(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 4 002 014 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
25.05.2022 Bulletin 2022/21

(21) Application number: **21209098.9**

(22) Date of filing: **18.11.2021**

(51) International Patent Classification (IPC):
G03G 15/16 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
G03G 15/162

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **20.11.2020 JP 2020193796**

(71) Applicant: **Ricoh Company, Ltd.**
Tokyo 143-8555 (JP)

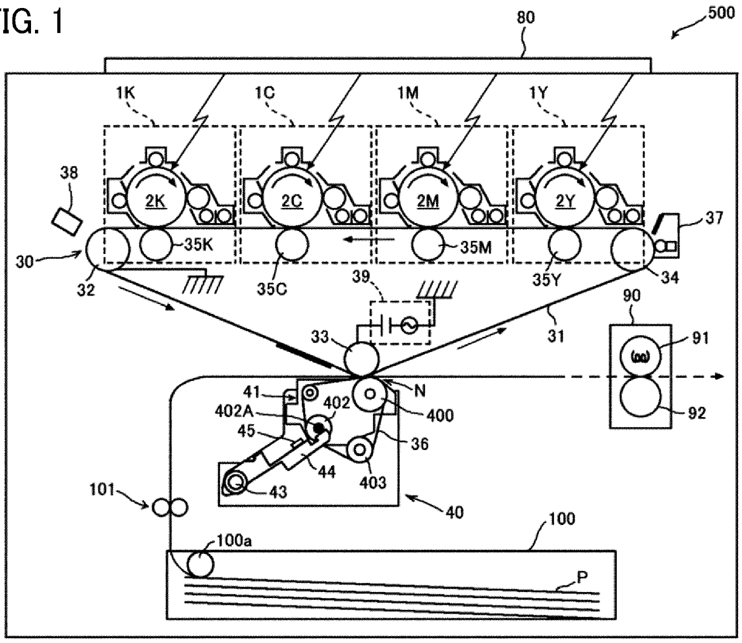
(72) Inventors:
- **AOKI, Yuuki**
Tokyo, 143-8555 (JP)
- **KOGURE, Seiichi**
Tokyo, 143-8555 (JP)
- **NAKAMOTO, Atsushi**
Tokyo, 143-8555 (JP)
- **HAMADA, Daisuke**
Japan, 143-8555 (JP)
- **AKIYAMA, Takuya**
Tokyo, 143-8555 (JP)
- **GOTO, Yutaka**
Tokyo, 143-8555 (JP)

(74) Representative: **SSM Sandmair**
Patentanwälte Rechtsanwalt
Partnerschaft mbB
Joseph-Wild-Straße 20
81829 München (DE)

(54) IMAGE BEARER AND IMAGE FORMING APPARATUS INCORPORATING SAME

(57) An image bearer (31) includes an elastic layer (31b), first fine particles (31c), and second fine particles (3 Id). The first fine particles (31c) have a volume resistivity lower than a volume resistivity of the elastic layer (31b) and are dispersed on a surface of the image bearer (31). The second fine particles (31d) have a volume resistivity lower than the volume resistivity of the first fine particles (31c) and are dispersed on the surface of the image bearer (31).

FIG. 1



EP 4 002 014 A1

Description

BACKGROUND

Technical Field

[0001] Embodiments of the present disclosure relate to an image bearer and an image forming apparatus incorporating the image bearer.

Related Art

[0002] One type of image forming apparatus includes an image bearer including an elastic layer and a transferor transferring a toner image borne on a surface of the image bearer onto a recording medium.

[0003] For example, Japanese Unexamined Patent Application Publication No. 2018-200407 discloses an image forming apparatus including an intermediate transfer belt as the image bearer. The intermediate transfer belt includes an elastic layer as a surface layer. On the surface of the elastic layer, fine particles are dispersed. The fine particles have a volume resistivity of $1 \times 10^0\ \Omega \cdot$ cm to $1 \times 10^6\ \Omega \cdot$ cm, which is lower than that of the elastic layer. The above-described publication describes that dispersing the above fine particles on the surface of the elastic layer prevents overcharge of the toner and ensures transferring a toner image onto a rough surface of a sheet in the image forming apparatus.

[0004] However, a new disadvantage has been found in dispersing the fine particles having the low volume resistivity on the surface of the image bearer. Such an image bearer deteriorates transfer performance for sheets not having rough surfaces.

SUMMARY

[0005] It is a general object of the present disclosure to provide an improved and useful image bearer in which the above-mentioned disadvantage is eliminated. In order to achieve the above-mentioned object, there is provided an image bearer according to claim 1. Advantageous embodiments are defined by the dependent claims.

[0006] Advantageously, the image bearer includes an elastic layer, first fine particles, and second fine particles. The first fine particles have a volume resistivity lower than a volume resistivity of the elastic layer and are dispersed on a surface of the image bearer. The second fine particles have a volume resistivity lower than the volume resistivity of the first fine particles and are dispersed on the surface of the image bearer.

[0007] According to the present disclosure, deterioration in transfer performance for sheets not having rough surfaces is prevented even when first fine particles having a low volume resistivity are dispersed on the surface of the image bearer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] A more complete appreciation of the disclosure and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

FIG. 1 is a schematic diagram illustrating a configuration of a color printer according to an embodiment of the present disclosure;
FIG. 2 is a schematic diagram illustrating a configuration of an image forming unit of the color printer of FIG. 1;
FIG. 3 is a block diagram illustrating an electrical configuration of a secondary transfer bias power source and a power controller in the color printer of FIG. 1;
FIG. 4 is a schematic diagram illustrating a configuration of an intermediate transfer belt in the color printer of FIG. 1;
FIG. 5 is a graph illustrating an effect of improving transfer performance in the intermediate transfer belt including first fine particles having a lower volume resistivity than that of an elastic layer in the intermediate transfer belt and being dispersed on the surface of the elastic layer;
FIG. 6 is a schematic view of a fine particle having a core-shell structure and a low volume resistivity;
FIG. 7 is a graph illustrating a relationship between the volume resistivity of the fine particles dispersed on the surface of the intermediate transfer belt, the secondary transfer rate of a halftone image, and a grade of abnormal image in the halftone image;
FIG. 8 is an enlarged schematic sectional view partially illustrating the intermediate transfer belt;
FIG. 9 is an enlarged top view partially illustrating the intermediate transfer belt;
FIG. 10 is a graph illustrating the secondary transfer rate and the grade of abnormal image in the halftone image

measured by changing a mixture ratio of the first fine particles on the intermediate transfer belt;
FIG. 11 is a graph illustrating the mixture ratio of the first fine particles at which an abnormal image does not occur with respect to the volume resistivity of the first fine particles;
FIG. 12 is a graph illustrating an example of an ideal transfer bias waveform;
FIG. 13 is a graph illustrating a waveform actually outputted aiming at the ideal waveform of FIG. 12; and
FIGS. 14A to 14E are graphs illustrating output waveforms when the duty is changed from 90% to 10% under conditions generating the transfer bias waveform illustrated in FIG. 13.

[0009] The accompanying drawings are intended to depict embodiments of the present disclosure and should not be interpreted to limit the scope thereof. The accompanying drawings are not to be considered as drawn to scale unless explicitly noted. Also, identical or similar reference numerals designate identical or similar components throughout the several views.

