improved version of the developing unit shown in Fig. 6. This improved developing unit has a rotary shaft 152 with a pair of elliptical cams 151 set to the same angular phase fixed on the front and the rear end of said shaft is disposed parallelly to said depressing shaft 142.

On the other hand, each of the side walls 121 at the front and the back of said developing unit housing 121 is provided with a square notch 121B so that said cams 151 can respectively fit into the openings of said notches 121B.

15 While the developing unit 120 is in operation, the rotation of said rotary shaft 152 is controlled by the signal from the controller of the recording unit to set the rotary angle of said rotary shaft to the point at which said cams 151 rise as illustrated in Fig. 11, and so some gap can be formed between the edge side 121C of the member with said notch 121B and said cam 151.

Thus, said developing unit 20 is pressed towards the left by the elastic force of said pressure spring 20 143 to cause the developing sleeve 122 with the developing agent deposited and carried on its surface to be pressed against the surface of said image carrier 111 to effect the development of the electrostatic latent image.

When the developing unit 120 has stopped to operate, said rotary shaft 152 is caused to rotate clockwise by about 90° starting from the angle indicated in Fig. 11 according to the signal issued from said
 25 controller and kept at the position indicated in Fig. 12.

During the course in which said can 151 reaches the angle indicated in Fig. 12, the edge side 121C of said notch 121B is depressed by the circumferential surface of the cam 151, so that said edge side 121C is caused to move on said rail 141 towards the right against the elastic force of said pressure spring 143 as said rollers 131A and 131B for the movement rotates and stop at the position indicated in Fig. 12.

30 Consequently, the developing unit 120 is caused to retreat towards the left to open the development area E between the developing sleeve 122 and the image carrier 111, so that the compressive force acting on the developing agent on the developing sleeve 122 can be removed.

With respect to each of the following embodiments, the systems such as those for bringing said developing unit 120 to be pressed against the image carrier 111 or bringing it to be released from the
 35 pressure will be explained.

Fig. 13 and 14 show the second embodiment of the present invention, in which the developing unit 120 is pressed against the image carrier 111 or released from the pressure by the pressing system as is explained in the following.

40 The pressure spring 243 is installed in compressed condition between the pressing shoe 244 and the guide cylinder 245 that contains said pressing shoe 244 so that the sliding stroke of said pressing shoe 244 is suppressed.

Said guide cylinder 245 is supported slidably in horizontal direction to the body of the developing unit, and the pressure pin 245A is linked to the slot cam 246A of the cam plate 246.

45 The cam plate 246 with said slot cam 246A is fixed to the rotary shaft 247 installed on the main unit and has the radius with the curvature that gradually diminishes in counterclockwise direction so as to enable said guide cylinder 245 to slide horizontally through said pin 245A as said rotary shaft 247 rotates.

Fig. 13 shows that the cam plate 246 is at the angular position where said cam plate came to rest after rotating counterclockwise due to the rotation of said rotary shaft 247, and that the guide cylinder 245 is at the leftmost position after being caused to slide towards the side of the developing unit by said slot cam
 50 246A.

In the course of the displacement of said guide cylinder 245, the end of the pressing shoe 244 comes to contact the side wall 121A of the developing unit 120 to cause said developing unit 120 to be pushed towards the side of the image carrier 111 and kept pushed even after the operation of the developing unit is stopped, and so the pressure said pressure spring 243 increases to cause said developing unit 120 to be
 55 pushed further thereby causing the developing sleeve 122 to be pressed slidably against the surface to the image carrier 111 to effect the development of the electrostatic latent image.

On the other hand, to cancel the contact pressure of the developing sleeve 122 to the image carrier 111, the cam plate 246 is caused to rotate counterclockwise and stop by the rotation of said rotary shaft

247, so that, as shown in Fig. 14, the guide cylinder 245, while suppressing the pressing shoe 244, is caused to move towards the right due to the change of the curvature radius of said slot cam 246A, whereby the pressure acting on the developing unit 120 can be cancelled.

Consequently, the developing unit 120 is set free on the rails 141 thereby opening the development area E as shown in Fig. 14.

Figs. 15 and 16 show the third embodiment. In this embodiment, the rails 241 are fixed at a predetermined declination against the image carrier 111 so that the developing unit 120 on said rails 241 is caused to move towards the image carrier 111 due to the component of the dead weight of the developing unit itself.

That is, where the total weight of said developing unit 120 including the weight of the developing agent is assumed to be 3.5 kgf, and said declination to be 6° , the component of the total gravity can be determined as

$$3.5 \text{ kgf} \times \sin 6^\circ = 0.36 \text{ kgf}$$

Thus, the developing sleeve 122 is pressed against the surface of the image carrier 111 with the force given above to provide a desirable condition for the development of the image.

Thus, this embodiment can dispense with the pressure spring 143 or 243 which is required in the first and the second embodiments, and the pressure to bring the developing sleeve 122 to contact the image carrier 111 can be cancelled by the rotation of the cam 151 like the case of the first embodiment; however, in this embodiment, the development area E can be opened by simply resisting the dead weight of said developing unit 20 as shown in Fig. 16.

Figs. 17 and 18 show the fourth embodiment, wherein the rails 341 are installed so as to be able to oscillate freely on the axis 342 to serve as the supporting point, and said rails are supported with the cam 343 located beneath said rails 341.

When said cam 343 makes the angle at which said cam rises as illustrated in Fig. 17, said rails 341 are declined at a predetermined angle, whereby said developing unit 120 on said rails 341 is caused to move towards the image carrier 111 due to the force deriving from the component of the dead weight of said developing unit itself.

Thus, the pressure spring 143 or 243 which is required in the first and the second embodiments is not required in this embodiment, since the developing sleeve 122 can be brought to be pressed against the surface of the image carrier 111 to effect the desired development of the image owing to the force deriving from the component of the dead weight of the developing unit 120 like the case of the third embodiment.

To cancel the pressure to cause the developing sleeve 122 to be brought to be pressed against the image carrier 111, as illustrated in Fig. 18, said cam 343 is caused to rotate clockwise by about 90° so that said rails 341 is brought to be horizontal or declined slightly to the image carrier 111, whereby the component deriving from the dead weight of the developing unit 120 can be cancelled to release the development area E as illustrated in Fig. 18.

An object of the present invention is to provide an electrostatic recording system wherein the gap between the developing sleeve and the image carrier of the developing unit can be adjusted automatically while the development process is in progress, whereas the gap can be kept larger than the adjustable range while the developing unit is at rest, so that the developing agent can be brought to slidably contact the image carrier while producing adequate brushing effect between the developing agent and the image carrier, and the packing of the developing agent that may occur while the developing unit is at rest can be prevented, whereby the developing unit capable of constantly developing the highquality images can be provided.

In the development system designed so that the relative positions of said developing unit comprising the magnetic brush supporter and electrostatic latent image carrier can be varied freely, and the magnetic brush that has passed the developing agent controller is pressed against said electrostatic latent image carrier to effect the desired development of the image, the packing or hardening of the developing agent that may occur when left unused for a long period of time can also be prevented where the rollers having the outside diameters larger than the outside diameter of the magnetic brush supporter and not coming into contact with the electrostatic latent image carrier during the development process are installed on the same axis as that of the magnetic brush supporter.

The embodiment wherein the developing unit incorporating said rollers will be explained in the following in reference to Figs. 19 through 23.

In said developing unit, the set position of the brush formation controller 407 is normally adjusted so that the developing agent controlling space DH range within 0.4 to 0.6 mm, and the pressing force (gf) is

adjusted so that the linear pressure (gf/cm) to be determined by dividing the pressing force by the axial length (cm) of the developing sleeve in the development area E ranges within 15 to 80 gf/cm where the development can be effected satisfactorily.

When said linear pressure is set to 38.3 gf/cm, the relationship between said developing agent
5 controlling space DH and the space DSD in the development area can be expressed graphically as in shown in Fig. 18, according to the result of the experiment.

Where the recording unit has been left unused over a long period of time, the developing agent D in the development area E is subjected to the compressive force, and said space DSD in the development area will be reduced gradually to cause the developing agent D to be packed and hardened, which adversely
10 affect the later development process. According to the present invention, however, the rollers 404 having the outside diameter larger by 0.4 to 0.5 mm than the outside diameter of the developing sleeve 433 of the development roller 403 as the supporter of the magnetic brush are installed on both ends of the development roller, so that said space DSD in the development area will not becomes smaller than the values ranging within 0.2 to 0.25 mm, whereby the packing and hardening of the developing agent D can be
15 prevented.

Fig. 21 is a cross-sectional view showing another embodiment of the present invention. In this embodiment, the photosensitive drum 401 as the electrostatic latent image carrier is movable in the form of the drum unit, whereas the developing unit 422 is stationary. That is, the photosensitive drum 401 rotably supported by the drum unit 425 through the shaft 401a and peripherally located cleaner 426 and the
20 charged electrode 427 are integrated into the drum unit, and the wheels 428 installed on the drum unit 425 move along the longitudinal groove 429 provided on the frame 423 of the body of the recording unit, whereby the space DSD in the development area can be varied according to the position of the drum unit. The pressure spring 424 is compressed between the frame 423 of the main unit and the drum unit 425 and exerts its pressure so as to cause the surface of the photosensitive body to be pressed against the
25 magnetic brush to effect the desired development of the image.

The developing unit 422 comprises the development roll 403 with the rollers 404 installed on its both ends, the brush formation controller 417, stirring blade 418 and toner replenisher 419.

The development rollers 403 used in the foregoing two embodiments will be explained in details in the following.

Fig. 22 is an oblique perspective view showing the development rollers according to the present invention. Fig. 23 is a lateral cross-sectional view showing said development rollers including their shaft. As shown in Fig. 23, the rollers 404 are installed rotably to the rotary shaft 433a of the developing sleeve 433 and to the stationary shaft 434a of the magnetic roller 434 through the ball bearing 436A. The bearing 436B is a bearing installed between the magnetic roll 434 and the rotary shaft 433a. The bearing 436C is a
35 bearing installed between the developing sleeve 433 and the stationary shaft 434a.

The magnetic roll 343 is provided with the main magnet and the auxiliary magnets which have already been explained in reference to Fig. 7.

As discussed previously, the outside diameters of rollers 404 being set larger by 0.4 - 0.5 mm than the outside diameter of the developing sleeve 433, even when the recording unit is left unused for a long period
40 of time not only leaving the developing agent in the development area subjected to compressive force but also causing the space DSD in the development area to be reduced, the circumferential surfaces of the rollers 404 contact the ends of the circumferential surfaces of the photosensitive drum 401 to prevent the space DSD in the development area from reducing below 0.2 - 0.25 mm. Thus, the compaction and hardening of the developing agent can be prevented.

As discussed in the foregoing, the developing unit according to the present invention is movable to the image carrier within the recording system, and said developing unit comprises the rotary parts such as the developing sleeve as the means for accomplishing the desired development. The present inventors have studied from various angles the means for transmitting the rotation and the driving force of the drive motor to the movable developing unit.