DETAILED DESCRIPTION

[0010] In describing embodiments illustrated in the drawings, specific terminology is employed for the sake of clarity. However, the disclosure of this patent specification is not intended to be limited to the specific terminology so selected and it is to be understood that each specific element includes all technical equivalents that operate in a similar manner and achieve similar results.
[0011] Referring now to the drawings, embodiments of the present disclosure are described below. As used herein, the singular forms "a," "an," and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. Identical reference numerals are assigned to identical components or equivalents and a description of those components is simplified or omitted.
[0012] A description is provided of an image forming apparatus according to the present disclosure with reference to drawings. It is to be noted that the present disclosure is not to be considered limited to the following embodiments but can be changed within the range that can be conceived of by those skilled in the art, such as other embodiments, additions, modifications, deletions, and the scope of the present disclosure encompasses any aspect, as long as the aspect achieves the operation and advantageous effect of the present disclosure.
[0013] The following describes an embodiment of an electrophotographic color printer as an image forming apparatus according to the present disclosure.
[0014] The image forming apparatuses according to the present disclosure is not limited to a printer and may be a copier, a stand-alone fax machine, and multifunction peripherals (MFPs) having at least two of scanning, printing, copying, and facsimile transmission capabilities.
[0015] FIG. 1 is a schematic diagram illustrating a configuration of the color printer according to the embodiment of the present disclosure.
[0016] As illustrated in FIG. 1, a printer body 500 includes four image forming units 1Y, 1M, 1C, and 1K to form toner images of yellow, magenta, cyan, and black, respectively. It is to be noted that the suffixes Y, M, C, and K denote colors of yellow, magenta, cyan, and black, respectively. To simplify the description, the suffixes Y, M, C, and K indicating colors may be omitted herein, unless differentiation of colors is necessary. Additionally, the printer body 500 includes a transfer unit 30 serving as transfer means, an optical writing unit 80 serving as latent image forming means, a fixing device 90 serving as a fixing means, a sheet tray 100, and a registration roller pair 101. The four image forming units 1Y, 1M, 1C, and 1K are detachably attached to the printer body 500 and can be replaced at the end of their lives.
[0017] FIG. 2 is a schematic diagram illustrating a configuration of the image forming unit in the present embodiment.
[0018] Since the image forming units 1Y, 1M, 1C, and 1K have identical configurations, differing only in the color of toner employed, FIG. 2 omits the suffixes Y, M, C, and K indicating colors used in the image forming units.
[0019] The image forming unit 1 includes a drum-shaped photoconductor 2 serving as a latent image bearer, a drum cleaner 3, a discharger, a charger 6, and a developing device 8. In the image forming unit 1, a common casing holds the above parts to form a process cartridge that is integrally attached to or detachable from the printer body 500. As a result, each of the image forming units can be separately replaced.
[0020] The photoconductor 2 includes a drum base and an organic photosensitive layer formed on the surface of the drum base, and a driver drives and rotates the photoconductor 2 clockwise (in a direction indicated by arrow in FIG. 2). The charger 6 includes a charging roller 7 to which a charging bias is applied. The charging roller 7 contacts or approaches the photoconductor 2 to generate an electrical discharge therebetween, thereby uniformly charging the surface of the photoconductor 2. Alternatively, instead of using the charging roller 7 that contacts or approaches the photoconductor 2, a corona charger or the like that does not contact the photoconductor 2 may be employed.
[0021] The optical writing unit 80 irradiates the surface of the photoconductor 2 uniformly charged by the charging roller 7 with exposure light such as a laser beam scanning the surface of the photoconductor 2 to form an electrostatic latent image for each color on the surface of the photoconductor 2. The developing device8 containing each color toner

develops the electrostatic latent image into the toner image of each color. The toner image on the photoconductor 2 is primarily transferred onto an intermediate transfer belt 31 that is an endless belt.

[0022] The drum cleaner 3 removes residual toner, which has failed to be transferred onto the intermediate transfer belt 31 and therefore remaining on the photoconductor 2, from the photoconductor 2. The drum cleaner 3 includes a cleaning brush roller 4 driven to rotate and a cleaning blade 5 cantilevered. That is, the cleaning blade 5 has one end fixed to a housing of the drum cleaner 3 and the other end (i.e., free end) contacting the surface of the photoconductor 2. In the drum cleaner 3, the cleaning brush roller 4 rotates and brushes off the residual toner from the surface of the photoconductor 2 while the cleaning blade 5 scraping off the residual toner from the surface of photoconductor 2.

[0023] After the drum cleaner 3 cleans the surface of photoconductor 2, the discharger removes residual charge remaining on the surface of the photoconductor 2. This removal of static electricity initializes the surface of the photoconductor 2, so as to prepare for a subsequent image formation.

[0024] The developing device 8 includes a developing portion 12 and a developer conveyor 13. Inside the developing portion 12, a developing roller 9 as a developer bearer is disposed. Inside the developer conveyor 13, the developer is stirred and conveyed. The developer conveyor 13 includes a first chamber that accommodates a first screw 10 and a second chamber that accommodates a second screw 11. The first screw 10 and the second screw 11 are rotatably supported by a case or the like of the developing device 8. Driving to rotate the first screw 10 and the second screw 11 conveys and circulates the developer in the developer conveyor 13 to supply a part of the developer to the developing roller 9.

[0025] As illustrated in FIG. 1, the optical writing unit 80 as a latent-image writing device is disposed above the image forming units 1Y, 1M, 1C, and 1K. The optical writing unit 80 optically scans the photoconductors 2Y, 2M, 2C, and 2K with laser light emitted from a laser diode based on image data sent from an external device such as a personal computer. This optical scan forms an electrostatic latent image for each color on the surface of each of the photoconductors 2Y, 2M, 2C, and 2K.

[0026] Below the image forming units 1Y, 1M, 1C, and 1K, the transfer unit 30 is disposed. The transfer unit 30 is a transfer device and a belt unit including the endless intermediate transfer belt 31 entrained around a plurality of rollers. The intermediate transfer belt 31 rotates counterclockwise as illustrated in FIG. 1. The transfer unit 30 includes, in addition to the intermediate transfer belt 31 serving as the image bearer, a drive roller 32, a secondary-transfer backup roller 33, a cleaning backup roller 34, and four primary transfer rollers 35Y, 35M, 35C, and 35K, as a plurality of rotators. The transfer unit 30 is removably mountable (replaceable) in the printer body 500.

[0027] Outside the loop formed by the intermediate transfer belt 31, a secondary transfer unit 41, a belt cleaner 37, and a potential sensor 38 as a detector are disposed. The secondary transfer unit 41 includes a secondary transfer belt 36 as an image bearer and also as a secondary transferor.

[0028] As described above, the intermediate transfer belt 31 is entrained around and supported by the plurality of rollers disposed inside the loop formed by the intermediate transfer belt 31, that is, the drive roller 32, the secondary-transfer backup roller 33, the cleaning backup roller 34, and the four primary transfer rollers 35Y, 35M, 35C, and 35K. As the driver drives and rotates the drive roller 32 counterclockwise, the rotation force of the drive roller 32 rotates the intermediate transfer belt 31 counterclockwise. In other words, the belt is entrained around, supported, and conveyed by the plurality of rotators in the transfer unit 30.

[0029] The intermediate transfer belt 31 rotating is sandwiched by the four primary transfer rollers 35Y, 35M, 35C, and 35K and the photoconductors 2Y, 2M, 2C, and 2K. The photoconductors 2Y, 2M, 2C, and 2K are in contact with an outer surface of the intermediate transfer belt 31 to form primary transfer nips that are transfer portions for transferring the yellow, magenta, cyan, and black toner images, respectively. Primary transfer bias power sources apply primary transfer biases to the primary transfer rollers 35Y, 35M, 35C, and 35K, respectively. As a result, transfer electric fields are formed between the photoconductors 2Y, 2M, 2C and 2K and the primary transfer rollers 35Y, 35M, 35C and 35K, respectively.

[0030] For example, the toner image of yellow formed on the surface of the photoconductor 2Y enters the primary transfer nip for yellow as the photoconductor 2Y rotates. Subsequently, the toner image of yellow is primarily transferred from the photoconductor 2Y onto the intermediate transfer belt 31 by the transfer electric field and pressure applied at the primary transfer nip. The intermediate transfer belt 31 bearing the toner image of yellow passes through the primary transfer nips for magenta, cyan, and black subsequently.

[0031] Then, a magenta toner image, a cyan toner image, and a black toner image are primarily transferred from the photoconductors 2M, 2C, and 2K and sequentially superimposed on the yellow toner image. The above-described primary transfer process superimposing the toner images forms a four-color superimposed toner image on the intermediate transfer belt 31. Instead of the primary transfer rollers 35Y, 35M, 35C, and 35K, a transfer charger or a transfer brush may be used as primary transferors.

[0032] The intermediate transfer belt 31 is sandwiched between the secondary-transfer backup roller 33 inside the loop of the intermediate transfer belt 31 and the secondary transfer unit 41 outside the loop of the intermediate transfer belt 31 to form a secondary transfer nip N that is a transfer portion at which the surface of the intermediate transfer belt

31 is in contact with the secondary transfer belt 36. A secondary transfer bias power source 39 applies a secondary transfer bias to the secondary-transfer backup roller 33. By contrast, the secondary transfer belt 36 is grounded via the secondary transfer roller 400. The above-described configuration forms a secondary transfer electric field between the secondary-transfer backup roller 33 and the secondary transfer belt 36. The secondary transfer electric field electrostatically moves the toner having a negative polarity from the intermediate transfer belt 31 to the secondary transfer belt 36.

[0033] Below the secondary transfer unit 41, the sheet tray 100 is disposed. The sheet tray 100 is an accommodating unit that accommodates a bundle of a plurality of recording media such as paper sheets and resin sheets. In the sheet tray 100, a sheet feeding roller 100a contacts an uppermost of the bundle of recording media P and rotates at a predetermined timing to feed the recording medium P to a conveyance path.

[0034] In the conveyance path, the registration roller pair 101 is disposed. As soon as the recording medium P fed from the sheet tray 100 is sandwiched between the registration roller pair 101, the registration roller pair 101 stops rotating. The registration roller pair 101 resumes rotating to send the recording medium P to the secondary transfer nip N, timed to coincide with the four-color superimposed toner image on the intermediate transfer belt 31.

[0035] In other words, the transfer unit 30 is a belt unit that conveys the toner image transferred to the intermediate transfer belt 31 to the secondary transfer nip N serving as a transfer portion in which the toner image is transferred to the recording medium P. The image bearer is the intermediate transfer belt 31 as an endless belt bearing the toner image that finally becomes an output image. The intermediate transfer belt 31 is wound around and supported by the drive roller 32, the secondary-transfer backup roller 33, the cleaning backup roller 34 as a plurality of rotators.

[0036] In the secondary transfer nip N, the recording medium P closely contacts the four-color superimposed toner image on the intermediate transfer belt 31, and the secondary transfer electric field and nip pressure work the toner image to be secondarily transferred to the recording medium P. As a consequence, a full-color toner image is formed on the recording medium P in combination with white color of the recording medium P. After the four-color superimposed toner image is transferred onto the recording medium P in the secondary transfer nip N, residual toner that has failed to be transferred onto the recording medium P remains on the intermediate transfer belt 31. The belt cleaner 37 contacts the outer circumferential surface of the intermediate transfer belt 31 and removes such residual toner from the intermediate transfer belt 31. The cleaning backup roller 34 disposed inside the loop formed by the intermediate transfer belt 31 supports the belt cleaner 37 to clean the intermediate transfer belt 31.

[0037] As described above, the potential sensor 38 is disposed outside the loop formed by the intermediate transfer belt 31. Specifically, the potential sensor 38 is disposed opposite a portion of the intermediate transfer belt 31 wound around the drive roller 32 in an entire circumferential portion of the intermediate transfer belt 31, and a predetermined gap is set between the potential sensor 38 and the intermediate transfer belt 31. The potential sensor 38 measures a surface potential of the toner image primarily transferred onto the intermediate transfer belt 31 when the toner image comes into an area where the potential sensor 38 faces the toner image.

[0038] The fixing device 90 is disposed downstream from the secondary transfer nip N in a conveyance direction of the recording medium P. The fixing device 90 receives the recording medium P on which the four-color superimposed toner image is transferred. The recording medium P is nipped at a fixing nip at which a pressure roller 92 is in contact with a fixing roller 91 having a heat source therein. Heat and pressure are applied to the four-color superimposed toner image to soften and melt toner in the four-color superimposed toner image and fix the four-color superimposed toner image onto the recording medium P. After the toner image is fixed on the recording medium P, the recording medium P is ejected from the fixing device 90, outside the printer body 500.

[0039] The printer body 500 in the present embodiment can also form a monochrome image. When the printer forms a monochrome image, a support plate supporting the primary transfer rollers 35Y, 35M, and 35C in the transfer unit 30 is moved to separate the primary transfer rollers 35Y, 35M, and 35C from the photoconductors 2Y, 2M, and 2C, respectively. Thus, the outer circumferential surface of the intermediate transfer belt 31 is separated from photoconductors 2Y, 2M, and 2C and is in contact with the photoconductor 2K only. In this state, only the image forming unit 1K is activated among the four image forming units 1Y, 1M, 1C, and 1K to form the black toner image on the photoconductor 2K.

[0040] In the present embodiment, the secondary transfer belt 36 functions as the secondary transferor that forms the secondary transfer nip N between the intermediate transfer belt 31 and the secondary transfer belt 36. Alternatively, the secondary transfer roller may function as the secondary transferor that forms the secondary transfer nip N between the intermediate transfer belt 31 and the secondary transfer roller. In the present embodiment, the secondary transfer bias power source applies the secondary transfer bias to the secondary-transfer backup roller 33 inside the loop formed by the intermediate transfer belt 31. Alternatively, the secondary transfer bias power source may apply the secondary transfer bias to the secondary transferor (e.g., secondary transfer roller) outside the loop formed by the intermediate transfer belt 31. The embodiments of the present disclosure may be applied not only to a color image forming apparatus (e.g., the color printer) to form a color image, but also to a monochrome image forming apparatus that forms a monochrome image.

[0041] FIG. 3 is a block diagram illustrating an electrical configuration of the secondary transfer bias power source and a power controller, according to the present embodiment.

[0042] As illustrated in FIG. 3, the secondary transfer bias power source 39 includes a direct current (DC) power source 110 and an alternating current (AC) power source 140. These power sources 110 and 140 are coupled to a power controller 200. The power controller 200 is, for example, a control device including a central processing unit (CPU), a read only memory (ROM), and a random-access memory (RAM) and controls the DC power source 110 and the AC power source 140.

[0043] The power controller 200 inputs a direct-current pulse-width modulation (DC_PWM) signal to the DC power source 110 to control an output level of a direct current (DC) voltage. The DC power source 110 outputs the DC voltage based on the DC_PWM signal. In the present embodiment, the DC power source 110 outputs a negative DC voltage (high voltage) that is the same polarity as the charging polarity of the toner. The DC power source 110 is controlled to output a constant current.

[0044] The power controller 200 inputs the AC power source 140 an alternating-current pulse-width modulation (AC_PWM) signal to control an output level of an alternating current (AC) voltage and an alternating-current clock (AC_CLK) signal to control an output frequency of the AC voltage. The AC power source 140 outputs the AC voltage having an amplitude (a peak-to-peak voltage) corresponding to the magnitude of the AC_PWM signal and a frequency corresponding to the magnitude of the AC CLK signal. The AC voltage (AC component) output from the AC power source 140 and the DC voltage (high voltage) output from the DC power source 110 are superimposed to generate a superimposed voltage.

[0045] As illustrated in FIGS. 1 and 3, the superimposed voltage as the secondary transfer bias is output to the secondary-transfer backup roller 33. In the present embodiment, the AC power source 140 is controlled to output a constant voltage but not limited to this. The AC power source 140 may be controlled to output a constant current. The same is applied to the DC power source 110. A DC component of the secondary transfer bias may be zero.