The developing unit according to the present invention is designed to accomplish the desired
50 development by causing the magnetic brush to be pressed against the image carrier by providing almost constant pressure, but it is no easy matter to provide a developing unit that is capable of performing the development operation at stable condition without having said contact pressure hindered or varied excessively due to the transmission of the driving force to the developing unit from the drive system. More particularly, in transmitting the electric power to the developing unit from the main system, depending on
55 the construction of the transmission system, the torque to be transmitted may include the component of the force that acts against the force required for the developing unit to be pushed, or the vibration due to the transmission of the electric power may reduce the necessary contact pressure, and thus it is not easy to

provide a system capable of keeping the developing unit pressed against the image carrier at a constant contact pressure.

Thus, it is another object of the present invention to overcome the above-mentioned difficulties and provide a developing unit capable of receiving the transmission of the electric power without adversely
5 affecting the contact pressure of the developing unit to the image carrier so that the developing process can be operated stably and efficiently at all times.

The above objective of the present invention can be attained by providing a development system featuring that the developing unit comprising the magnetic brush support is designed movable and that the
10 developing unit designed to accomplish the desired development by bringing the magnetic brush to be pressed against the electrostatic latent image carrier is driven by the drive motor installed on said movable developing unit.

The electric power to drive said developing unit according to the present invention is provided by the drive mechanism described in the following.

Fig. 24 shows the gear system of said developing unit 120 located on the back of the side wall 121A at
15 the innermost side of the housing 121 of said developing unit. The shafts S1, S2, S3, S4 and S5 are the shafts as the axis of rotation of said developing sleeve 122, main stirring blade 125A, auxiliary stirring blade 125B, toner replenishing roller 126 and toner stirring plate 127 which are extended through said side wall 121A.

The spur gears G1, G2 and G3, the intermediate gear G6 meshing with said spur gear G3 and the spur
20 gears G4 and G5 meshing parallelly with said intermediate gear G6 are fixed to each of said shafts respectively so that when the drive power is transmitted to said spur gear G1, all said spur gears or all said shafts start to turn simultaneously to drive various parts within said developing unit 120 in the directions indicated by arrows respectively for operating the development process.

The stepped gear consisting of the drive gear G0 meshing with said spur gear G1 and the worm gear
25 WG which are combined into a unit is rotably supported with the shaft S0 installed at the back of said side wall 121A, and said worm gear WG meshes with the worm gear W on the shaft of the drive motor M supported with the bracket B installed on the back of said side wall 121A.

Said drive motor M is supplied with the power from the power source of the recording unit through a
30 cable and causes said spur gear G1 to rotate counterclockwise at the rate of 214 revolutions per minute through said worm gear system and the drive gear G0.

As described in the foregoing, the developing unit 120 according to the present invention contains the power source to drive various parts and all the power transmission systems, so that the operations of
35 various parts are not affected at all by the position of the developing unit 120. Consequently, the elastic action of said pressure spring 143 can be utilized fully, and this enables the space DSD in the developing area to be maintained stably and accurately.

Fig. 25 is a diagram showing the relationship between the pressure load by the pressure spring 143
40 and the value of the space DSD in the development area as to the Case I where the developing agent controlling space DH is set to 0.55 mm and the Case II where the same is set to 0.40 mm. This diagram indicates that, in each of said cases, the elastic action of the said pressure spring 143 enables the near side and the far side of said developing unit 120 to be subjected to uniform pressure load, so that the space DSD in the development area can be maintained uniform throughout the full length of the developing sleeve.

The developing unit according to the present invention is designed so that the space in the develop-
45 ment area formed between the image carrier and the developing unit can be varied automatically depending on the quantity of the developing agent by means of the pressing force acting to cause the developing unit to be pushed towards the image carrier, and whereby the brushing force produced between the image carrier and the developing agent can be stabilized; furthermore, the power source to drive said developing unit and the rela-power transmission systems are all contained in the developing unit, so that the zigzag motion of the developing unit caused by the component of the drive force occurring in transmitting the
50 power from the drive system can be eliminated; consequently, almost uniform space in the development area can be provided covering the full length of the developing sleeve corresponding to the pressure given from the back; as a result, a developing unit featuring the freedom from the unnecessary vibration during the development process and the extremely reliable performance to promise the stable and efficient development operation can be provided.

55 The transmission of the power to the developing unit according to the present invention, however, can also be accomplished even when the power transmission system that causes the component of the force from the power transmission system provided on the side of the main system to be exerted in the direction of said compact pressure.

Fig. 26 shows the gear system of said developing unit provided on the back of the innermost side wall 121 of the housing 121 of the developing unit.

The part of the power from the power source of the main unit of the recording system is transmitted to the shaft S0 supported with the bearing on the base of the main unit through the power transmission system not shown in the drawing and said image carrier 111 to cause the drive gear G0 fixed to said shaft S0 to turn clockwise.

Said drive gear G0 is installed on the fixed location on the main unit, but, as explained previously, when the developing unit is pressed leftward to cause the developing sleeve 122 to be pressed against the image carrier 111, said drive gear is meshed with the said spur gear G1 to cause the drive power of the main unit of the recording system to be transmitted to the developing unit 120.

According to the present invention, the center of rotation of said drive gear G0 or the position of said shaft S0 is set so as to make an angle θ with the horizontal line passing the center of rotation of said spur gear G1 as illustrated in Fig. 26, whereby the angular moment F of said drive gear G0 to be transmitted to said spur gear G1 comprises the component of force F1 in vertical direction and the component of force F2 in horizontal direction that is to cause said spur gear G1 to be pushed towards the image carrier 111.

Consequently, the developing unit 120 is subjected not only to the elastic action of the pressure spring 143 but also to the pressure deriving from the component of the force F2 occurring in transmitting the power from said drive gear G0 so that said developing unit can be pressed more surely against the image carrier 111 to ensure the stable and accurate development operation at all times.

Besides, said angle θ should not be too small nor too large in order to expect the aforementioned effect, and so the angle should preferably range within 20° to 35° . If the component of force F2 causes the negative pressure, the drive power cannot be transmitted adequately, thereby causing the vibration and unstable operation of the developing unit 120.

Thus, in the developing unit 120 according to the present invention, the space DSD in the development area is dependent on the pressure load consisting of the pressure from said two pressure springs 143 and said component of force F2 deriving from the drive gear G0. The result of the actual measurement of the relationship between DSD and the pressure load indicates that the DSD varies almost linearly.

In Fig. 27, Case I represents the relationship between the pressure of the pressure spring 143 and the space DSD in the development area where the developing agent controlling space DH is set to 0.55 mm, and Case II represents the same where the developing agent controlling space DH is set to 0.40 mm. In each of these cases, the added pressure acts on the far side of the developing sleeve 122 due to the reason that the said component of force F2 acts only on the far side, and the space DSD in the development area is relatively small for the far side of the developing sleeve, whereas the same is slightly large for the near side, thereby producing slight difference in the value of DSD. Such slight difference, however, scarcely affect the actual image processing as far as the development process according to the present invention is applied, so that the difference can scarcely be recognized as far as the developed images are concerned.

The developing unit according to the present invention is designed so that the space in the development area formed between the developing unit and the image carrier can be varied automatically depending on the quantity of the developing agent by the pressing force to cause the developing unit to be pushed towards the image carrier in order to stabilize the brushing force produced between the image carrier and the developing agent. Furthermore, said developing unit is designed so that the component of the force deriving from the power transmission system can be used positively together with said pressure to ensure the developing unit to be pushed more securely or prevent undesirable condition such as the vibration during the development operation. Thus, the pressing force acting on said developing unit can always be maintained at an appropriate level, and so the developing unit promising high-quality development through stable operation can be provided.

50 Claims

1. An image forming apparatus for use in electrophotography comprising
 - an image holding means having an image surface capable of forming an electrostatic latent image thereon,
 - a developing means having a magnetic brush-supporting surface and a magnet member, thereby forming a developing agent in a magnetic brush on said magnetic brush-supporting surface,
 - said image surface and said magnetic brush-supporting surface being disposed to opposite to each

other so as to contact the magnetic brush with said image surface, and
a relative positional relation between said image surface and said magnetic brush-supporting surface capable of being variable while performing the development.

2. The image forming apparatus of claim 1,

5 wherein said magnetic brush exerts a press contact force between said image surface and said magnetic brush-supporting surface and the press contact force is controlled within a predetermined range.

3. The image forming apparatus of claim 2,

wherein said image forming means is adapted to be movable in response to the press contact force.

4. The image forming apparatus of claim 2,

10 wherein said developing means is adapted to be movable in response to the press contact force.

5. The image forming apparatus of claim 2,

wherein said predetermined range of the press contact force is represented by 5 - 200 gf/cm in the term of line pressure with respect to the width of said magnetic brush-supporting surface.

6. The image forming apparatus of claim 5,

15 wherein said predetermined range is preferably determined in the range of 15 - 80 gf/cm.

7. The image forming apparatus of claim 1,

wherein, while said image forming apparatus does not perform the development, said relative positional relation is made not to contact the magnetic brush with said image surface.

8. The image forming apparatus of claim 7,

20 wherein at least one of said image surface and said magnetic brush-supporting means is biased by a spring to exert a press contact force between them.

9. The image forming apparatus of claim 8,

wherein, while said image forming apparatus does not perform the development, said spring is released from the biasing operation.

25 10. The image forming apparatus of claim 7,

wherein a disposing condition of said developing means is oriented to exert a component force of its gravity onto said image surface so as to press the developing agent.

11. The image forming apparatus of claim 10,

30 wherein, while said image forming apparatus does not perform the development, said orientation of the disposing condition of said developing means is corrected so as not to exert the component force onto said image surface.

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FIG. 1

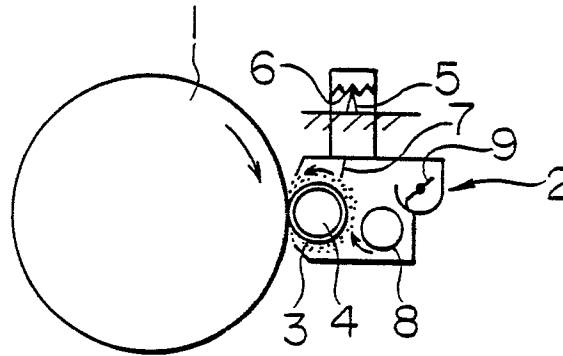


FIG. 2

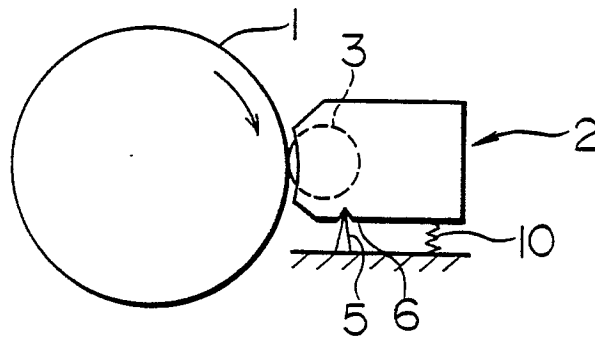


FIG. 3

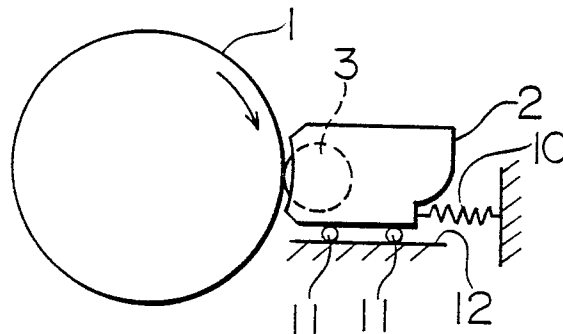


FIG. 4