[0046] The secondary transfer bias power source 39 may also output the secondary transfer bias composed of only a DC voltage by setting the output of the AC power source 140 to zero. The AC voltage generated by the AC voltage transformer in the AC power source 140 may have either a sine wave or a rectangular wave. In the present embodiment, the AC voltage has a short-pulse rectangular wave. This is because the short-pulse rectangular wave of the AC voltage improves image quality.

[0047] FIG. 4 is a schematic diagram illustrating a configuration of an intermediate transfer belt 31 in the present embodiment.

[0048] As illustrated in FIG. 4, the intermediate transfer belt 31 includes a base layer 31a and a flexible elastic layer 31b layered on the base layer 31a. When the toner image is secondarily transferred onto the recording medium P, the secondary transfer bias is applied from the secondary-transfer backup roller 33 to the intermediate transfer belt 31. The secondary transfer current flows from the secondary-transfer backup roller 33 to the base layer 31a, the elastic layer 31b, the toner in the toner image, the recording medium P, the secondary transfer belt 36, and the secondary transfer roller 400 in this order and secondarily transfers the toner image on the intermediate transfer belt 31 onto the recording medium P.

[0049] An example of materials for the base layer 31a is resin in which electric resistance adjusting materials such as a filler and an additive for adjusting electric resistance are dispersed. A preferable example of the resin includes a fluorine-based resin such as polyvinylidene fluoride (PVDF) or ethylenetetrafluoroethylene (ETFE), a polyimide resin, a polyamideimide resin from the viewpoint of flame retardancy. Particularly, the polyimide resin or the polyamideimide resin is preferable to enhance mechanical strength while providing good elasticity and heat resistance.

[0050] The electrical resistance adjusting material dispersed in the resin is, e.g., a metal oxide, a carbon black, an ion conductive material, or a conductive polymer material. The metal oxide is, e.g., zinc oxide, tin oxide, titanium oxide, zirconium oxide, aluminum oxide, or silicon oxide. In order to enhance dispersiveness, surface treatment may be applied to the metal oxide in advance. The carbon black is, e.g., ketjen black, furnace black, acetylene black, thermal black, or gas black. The ion conductive material is, e.g., tetraalkylammonium salt, trialkyl benzyl ammonium salt, alkylsulfonate, alkylbenzene sulfonate, alkylsulfate, glycerol fatty acid ester, sorbitan fatty acid ester, polyoxyethylene alkylamine, polyoxyethylene fatty acid alcohol ester, alkylbetaine, or lithium perchlorate. Alternatively, two or more of these ion conductive materials may be mixed. It is to be noted that the electrical resistance adjusting material of the base layer 31a is not limited to the materials described above.

[0051] Optionally, a dispersion auxiliary agent, a reinforcing material, a lubricant, a heat conduction material, an antioxidant, and the like may be added to a coating liquid as a precursor of the base layer 31a. The coating liquid is a liquid resin in which the electrical resistance adjusting material is dispersed before curing. Preferably, an amount of the electrical resistance adjusting material included in the base layer 31a of a seamless belt, i.e., the intermediate transfer belt 31, is in a range of from 1×10^8 Ω /sq to 1×10^{13} Ω /sq in surface resistivity, and in a range of from 1×10^6 Ω • cm to 1×10^{12} Ω • cm in volume resistivity.

[0052] The amount of the electrical resistance adjusting material is determined to enhance mechanical strength, such that the formed film is not fragile and broken easily. That is, the intermediate transfer belt 31 is preferably a seamless belt with well-balanced mechanical strength and electrical characteristics (i.e., the surface resistivity and the volume resistivity) manufactured by use of the coating liquid having a properly adjusted blending proportion between the resin component (e.g., a polyimide resin precursor or a polyamideimide resin precursor) and the electrical resistance adjusting material.

[0053] If the electrical resistance adjusting material is carbon black, the amount of the electrical resistance adjusting material contained in the coating liquid is in a range of preferably from 10% to 25% by weight, and more preferably from 15% to 20% by weight, relative to all solid components of the coating liquid. If the electrical resistance adjusting material is a metal oxide, the amount of the electrical resistance adjusting material contained in the coating liquid is preferably from 1% to 50% by weight, and more preferably from 10% to 30% by weight, relative to all the solid components of the coating liquid. If the content of the electrical resistance adjusting material is less than the above-described respective range, a desired effect is not achieved. If the content of the electrical resistance adjusting material is greater than the above-described respective range, the mechanical strength of the intermediate transfer belt (seamless belt) 31 drops, which is undesirable in actual use.

[0054] The thickness of the base layer 31a is not limited to a particular thickness. The thickness of the base layer 31a may be determined in a proper range. Preferably, the base layer 31a may have a thickness in a range of from 30 μm to 150 μm. More preferably, the base layer 31a may have a thickness of from 40 μm to 120 μm, and even more preferably from 50 μm to 80 μm. If the thickness of the base layer 31a is less than 30 μm, the base layer 31a may crack, which may tear the intermediate transfer belt 31. By contrast, if the thickness of the base layer 31a is greater than 150 μm, the intermediate transfer belt 31 may be broken when the intermediate transfer belt 31 is bent. By contrast, the base layer 31a having a thickness in the range of from 50 μm to 80 μm described above enhances durability.

[0055] In order to increase a traveling stability of the intermediate transfer belt 31, the base layer 31a preferably has a uniform thickness. Adjusting the thickness of the base layer 31a is not limited to a particular way. The thickness of the base layer 31a may be properly adjusted in a selected way. For example, a contact-type thickness meter or an eddy-current thickness meter may be used to measure the thickness of the base layer 31a. Alternatively, a scanning electron microscope (SEM) may be used to measure a cross-section of film, in this case, the base layer 31a.

[0056] Now, the following describes the elastic layer 31b. The elastic layer 31b of the intermediate transfer belt 31 has a surface having a plurality of convex shapes formed by a plurality of fine particles 31c and 31d dispersed on the elastic layer 31b. The elastic layer 31b is made of an elastic material such as general resin, elastomer, and rubber. In particular, the elastic material having good softness (i.e., elasticity) is preferable for the elastic layer 31b, such as an elastomer material or a rubber material. The elastomer material is, e.g., polyester, polyamide, polyether, polyurethane, polyolefin, polystyrene, polyacrylic, polydien, or silicone-modified polycarbonate. Alternatively, the elastomer material may be thermoplastic elastomer such as fluorine-based copolymer thermoplastic elastomer.

[0057] Thermosetting resin is, e.g., polyurethane resin, silicone-modified epoxy resin, or silicone modified acrylic resin. The rubber material is, e.g., isoprene rubber, styrene rubber, butadiene rubber, nitrile rubber, ethylene-propylene rubber, butyl rubber, silicone rubber, chloroprene rubber, acrylic rubber, chlorosulfonated polyethylene, fluororubber, urethane rubber, or hydrin rubber.

[0058] A material having desired characteristics can be selected from the materials described above. In particular, a soft material is preferable to conform a rough surface of the recording medium such as LEATHAC (registered trademark) paper. The thermosetting material is preferable to the thermoplastic material for the elastic layer 3 1b to disperse the fine particles 31c and 31d therein. The thermosetting material has a good adhesion property relative to resin particles due to an effect of a functional group contributing to the curing reaction. In short, the elastic layer 31b made of the thermosetting material reliably fixes the fine particles 31c and 31d therein. For the same reason, vulcanized rubber is also preferable.

[0059] Acrylic rubber is also preferable for the elastic layer 31b among the elastic materials described above to enhance ozone resistance, softness, adhesion properties relative to the fine particles, application of noncombustibility, environmental stability, and the like. The acrylic rubber is not limited to a specific product. Commercially available acrylic rubber can be used for the elastic layer 31b. Among various types of acrylic rubbers having cross-links (formed with epoxy group, active chlorine group, or carboxyl group), those having carboxyl-group-based cross-links are preferable for excellent rubber properties (in particular, compression set) and processability thereof. As a cross-linking agent used for the acrylic rubber having carboxyl-group-based cross-links, an amine compound is preferable, and a polyvalent amine compound is more preferable. Examples of the amine compound include, but are not limited to, aliphatic polyvalent amine cross-linking agents and aromatic polyvalent amine cross-linking agents. Specific examples of the aliphatic polyvalent amine cross-linking agents include, but are not limited to, hexamethylenediamine, hexamethylenediamine carbamate, and N, N'-dicinnamylidene-1,6-hexanediamine. Examples of the aromatic polyvalent amine cross-linking agents include, but are not limited to, 4,4'-methylenedianiline, m-phenylenediamine, 4,4'-diaminodiphenyl ether, 3,4'-diaminodiphenyl ether, 4,4'-(m-phenylenediisopropylidene) dianiline, 4,4'-(p-phenylenediisopropylidene) dianiline, 2,2'-bis[4-(4-aminophenoxy) phenyl] propane, 4,4'-diaminobenzanilide, 4,4'-bis(4-aminophenoxy) biphenyl, m-xylylenediamine, p-xylylenediamine, 1,3,5-benzenetriamine, and 1,3,5-benzenetriaminomethyl.

[0060] The amount of the cross-linking agent to be blended with 100 parts by weight of the acrylic rubber is preferably from 0.05 to 20 parts by weight, more preferably from 0.1 to 5 parts by weight. When the blending amount of the cross-linking agent is too small, cross-linking is not sufficiently performed, so that it becomes difficult to maintain the shape of the cross-linked product. When the blending amount is too large, the cross-linked product becomes so hard that elasticity as cross-linked rubber is impaired.

[0061] To enhance a cross-linking reaction, a cross-linking accelerator may be mixed in the acrylic rubber employed for the elastic layer 31b. The cross-linking accelerator is not limited to a particular type. However, the cross-linking accelerator may be preferably used in combination with the polyvalent amine cross-linking agent described above. Examples of such a cross-linking accelerator include, but are not limited to, guanidine compounds, imidazole compounds, quaternary onium salts, tertiary phosphine compounds, and alkali metal salts of weak acids. Specific examples of the guanidine compounds include, but are not limited to, 1,3-diphenylguanidine and 1,3-diorthotolylguanidine. Specific examples of the imidazole compounds include, but are not limited to, 2-methylimidazole and 2-phenylimidazole. Specific examples of the quaternary onium salts include, but are not limited to, tetra n-butyl ammonium bromide and octadecyl tri-n-butyl ammonium bromide. Specific examples of the polyvalent tertiary amine compounds include, but are not limited to, triethylenediamine and 1,8-diaza-bicyclo [5.4.0] undecene-7 (DBU). Specific examples of the tertiary phosphine compounds include, but are not limited to, triphenylphosphine and trip-tolylphosphine. Specific examples of the alkali metal salts of weak acids include, but are not limited to, inorganic weak acid salts (such as phosphate and carbonate) and organic weak acid salts (such as stearate and laurate) of sodium or potassium.

[0062] The amount of the cross-linking accelerator used for 100 parts by weight of the acrylic rubber is preferably from 0.1 to 20 parts by weight, more preferably from 0.3 to 10 parts by weight. When the amount of the cross-linking accelerator is too large, the cross-linking rate may become too fast at the time of cross-linking, blooming of the cross-linking accelerator to the surface of the cross-linked product may occur, or the cross-linked product may become too hard. When the amount of the cross-linking accelerator is too small, tensile strength of the cross-linked product may be remarkably lowered, or elongation change or tensile strength change after thermal loading may be too large.

[0063] In preparing the acrylic rubber, an appropriate mixing method can be employed, such as roll mixing, Banbury mixing, screw mixing, and solution mixing. There are no particular limitation on the order of blending of components. Preferably, components that are hardly react or decompose by heat are sufficiently mixed first, and components that are easily react or decompose by heat (such as the cross-linking agent) are thereafter mixed in a short time at a temperature at which no reaction or decomposition occurs.

[0064] The acrylic rubber can be made into a cross-linked product by heating. The heating temperature is preferably from 130°C to 220°C, more preferably from 140°C to 200°C. The cross-linking time is preferably from 30 seconds to 5 hours. The heating method may be appropriately selected from known methods for cross-linking rubber, such as press heating, steam heating, oven heating, and hot air heating. Also, post-cross-linking may be performed after the cross-linking in order to ensure cross-linking inside the cross-linked product. The post-cross-linking is preferably performed for 1 to 48 hours, but the time varies depending on the heating method, cross-linking temperature, and shape. The heating method and heating temperature in the post-cross-linking may be appropriately selected.

[0065] The electrical resistance adjusting agent and the flame retardant may be included in the selected materials to adjust electrical characteristics and to enhance noncombustibility, respectively. Optionally, materials such as an anti-oxidant, a reinforcing agent, a filler, and the cross-linking accelerator may be added to the selected materials. The electrical resistance adjusting agent to adjust electrical resistance can be selected from the materials described above. However, a minimal amount of the carbon black and the metal oxide may be used so as not to impair softness. Use of the ion conductive material or the conductive high polymer is effective. Alternatively, these materials can be used in combination.

[0066] Specifically, various types of perchlorates and ionic liquids are preferably added in an amount of from 0.01 parts by weight to 3 parts by weight relative to 100 parts by weight of rubber. The ion conductive material in an amount of 0.01 parts by weight or less is insufficient to reduce resistivity. By contrast, the ion conductive material in an amount of 3 parts by weight or more may possibly cause the conductive material to bloom or bleed on the surface of the intermediate transfer belt 31.

[0067] In order to obtain transfer performance as is desired in recent electrophotographic image forming apparatuses that can transfer the toner image onto a rough surface of the recording medium, the elasticity of the elastic layer 31b is preferably adjusted to have a micro rubber hardness of 35 or less at a temperature of 23°C with a relative humidity (RH) of 50%. In measurement of microhardness with, e.g., Martens and Vickers hardness test methods, the hardness of a shallow area of a measurement target in a bulk direction thereof is measured. In other words, the hardness of only a very limited area near the surface is measured. That is, deformability of the entire intermediate transfer belt 31 may not be evaluated. For example, if a soft material is used for the top layer of an intermediate transfer belt having a relatively low deformability as a whole, the microhardness may decrease as a consequence. Such an intermediate transfer belt having a relatively low deformability does not reliably conform to the rough surface of the recording medium. As a result, the transfer performance to the rough surface of the recording medium becomes insufficient. Accordingly, measuring the micro rubber hardness of the intermediate transfer belt 31 is preferable to evaluate the deformability of the entire intermediate transfer belt 31.

[0068] The micro rubber hardness (a micro hardness) of the intermediate transfer belt can be measured by a micro durometer MD-1 available from KOBUNSHI KEIKI CO., LTD. At the temperature of 23°C with the relative humidity (RH) of 50%, the micro durometer pushes a pressing needle against a belt piece with a predetermined force to deform the belt piece and measures the hardness based on the pressing depth of the pressing needle.

[0069] The layer thickness of the elastic layer 3 1b is preferably from 200 μm to 2 mm, and more preferably from 400 μm to 1000 μm. If the thickness of the elastic layer 31b is less than 200 μm, the elastic layer 31b may not reliably conform to the rough surface of the recording medium, hampering effective reduction of transfer pressure. By contrast, if the thickness of the elastic layer 31b is greater than 2 mm, the elastic layer 31b may be deformed by its own weight. As a consequence, the intermediate transfer belt 31 may unstably rotate or may be damaged as is entrained around the plurality of rollers. In order to measure the thickness of the elastic layer 31b, for example, the scanning electron microscope (SEM) may be used. The SEM observes the cross-section of the elastic layer 31b, thereby measuring the thickness of the elastic layer 31b.