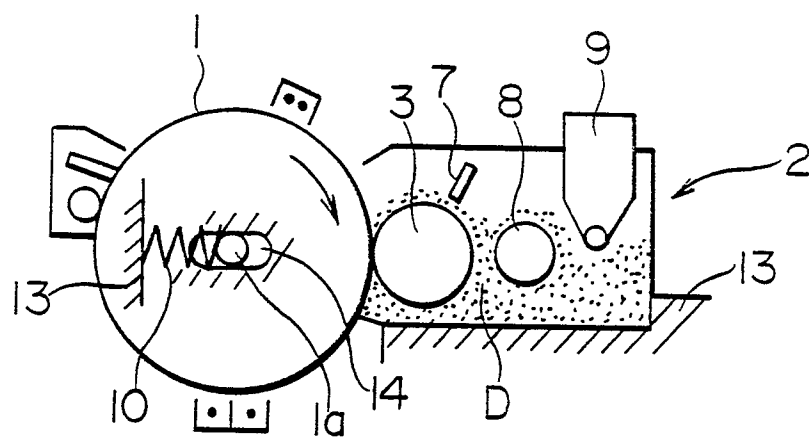


FIG. 5

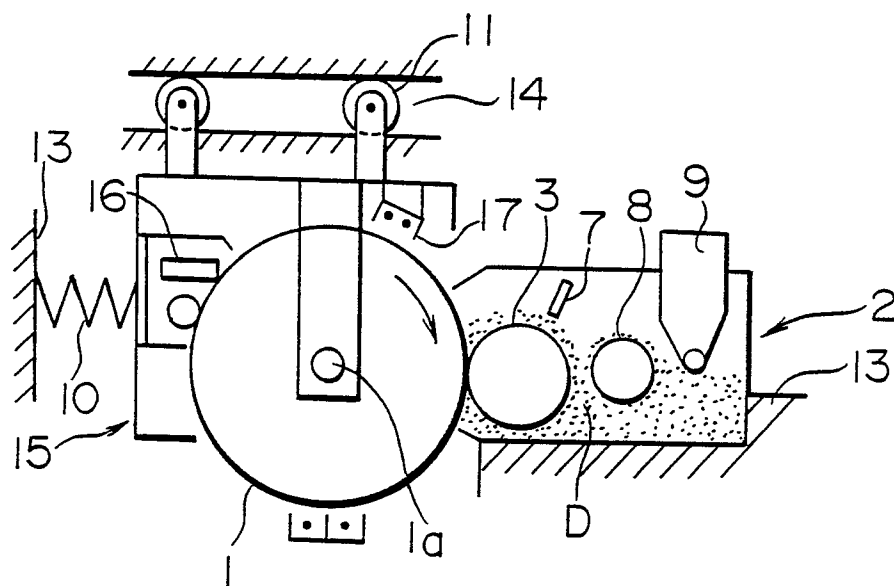


FIG. 6

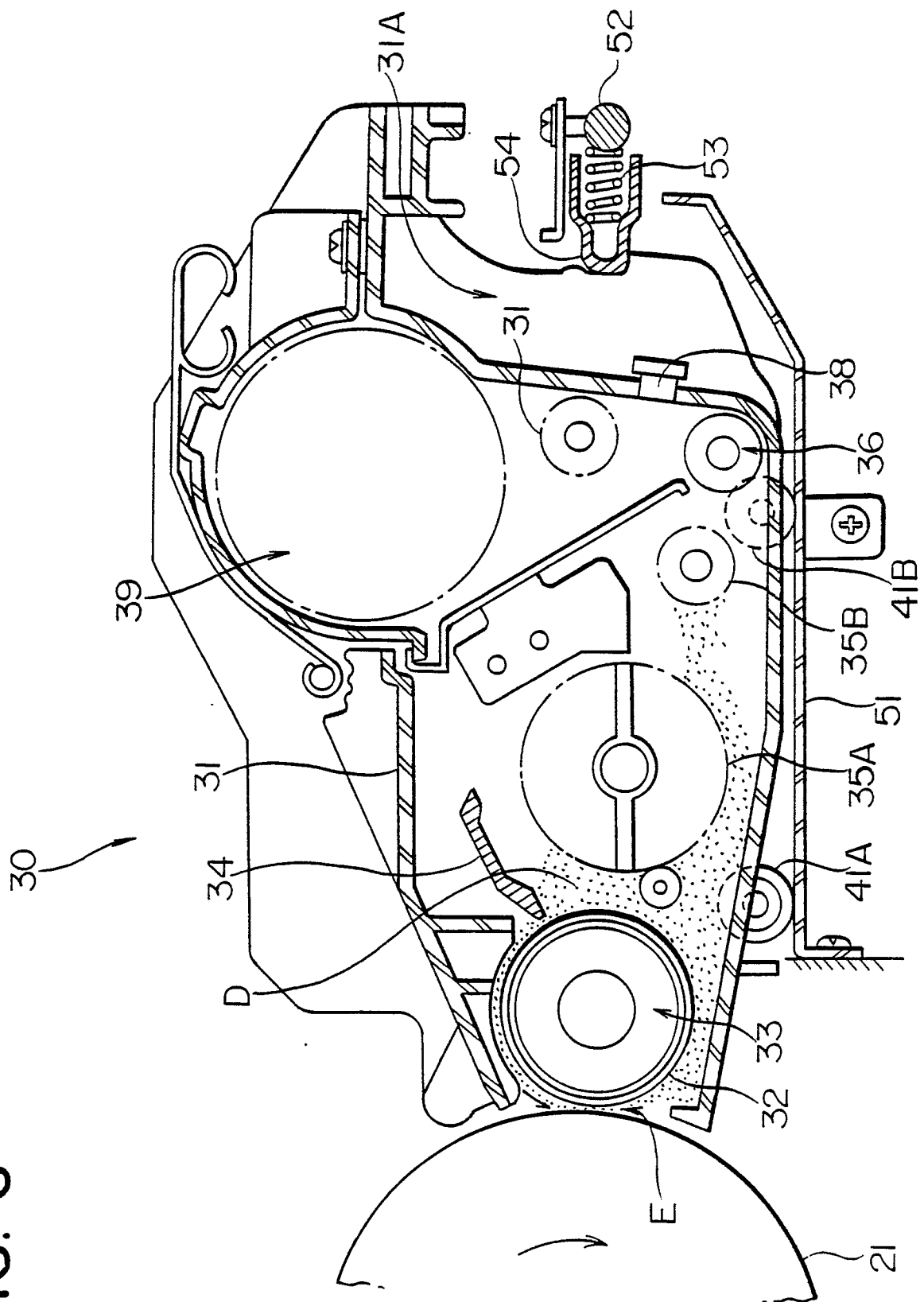


FIG. 7

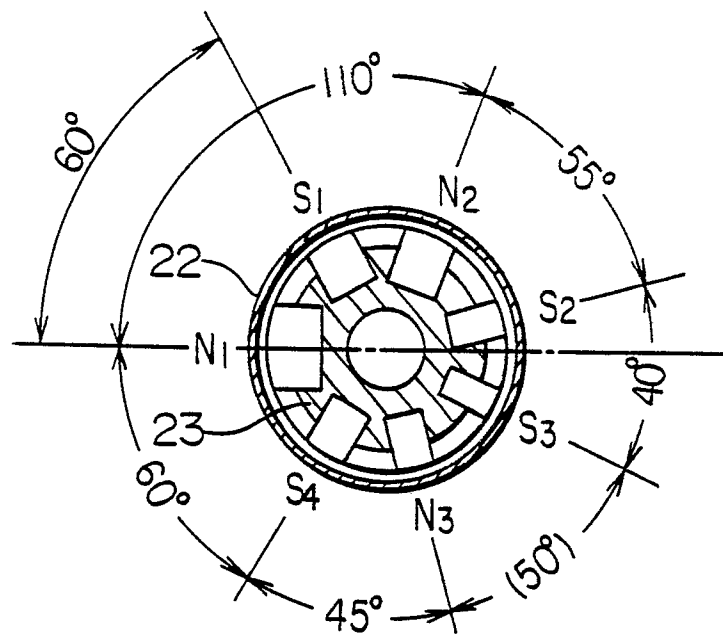


FIG. 8

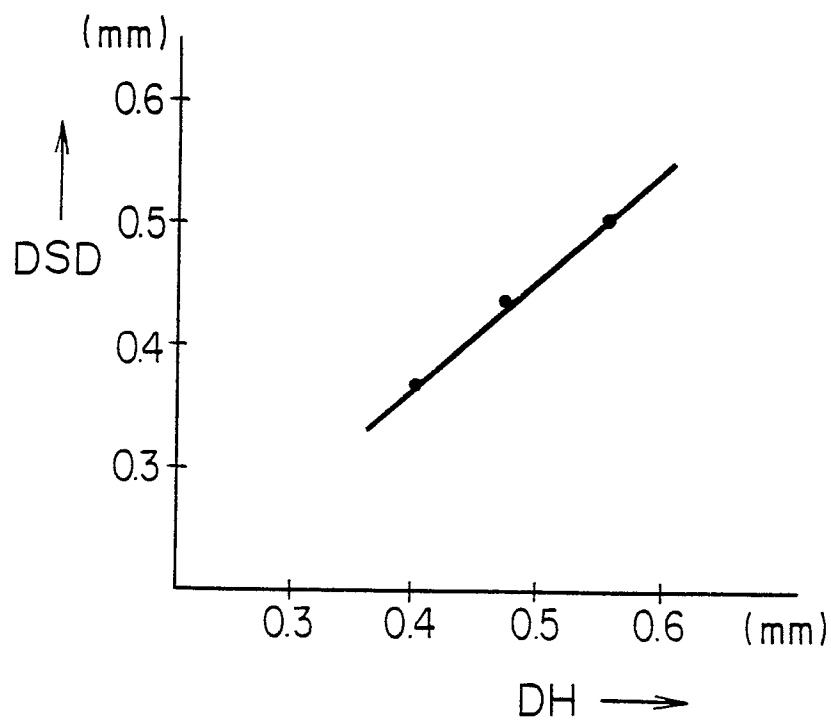


FIG. 9

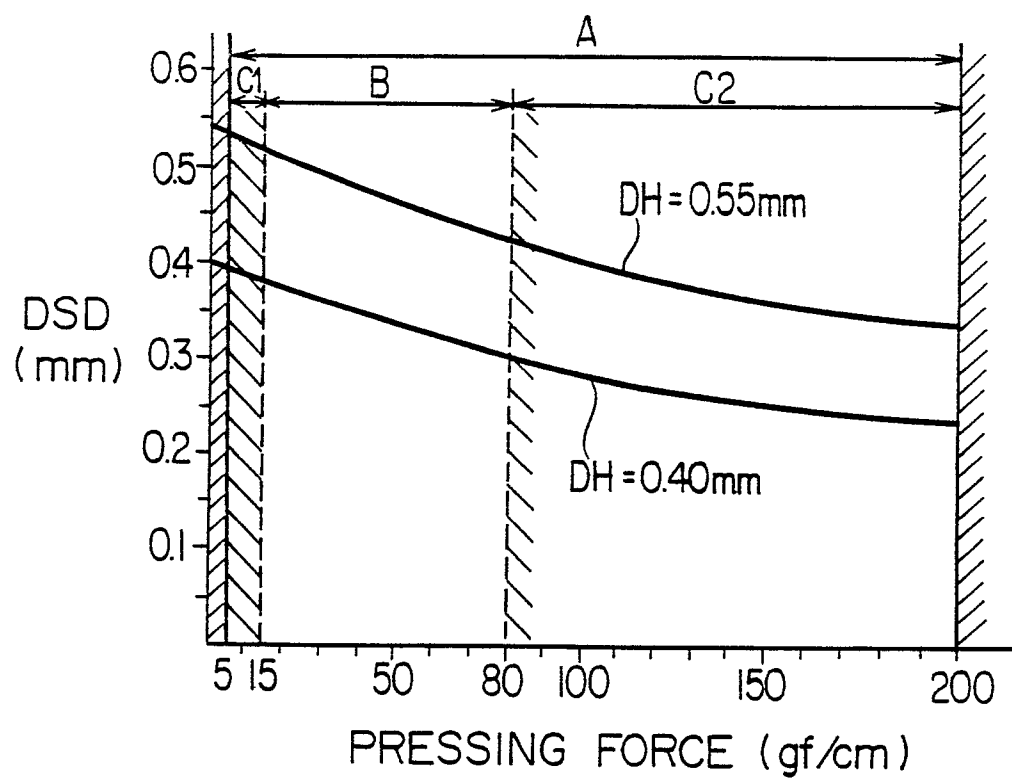


FIG. 10

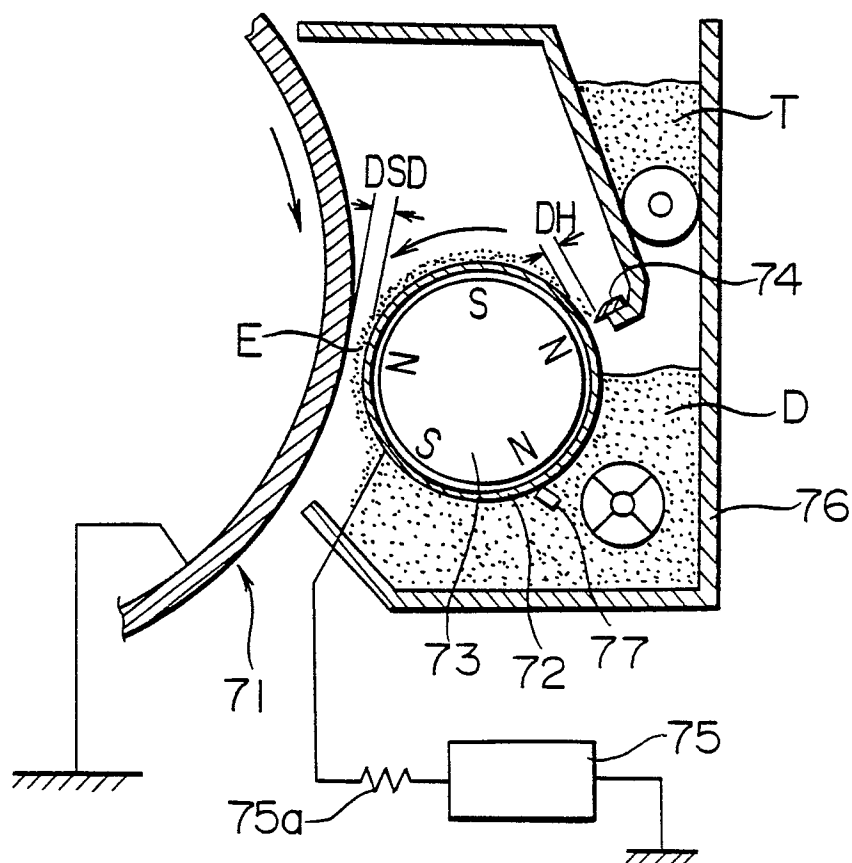


FIG. 11

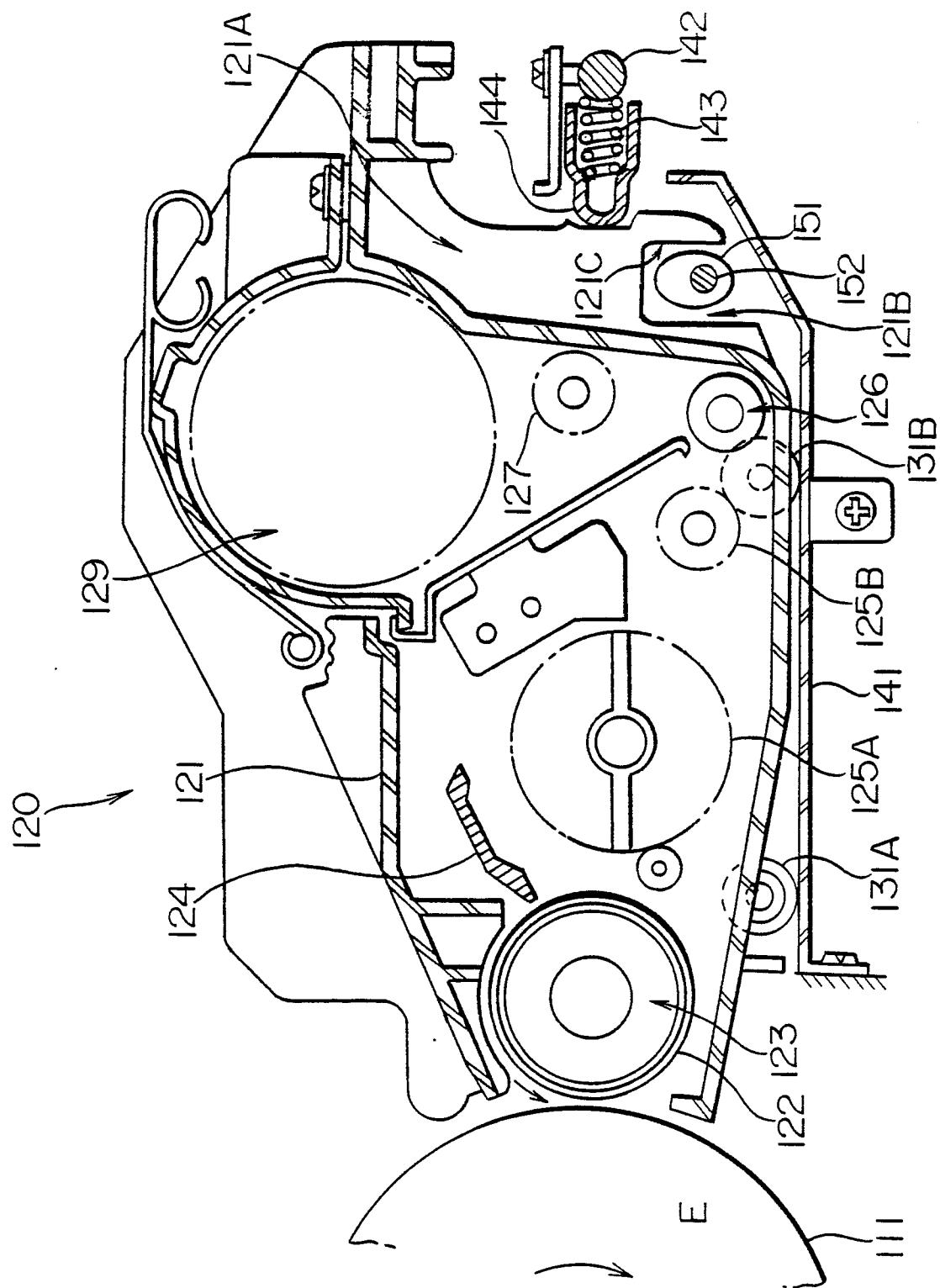


FIG. 13

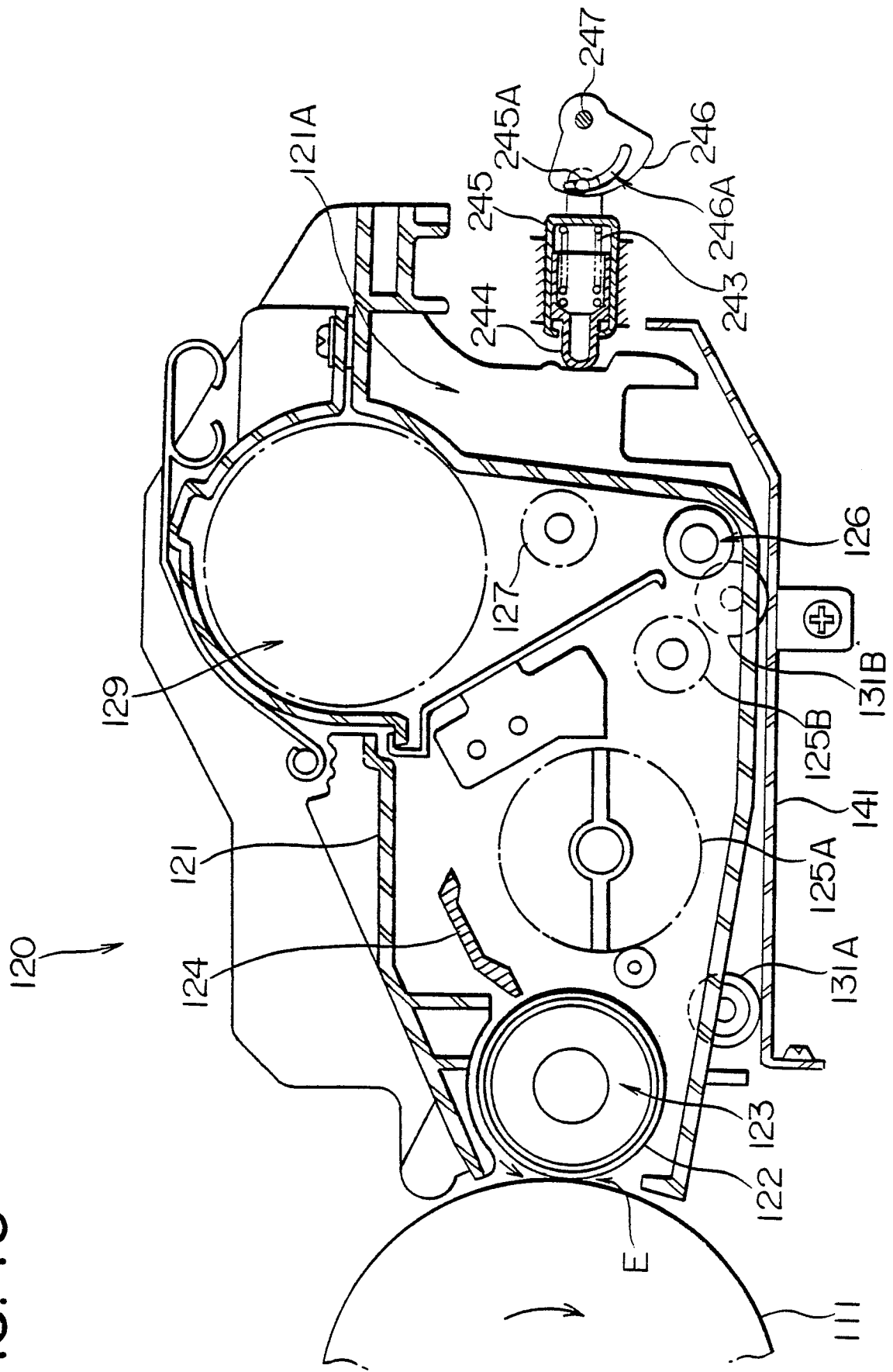


FIG. 14