[0070] The secondary transfer bias is applied to the intermediate transfer belt 31 including the elastic layer 31b as the surface layer having a high electrical resistance to secondarily transfer the toner image from the intermediate transfer belt 31 to the recording medium P and is likely to cause electric discharge in a minute gap between the toner and the recording medium P. For example, a wedge-shaped minute gap is formed at the entrance of the secondary transfer nip N (that is an upstream portion of the secondary transfer nip N in the recording medium conveyance direction), and the electric discharge may occur to the toner in the minute gap. In addition, when the recording medium P has the rough surface, the rough surface of the recording medium P forms the minute gap between the recording medium P and the toner even in the secondary transfer nip N, and the electric discharge may occur to the toner in the minute gap.

[0071] When the electric discharge occurs to the toner in such a minute gap, the toner may be reversely charged. Such reversely charged toner is not secondarily transferred from the intermediate transfer belt 31 to the recording medium P. Even after the toner is secondarily transferred to the recording medium P, the electric discharge may reversely charge the toner on the recording medium, and the toner may be reversely transferred to the intermediate transfer belt 31. As a result, the electric discharge deteriorates the transfer performance.

[0072] A method to prevent the above-described deterioration in the transfer performance caused by reversely charged toner is dispersing first fine particles having a lower volume resistivity than a volume resistivity of the elastic layer 31b of the intermediate transfer belt 31 on the surface of the intermediate transfer belt 31. According to this method, the current easily flows between the first fine particles on the surface of the intermediate transfer belt 31 and between the first fine particles and the toner. As a result, the intermediate transfer belt 31 made based on this method prevents the occurrence of the electric discharge in the minute gap between the toner and the recording medium P or the minute gap between the intermediate transfer belt 31 and the recording medium P (hereinafter, simply referred to as "the minute gap" when both minute gaps are not distinguished from each other). Since the above-described method reduces the amount of toner reversely charged by the electric discharge, it is considered that the above-described method prevents the deterioration in the transfer performance caused by the reversely charged toner.

[0073] FIG. 5 is a graph illustrating an effect of improving transfer performance of the intermediate transfer belt 31 including the first fine particles having the lower volume resistivity than that of the elastic layer 31b in the intermediate transfer belt 31 and being dispersed on the surface of the elastic layer 31b.

[0074] In the graph of FIG. 5, a secondary transfer rate when metal-plated particles made of core fine particles having a high volume resistivity and covered by metal-plated surfaces are dispersed on the surface of the intermediate transfer belt is compared with a secondary transfer rate when the core fine particles having the high volume resistivity and not covered by metal are dispersed on the surface of the intermediate transfer belt. Each of the secondary transfer rates was measured when a black halftone image is formed on each intermediate transfer belt 31 including each of fine particles described above, and the secondary transfer bias is applied so as to flow the secondary transfer current that is enough to transfer a full-color solid image.

[0075] In order to transfer the full-color solid image, a large amount of secondary transfer current is required. The large amount of secondary transfer current is likely to cause the above-described electric discharge in the minute gap, and the toner is likely to be reversely charged. As illustrated in FIG. 5, the secondary transfer rate was equal to or higher than a certain level in both of the intermediate transfer belt 31 including the metal-plated fine particles having a low volume resistivity and being dispersed on the surface of the intermediate transfer belt 31 and the intermediate transfer belt 31 including the non-plated fine particles having a high volume resistivity and being dispersed on the surface of the intermediate transfer belt 31. However, the secondary transfer rate in the intermediate transfer belt 31 including the metal-plated fine particles was higher than the secondary transfer rate in the intermediate transfer belt 31 including the non-plated fine particles. It is considered that dispersing the fine particles having the low volume resistivity on the surface of the intermediate transfer belt 31 prevents the occurrence of the electric discharge in the minute gap, reduces the amount of the reversely charged toner, and prevents the deterioration of the transfer performance caused by the reversely charged toner.

[0076] The fine particles having the low volume resistivity as the first fine particles may be made of one type of material. However, low volume resistivity materials (such as metals) are often relatively expensive. Accordingly, it is preferable that the fine particles have a core-shell structure in which the surfaces of core fine particles made of a material having a high volume resistivity (such as a resin) are coated with a material having the low volume resistivity (such as a metal) to form fine particles having the low volume resistivity as a whole. In particular, when a surface portion of the fine particle has the low volume resistivity, the current easily flows along the surface of the fine particle, that is, easily flows between the fine particles or between the fine particle and the toner. In fact, as illustrated in FIG. 5, the secondary transfer rate in the intermediate transfer belt 31 including the metal-plated fine particles having the low volume resistivity and being dispersed on the surface of the intermediate transfer belt 31 was higher than the secondary transfer rate in the intermediate transfer belt 31 including the non-plated fine particles having the high volume resistivity and being dispersed on the surface of the intermediate transfer belt 31.

[0077] FIG. 6 is a schematic view of the first fine particle 31c having the core-shell structure and the low volume resistivity.

[0078] As illustrated in FIG. 6, the fine particle 31c having the core-shell structure includes a base particle 31c1 (that is a high-resistance particle) and a conductive layer 31c2 coating the base particle 31c1.

[0079] Examples of the base particle 31c1 (that is the high-resistance particle) includes an acrylic resin particle, a melamine resin particle, a silicone resin particle, a polyamide resin particle, a polyester resin particle, and a polyvinyl chloride resin particle. Examples of the conductive layer 31c2 include a conductive resin layer made by coating a conductive resin such as polypyrrol, polyaniline, polythiol, polythiophene, polyethylenedioxythiophene, and poly 3, 4-ethylenedioxythiophene and a conductive layer plated with metal such as copper or silver. Among them, a conductive resin layer formed by coating a conductive resin of polythiophene or polypyrrole is more preferable from the viewpoint of toner releasability.

[0080] A method of coating the surface of the base particle 31c1 with the conductive resin may be a spray-coating the surface of the base particle or known methods.

[0081] The conductive resin may be a commercially available product such as polythiophene obtained from Nagase ChemteX Corporation, Heraeus Corporation, Rigaku Corporation, or the like. The commercially available product may be polyaniline, polyethylenedioxythiophene, and poly-3, 4-ethylenedioxythiophene obtained from Kaken Sangyo Co., Ltd., Sankyo Kasei Kogyo Co., Ltd., and the like.

[0082] The volume resistivity of the fine particles 31c is appropriately adjusted by changing the thicknesses of the coating layers made of low-resistance material such as the conductive resin. For example, in order to adjust the volume resistivity to be higher, the thickness of the coating layer may be reduced, and in order to adjust the volume resistivity to be lower, the thickness of the coating layer may be increased. When the material having too high conductivity such as metals is used, care should be taken so that the volume resistivity of the fine particles 31c does not become too lower than the lower limit value of the above-described range.

[0083] The material of the surface layer (that is the conductive layer) covering the surfaces of the fine particles 31c as the first fine particles having the low volume resistivity preferably has the volume resistivity from 1×10^{-6} Ω • cm to 1×10^{-4} Ω • cm. Specific examples thereof include metals such as Ag, Ni, Au, Co, and Pt, which may be one type of material or two or more types of materials.

[0084] The volume resistivity of the fine particles may be measured by, for example, MCP-PD51 or Loresta GP™ (Hiresta GP™ if resistance is high) manufactured by Mitsubishi Chemical Analytech Co., Ltd. Specifically, the volume resistivity was obtained by placing 1 g of the fine particles in a pressurized vessel having a diameter of 15 mm under an environment of 23°C and 50% RH, applying a voltage of 20 kV after applying a load of 20kN, and then reading the value measured and calculating.