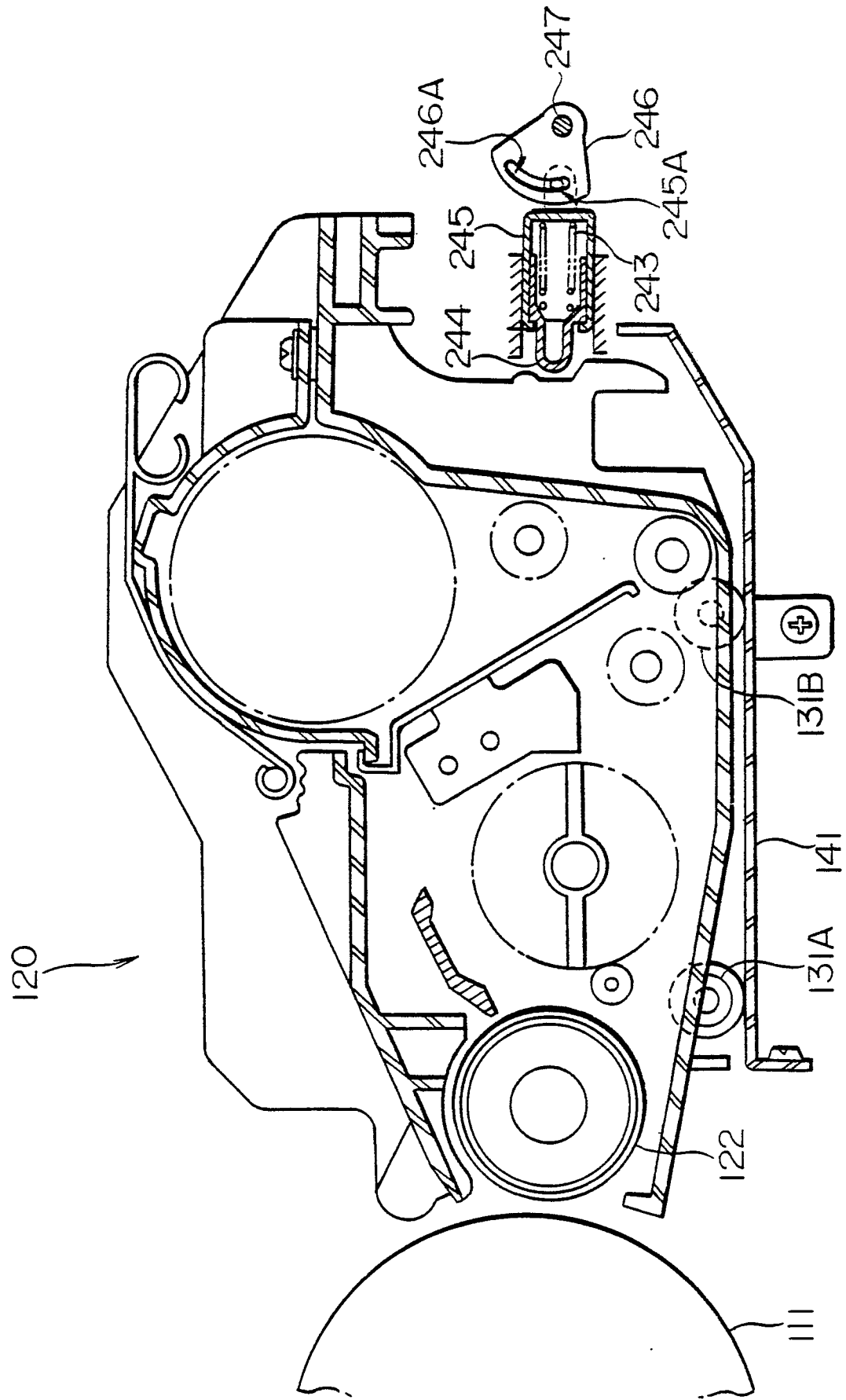


FIG. 15

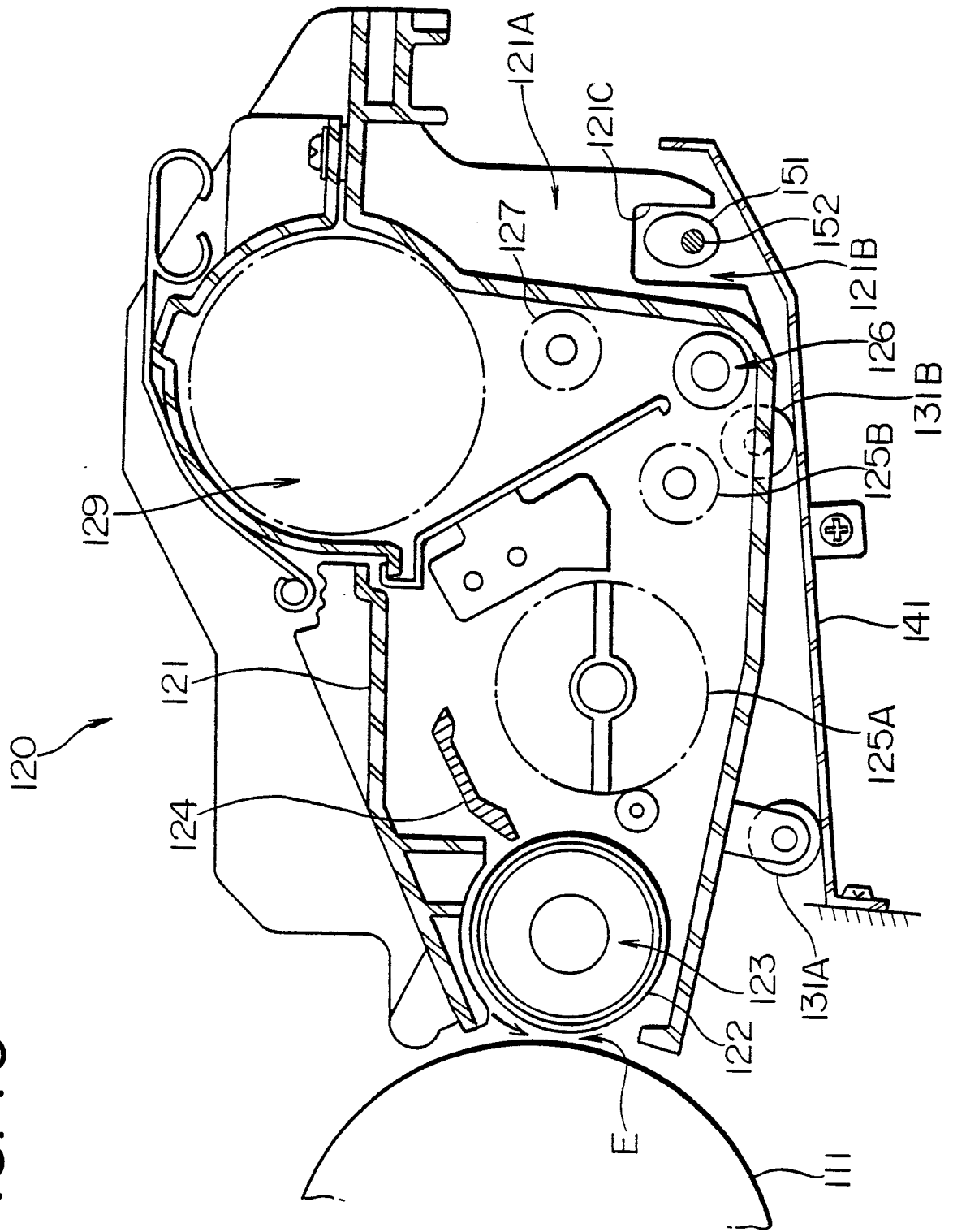


FIG. 16

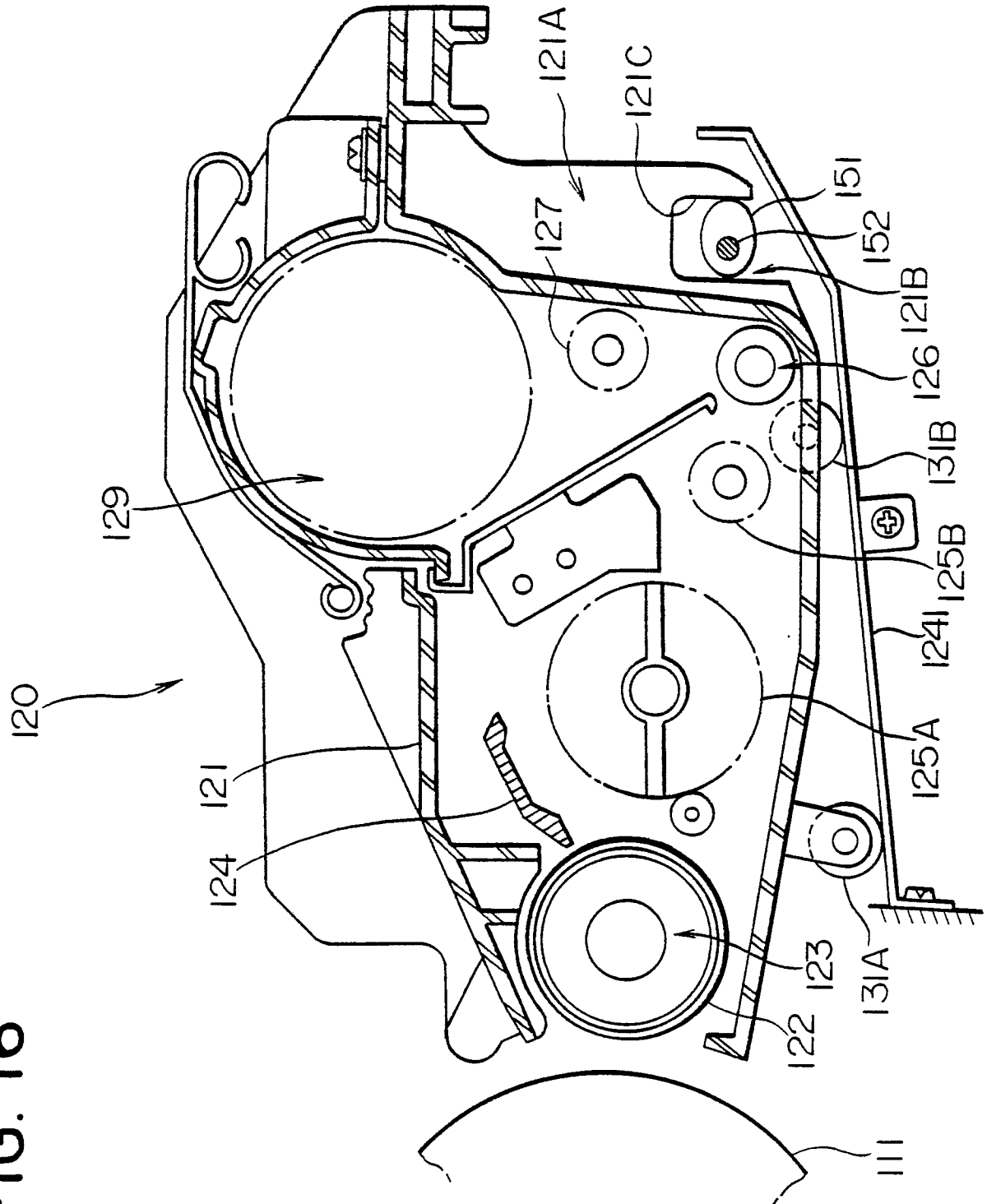


FIG. 17

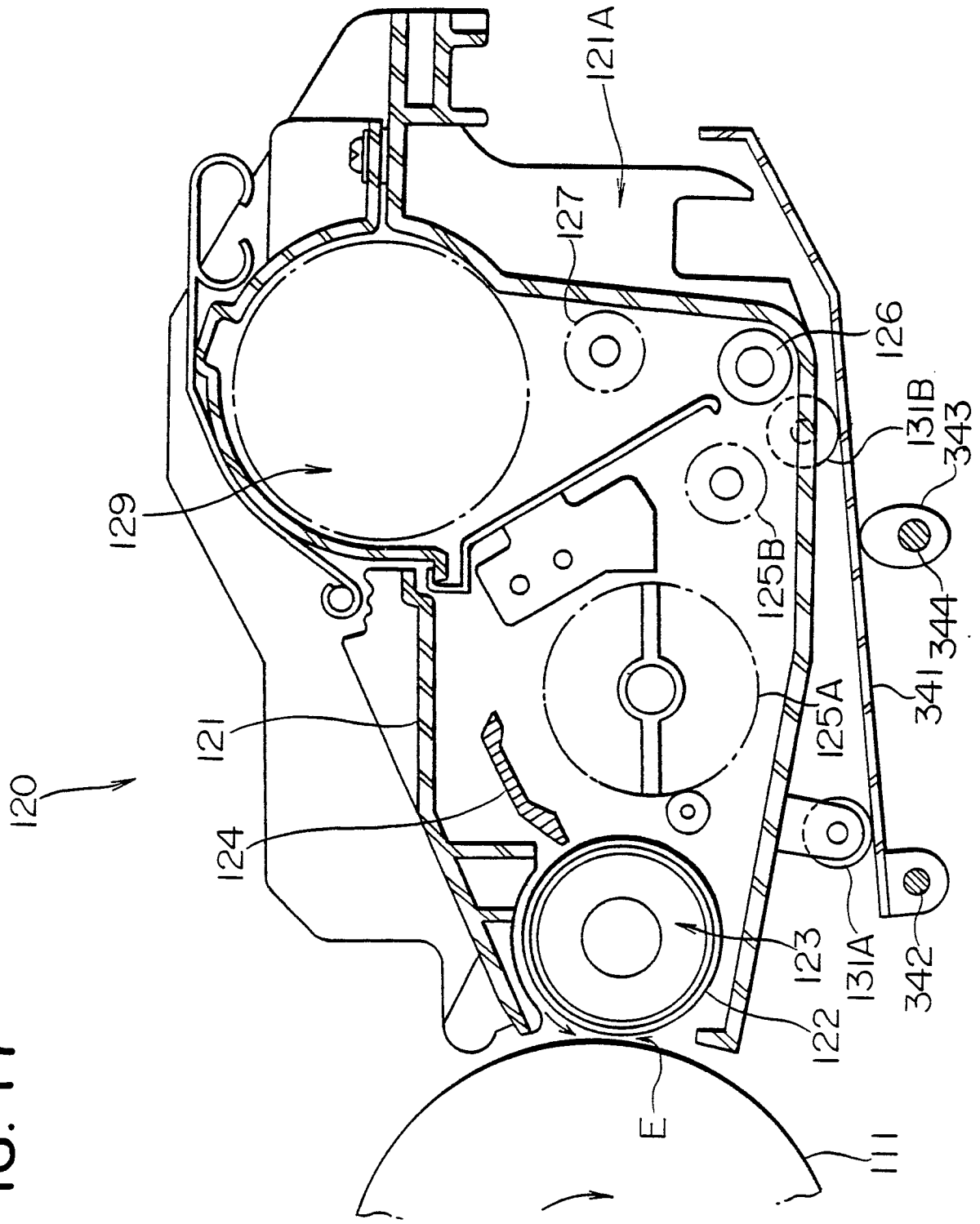


FIG. 18

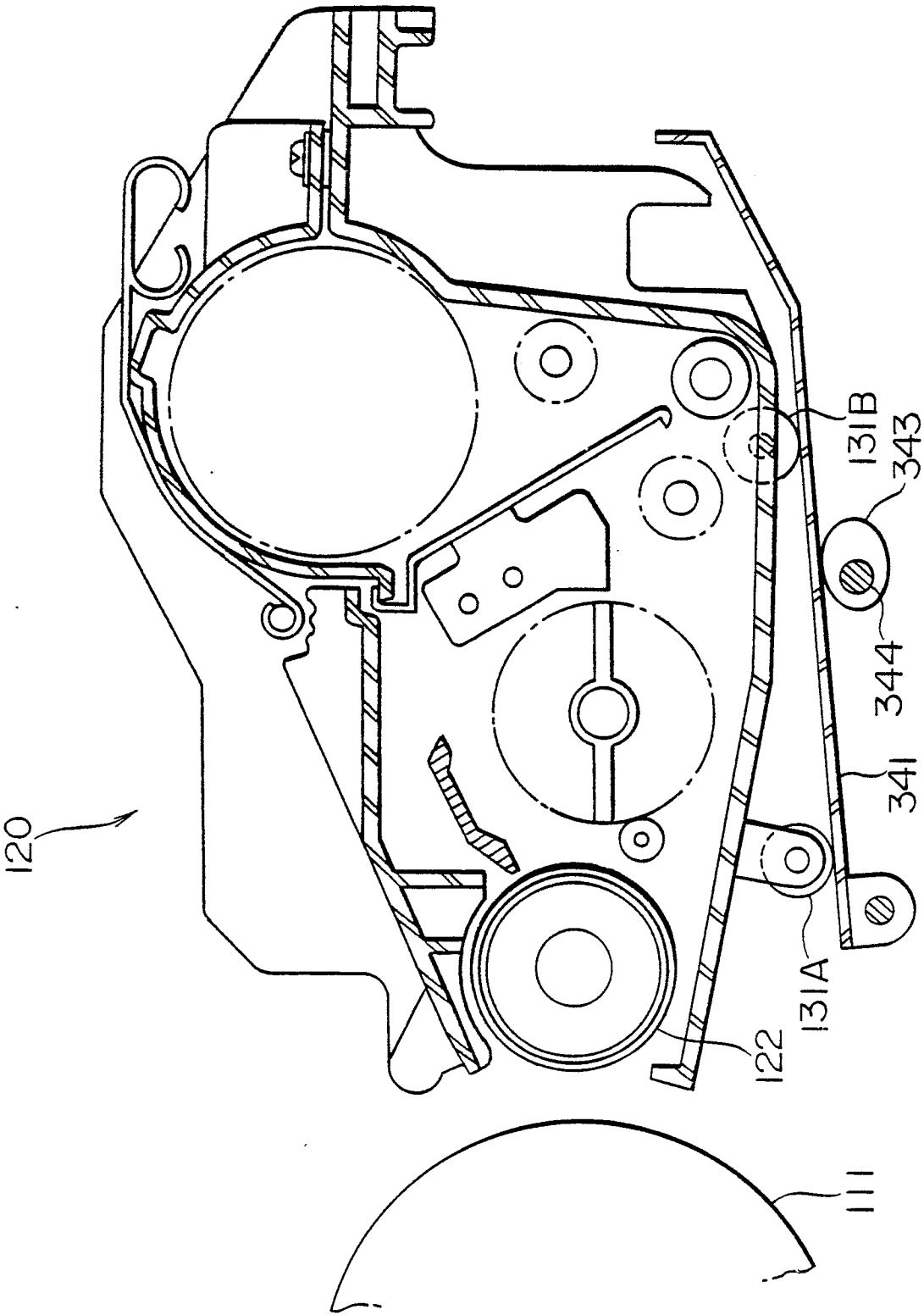


FIG. 19

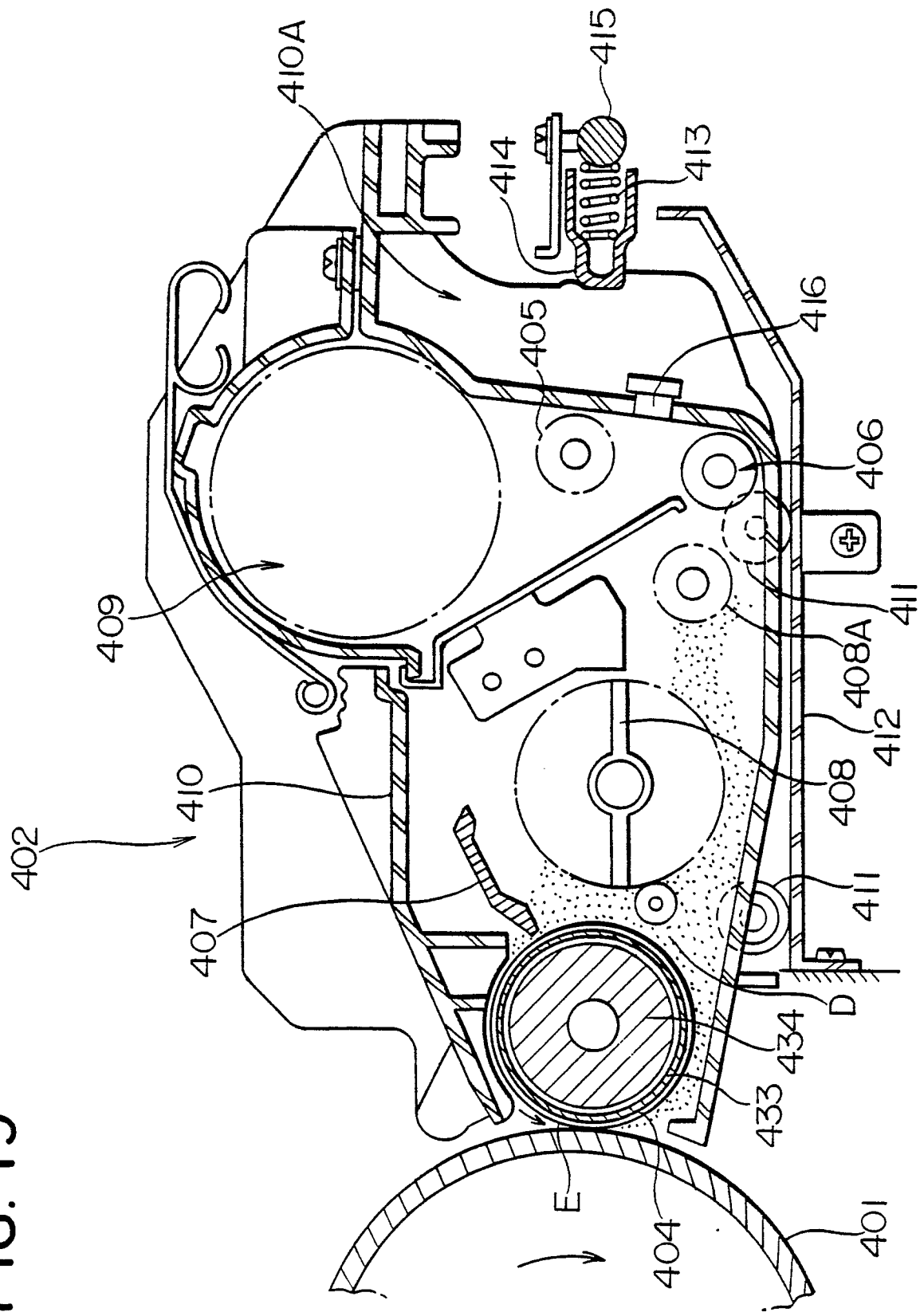


FIG. 20

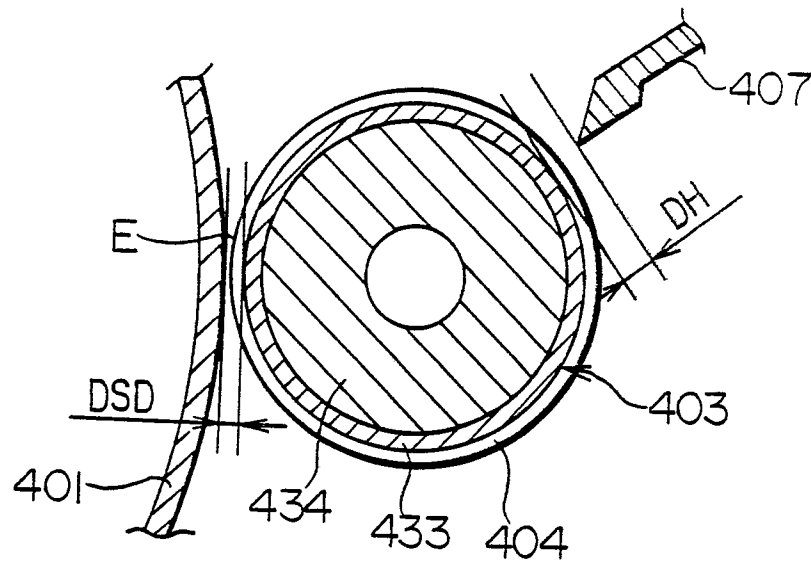


FIG. 21

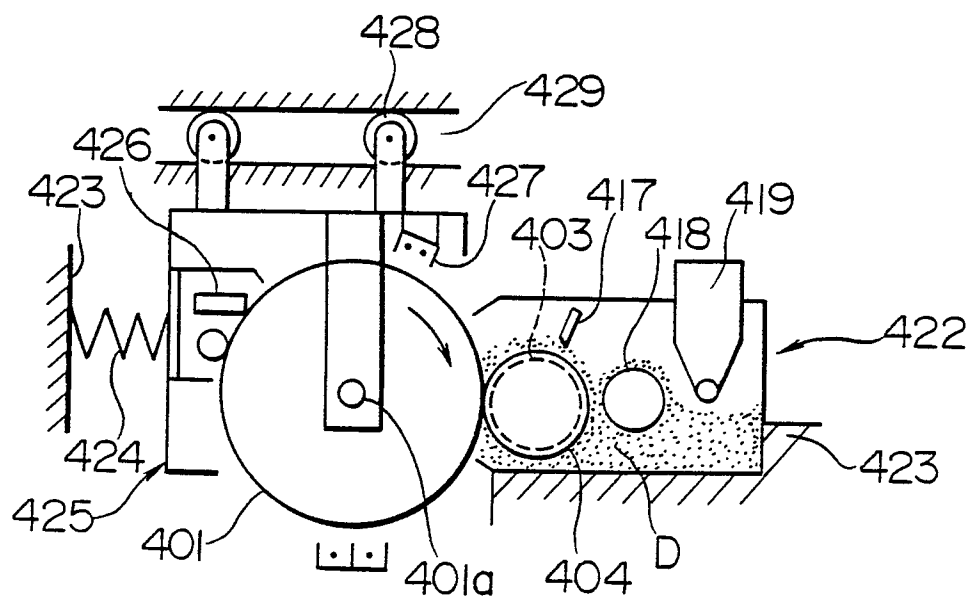


FIG. 22

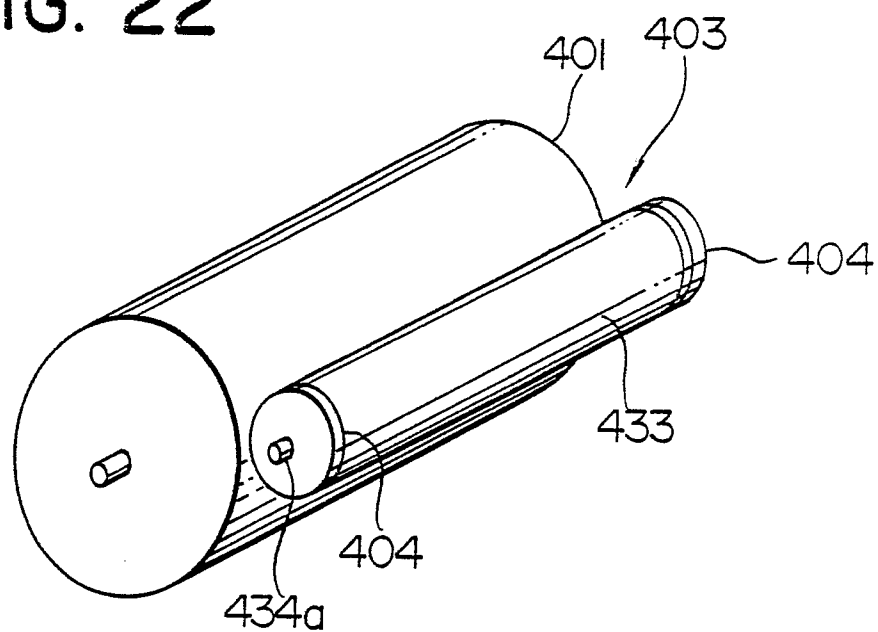