[0085] The thickness of the surface layer is preferably 100 nm or less. The fine particle having the surface layer thicker than 100 nm has too low volume resistivity and is difficult to adjust the volume resistivity of the fine particle to a desired value even if the material having a high volume resistivity is selected as the material of the core fine particles, and even if the size of core fine particle is adjusted. In addition, metal-plated portions of the surface layers thicker than 100 nm easily adhere to each other to form aggregation of the fine particles. The surface layer thicker than 100 nm easily forms a crater. The layer thickness of the surface layer may be reduced within a range in which the volume resistivity of the fine particles can be adjusted to a desired value but is preferably 1 nm or more. The thickness of the surface layer is measured based on the difference between the weight of core particles and the weight of the fine particles coated by the surface layer.

[0086] The material of the core fine particles as the base particles of the fine particles as the first fine particles having the low volume resistivity may be appropriately determined in consideration of the volume resistivity of the surface layer material, the layer thickness, and the like. When the surface layer material is a material having the low volume resistivity such as metal, the core fine particle preferably has the volume resistivity higher than that of the metal in order to adjust the volume resistivity of the entire fine particle.

[0087] The core fine particle preferably has a nearly spherical shape. This is because the core fine particle coated with the surface layer, that is, the finished fine particle tends to be spherical. Depending on the coating method of the surface layer, a fine particle having a shape very different from the spherical shape may have an exposed part at which the core fine particles is exposed, which may cause unexpected discharge. The material of the core fine particle is not particularly limited as long as the volume resistivity of the finished fine particles exhibits a desired volume resistivity and may be appropriately selected according to the purpose.

[0088] FIG. 7 is a graph illustrating a relationship between the volume resistivity of the fine particles dispersed on the surface of the intermediate transfer belt 31, the secondary transfer rate of a halftone image, and a grade of abnormal image in the halftone image.

[0089] In the graph of FIG. 7, the secondary transfer rates were measured when black halftone images were transferred from the intermediate transfer belts 31 including dispersed fine particles having different volume resistivities to the recording medium P under the environment of the temperature of 23°C and the humidity of 50% RH, and the abnormal images were evaluated in the black halftone images formed on the recording mediums P.

[0090] As illustrated in the graph of FIG. 7, increasing the volume resistivity of the fine particles decreases the secondary transfer rate. The reason is considered that the electric discharge in the minute gap reversely charges the toner as described above.

[0091] On the other hand, the fine particles having too low volume resistivity cause decrease in the secondary transfer rate. This is because the secondary transfer current easily flows between the fine particles having too low volume resistivity on the surface of the intermediate transfer belt 31. Most of the secondary transfer current flows between the fine particles on the surface of the intermediate transfer belt 31 along the surface of the intermediate transfer belt 31 and reaches a non-toner adhesion portion (a background portion, a non-image portion, or the like) to which no toner adheres. As a result, the secondary transfer current does not reach the toner and flows between the first fine particles on the surface of the intermediate transfer belt 31 and the recording medium P. It is considered that the shortage of the secondary transfer current reaching the toner increases the amount of the toner which is not transferred from the intermediate transfer belt 31 to the recording medium P and rather deteriorates the transfer performance.

[0092] In addition, reducing the volume resistivity of the fine particles, specifically, reducing the volume resistivity of the fine particles to be lower than $1 \times 10^{-2}\ \Omega \cdot \mathrm{cm}$ causes occurrence of a low grade of abnormal image as illustrated in the graph of FIG. 7. The reason of the occurrence of the abnormal image is considered that reducing the volume resistivity of the fine particles causes most of the secondary transfer current to flow between the fine particles on the surface of the intermediate transfer belt 31 along the surface of the intermediate transfer belt 31, thereby disturbing the secondary transfer electric field and disturbing the toner image.

[0093] The grade of abnormal image is a result of sensory evaluation evaluating the degree of disturbance in the abnormal image. the grade "1" means the worst degree of abnormal image, and the grade "5" means that the degree of abnormal image is minor level and acceptable. In this case, the grade of abnormal image lower than "5" means that the degree of disturbance in the abnormal image is an unacceptable level. Accordingly, the volume resistivity of the fine particles as the first fine particles having the low volume resistivity is preferably $1 \times 10^{-2}\ \Omega \cdot \mathrm{cm}$ or more from the viewpoint of preventing occurrence of the abnormal images.

[0094] FIG. 8 is an enlarged schematic sectional view partially illustrating the intermediate transfer belt 31 according to the present embodiment.

[0095] FIG. 9 is an enlarged top view partially illustrating the intermediate transfer belt 31 according to the present embodiment.

[0096] In the present embodiment, the intermediate transfer belt 31 includes the base layer 31a and the elastic layer 31b layered on the surface of the base layer 31a. The base layer 31a is an endless belt made of a material having a certain flexibility and an increased rigidity, that is, a belt made of hard material. The elastic layer 31b is made of an elastic material having excellent flexibility. On the elastic layer 31b, the first fine particles 31c having the low volume resistivity and second fine particles 31d having a high volume resistivity are dispersed. As illustrated in FIG. 8, the first fine particles 31c and the second fine particles 31d are densely arranged in the belt surface portion, and a part of the first fine particles 31c and a part of the second fine particles 31d protrude from the surfaces of the elastic layer 31b. The first fine particles 31c and the second fine particles 31d form a plurality of projections on the belt surface.

[0097] As illustrated in FIG. 9, the first fine particles 31c and the second fine particles 31d are intermixtedly arranged. This is because the second fine particles 31d appropriately blocks the current flowing between the first fine particles 31c and reduce the current flowing along the surface of the intermediate transfer belt 31 and reaching the non-toner adhesion portion (the background portion, the non-image portion, or the like) to which no toner adheres.

[0098] More specifically, dispersing the second fine particles 31d together with the first fine particles 31c enables the second fine particles 31d to block the current flowing between the first fine particles 31c on the surface of the intermediate transfer belt along the surface of the intermediate transfer belt even if the volume resistivity of the first fine particles 31c is set to be low. The above-described arrangement of the first fine particles 31c and the second fine particles 31d can reduce the current flowing along the surface of the intermediate transfer belt 31 and reaching the non-toner adhesion portion to which the toner is not adhered. In addition, the current easily flows between the first fine particle 31c having the low volume resistivity and the toner. As a result, most of the secondary transfer current can flow between the first fine particle 31c and the toner. Accordingly, the above-described arrangement prevents the deterioration in the transfer performance caused by the first fine particles 31c having the low volume resistivity that leads the current to the non-toner adhesion portion.

[0099] In other words, the above-described arrangement according to the present embodiment can obtain the effect of the first fine particles 31c (the effect of reducing the reversely charged toner to improve the transfer performance) and prevent the disadvantage due to the first fine particles 31c (the disadvantage that the shortage of the current flowing to the toner deteriorates the transfer performance). As a result, a transfer device using the intermediate transfer belt 31 including the elastic layer 31b can have a higher secondary transfer rate and a high transfer performance.

[0100] The first fine particles 31c and the second fine particles 31d are preferably dispersed on the surface of the intermediate transfer belt 31 so that the same type of fine particles are not adjacent to each other as much as possible, as illustrated in FIG. 9. An uneven distribution of the first fine particles 31c and the second fine particles 31d may generate a portion in which the first fine particles 31c having the low volume resistivity do not produce the above-described effect or a portion in which the second fine particles 31d having the high volume resistivity do not produce the above-described effect.

[0101] Further, the arrangement of the second fine particles 31d dispersed together with the first fine particles 31c as in the present embodiment is effective not only in obtaining the high secondary transfer rate but also in preventing the occurrence of the abnormal image. As described above, the low volume resistivity of the first fine particles 31c (for example, lower than $1 \times 10^{-2}\ \Omega \cdot$ cm as illustrated in the graph of FIG. 7) provides a high secondary transfer rate but may cause the abnormal image. The reason of the occurrence of the abnormal image is considered that the low volume resistivity of the first fine particles 31c causes most of the secondary transfer current to flow between the first fine particles 31c on the surface of the intermediate transfer belt 31 along the surface of the intermediate transfer belt 31, thereby disturbing the secondary transfer electric field and disturbing the toner image.