FIG. 23

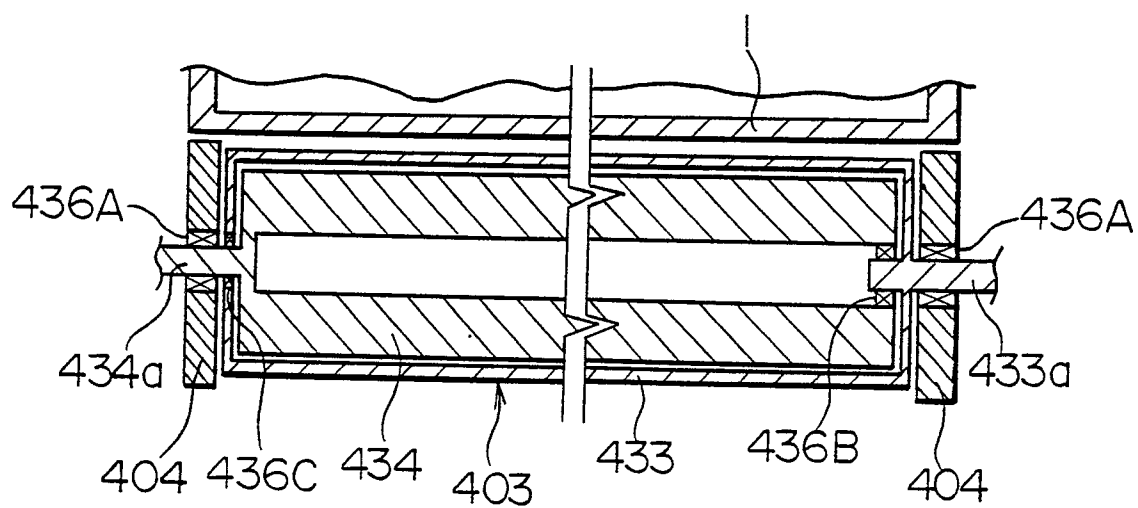


FIG. 24

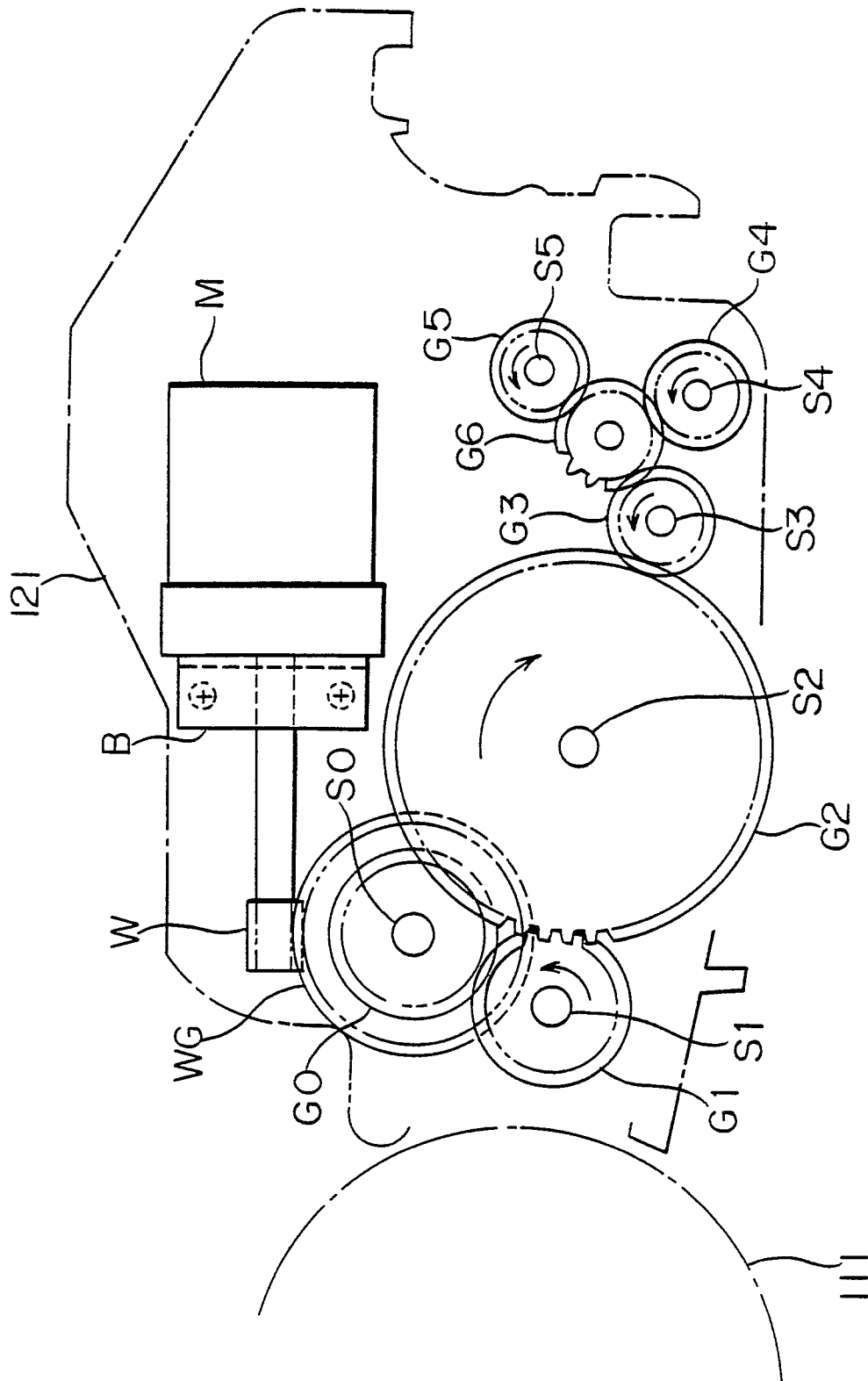


FIG. 25

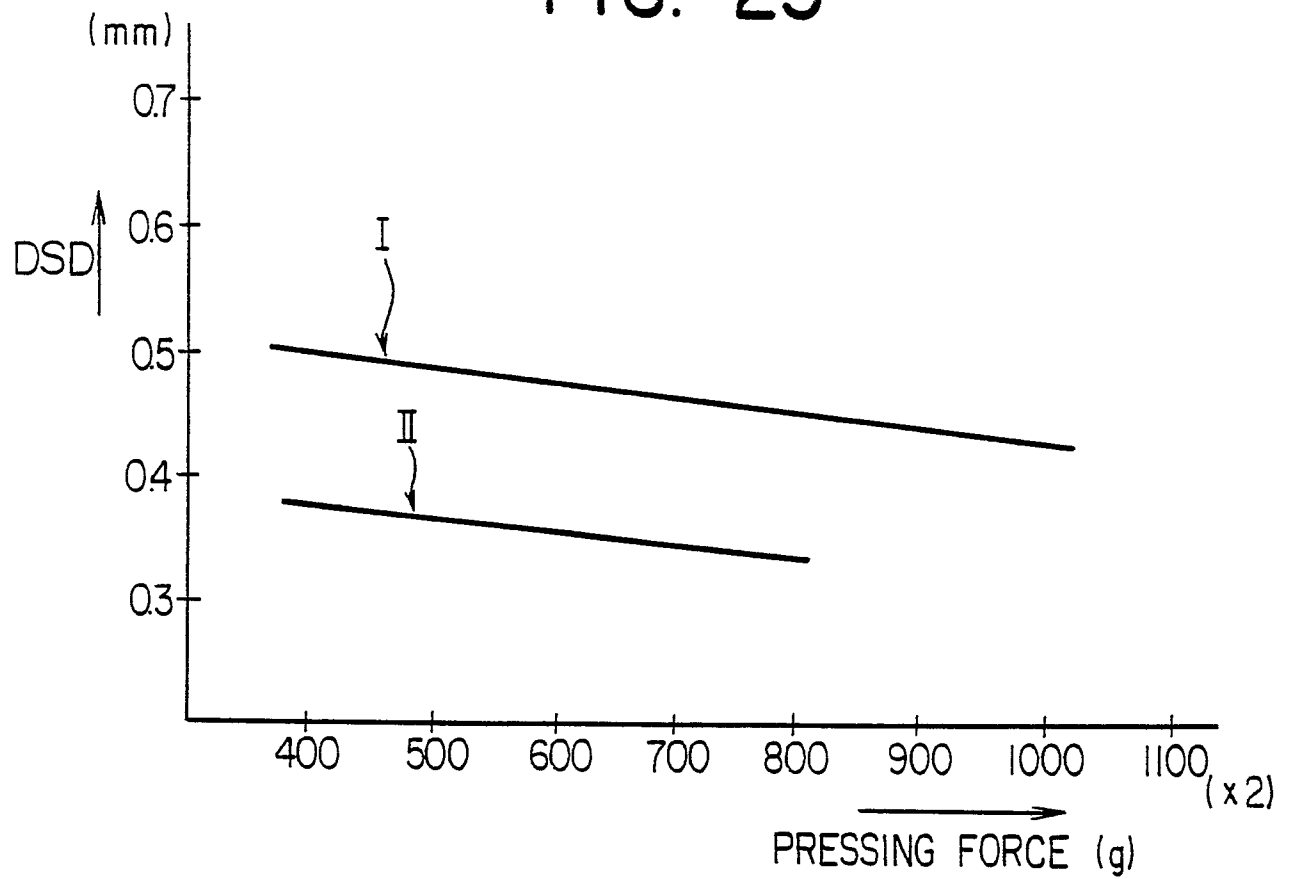


FIG. 27

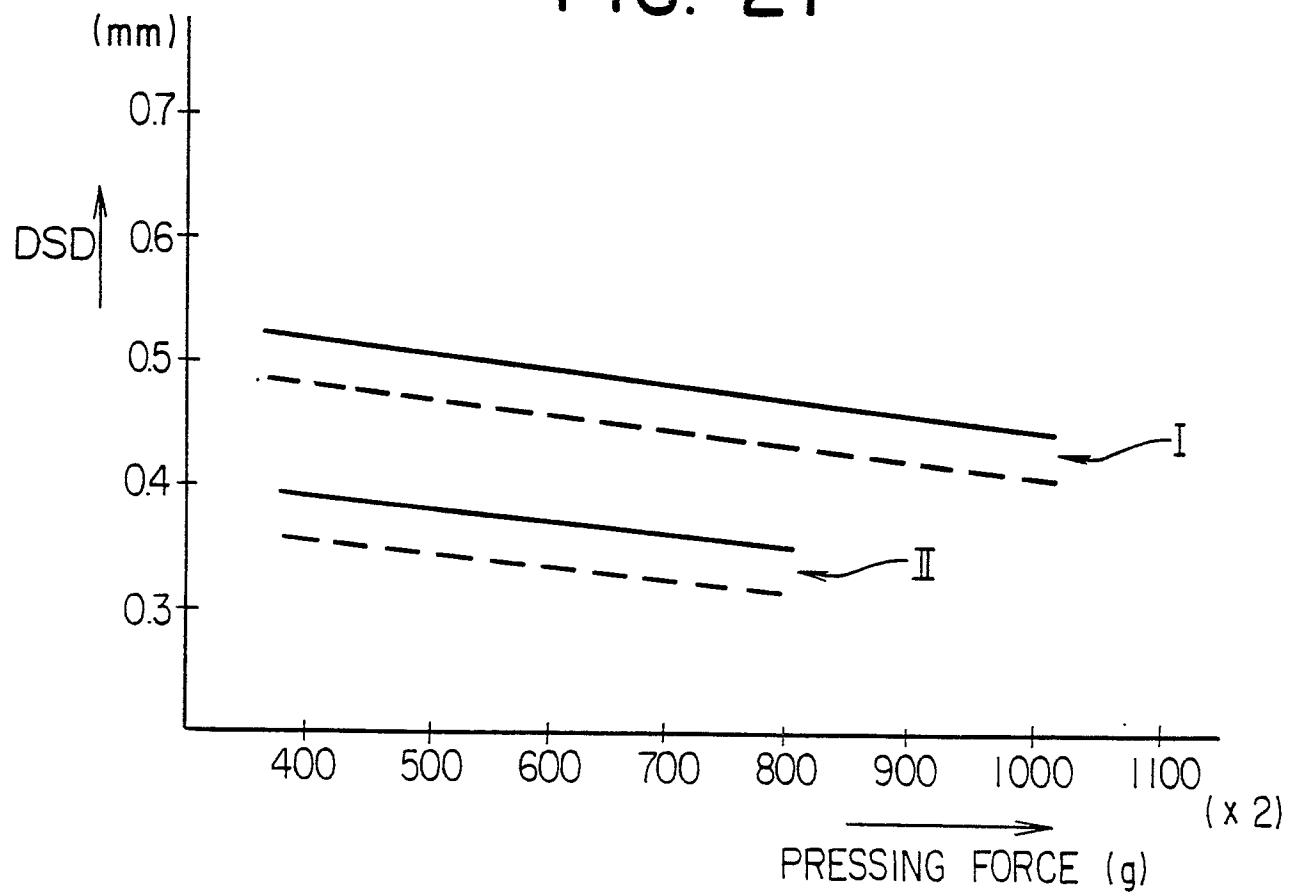


FIG. 26