[0102] Increase in electrical resistances of materials of components under a low-temperature and low-humidity environment increases the secondary transfer bias to normally transfer the toner from the intermediate transfer belt 31 to the recording medium P to be higher than the secondary transfer bias under a high temperature environment. The higher secondary transfer bias decreases a margin for the occurrence of the abnormal image. That is, when the secondary transfer bias increases, the value of the volume resistivity of the first fine particles 31c that causes the abnormal image increases to be higher than $1 \times 10^{-2}\ \Omega \cdot$ cm in the graph illustrated in FIG. 7.

[0103] FIG. 10 is a graph illustrating the secondary transfer rate and the grade of abnormal image in the halftone image measured by changing a mixture ratio of the first fine particles 31c on the intermediate transfer belt 31. The mixture ratio on the horizontal axis is a ratio of areas where the first fine particles 31c exist on the intermediate transfer belt 31. The grade of the abnormal image was evaluated in the low-temperature and low-humidity environment (10°C, 15% RH), and the secondary transfer rate was measured in a normal-temperature environment (23°C, 50% RH).

[0104] Increase in the mixture ratio of the second fine particles 31d, that is, relative decrease in the mixture ratio of the first fine particles 31c improves the grade of abnormal image as illustrated in FIG. 10. In particular, the graph of FIG. 10 illustrates both the high secondary transfer rate and the grade "5" of the abnormal image in a region of the mixture ratio of the first fine particles 31c from 40% to 50%.

[0105] The volume resistivity of the second fine particles 31d is preferably $1 \times 10^{2}\ \Omega \cdot$ cm or more. This is because the second fine particles 31d having the volume resistivity $1 \times 10^{2}\ \Omega \cdot$ cm or more easily prevents the disadvantage caused by the first fine particles 31c having the low volume resistivity (that is the disadvantage that the shortage of the current flowing to the toner deteriorates the transfer performance). The material and structure of the second fine particles 31d are not particularly limited as long as a desired volume resistivity is obtained and may be appropriately selected according to the purpose. The structure of the second fine particle 31d may be a single-layer structure or a structure of two or more layers in which a base particle is coated with a resin or the like. Examples of the base particle include the acrylic resin particle, the melamine resin particle, the silicone resin particle, the polyamide resin particle, the polyester resin particle, and the polyvinyl chloride resin particle. Examples of coating material include polypyrrol, polyaniline, polythiol, polythiophene, polyethylenedioxythiophene, and poly 3, 4-ethylenedioxythiophene.

[0106] FIG. 11 is a graph illustrating the mixture ratio of the first fine particles 31c at which the abnormal image does not occur with respect to the volume resistivity of the first fine particles 31c. In experiments that provided data illustrated in the graph of FIG. 11, the second fine particle 31d had a volume resistivity of $1 \times 10^{5}\ \Omega \cdot$ cm.

[0107] As illustrated in the graph of FIG. 11, when the volume resistivity of the first fine particle 31c was smaller than $1 \times 10^{-2}\ \Omega \cdot$ cm, the mixture ratio of the first fine particles 31c and the second fine particles 31d at which the abnormal image does not occur was not found. Decreasing the volume resistivity of the first fine particles 31c provides the effect of the first fine particles having the low volume resistivity (that is the effect of reducing the reversely charged toner and preventing the deterioration of transfer performance). However, when the volume resistivity of the first fine particles was too low, increasing the amount of the second fine particles 31d in a range in which the effect of the first fine particles 31c was obtained did not provide the effect that the second fine particles 31d appropriately blocks the current flowing between the first fine particles 31c and reduce the current flowing along the surface of the intermediate transfer belt 31 and reaching the non-toner adhesion portion.

[0108] On the other hand, when the volume resistivity of the first fine particle 31c was equal to or greater than $1 \times 10^{-2}\ \Omega \cdot cm$, adjusting the mixture ratio of the first fine particles 31c and the second fine particles 31d provided a configuration in which the abnormal image does not occur. Therefore, the volume resistivity of the first fine particles 31c is preferably $1 \times 10^{-2}\ \Omega \cdot cm$ or more.

[0109] In addition, densely dispersing the first fine particles 31c and the second fine particles 31d on the elastic layer 31b forms recesses between fine particles including the first fine particles 31c and the second fine particles 31d. The toner may be physically caught in the recesses. In this case, the toner is not transferred to the recording medium P, and the transfer performance is deteriorated. In order to set the size of the recess between the fine particles in which the toner is not caught, the volume average particle diameter of each of the first fine particles 31c and the second fine particles 31d is preferably 100 μm or less. More specifically, the volume average particle diameter of each of the first fine particles 31c and the second fine particles 31d is preferably 5 μm or less, more preferably 0.5 μm to 5 μm, and particularly preferably 1 μm to 2 μm.

[0110] Next, the superimposed voltage used as the secondary transfer bias is described.

[0111] A certain amount of voltage is applied to transfer the toner image onto the recording medium P. However, continuously applying the certain amount of a direct current voltage not including an alternating current component may not sufficiently transfer a halftone toner image onto the recording medium P having the rough surface.

[0112] FIG. 12 is a graph illustrating an example of an ideal transfer bias waveform. In FIG. 12, the horizontal axis represents time (second), and the vertical axis represents voltage (Volt).

[0113] Each parameter in FIG. 12 is set as follows.

$$\mathrm{Voff} = (\mathrm{Vr} + \mathrm{Vt}) / 2$$

$$\mathrm{Vpp} = (\mathrm{Vr} - \mathrm{Vt})$$

$$\mathrm{Vave} = (\mathrm{Vr} \times \mathrm{Duty} / 100) + \mathrm{Vt} \times (1 - \mathrm{Duty}) / 100$$

$$\mathrm{Duty}: (\mathrm{B} - \mathrm{A}) / \mathrm{B} \times 100\ [\%]$$

[0114] In the above expressions, Vt is the peak value of the voltage for transferring the toner from the intermediate transfer belt to the recording medium in FIG. 12, Vr is the peak value opposite to Vt in the waveform illustrated in FIG. 12, and Vpp is the peak-to-peak voltage. In addition, A is a duration time applying the voltage Vt, in other words, a duration time of transfer-side peak waveform, and B is the period of the transfer bias waveform. The transfer-side peak waveform is a waveform while the voltage for transferring the toner from the intermediate transfer belt to the recording medium is applied in the waveform illustrated in FIG. 12.

[0115] The transfer bias waveform illustrated in FIG. 12 is an ideal waveform to transfer the halftone toner image that applies enough voltage to transfer, but the duty set to be higher than 50% shortens a time applying the voltage to prevent overcharge of the toner.

[0116] FIG. 13 is a graph illustrating a waveform actually outputted aiming at the ideal waveform of FIG. 12.

[0117] This waveform has Vt = - 4.8 kV, Vr = 1.2 kV, Voff = - 1.8 kV, Vave = 0.08 kV, Vpp = 6.0 kV, the duration of time of Vt peak A = 0.10 ms, the period of waveform B = 0. 66 ms, and Duty = 90%.

[0118] FIGS. 14A to 14E illustrate output waveforms when the duty is changed from 90% to 10% under conditions generating the transfer bias waveform illustrated in FIG. 13.

[0119] Using the secondary transfer biases having these output wave forms, the secondary transfer rates of a halftone black image was evaluated. The experimental conditions as follows:

Environment: High temperature and high humidity of 27°C and 80% RH,
Paper sheet: OK TOPCOAT 128gsm (450 mm × 320 mm),
Output image: the black halftone image.

[0120] When the duty was as high as 90% and 70%, a sufficient halftone transfer rate was obtained. On the other hand, the halftone transfer rate in the low duty such as 50%, 30%, and 10% was smaller than the halftone transfer rate in the high duty such as 90% and 70%. In addition, the halftone transfer rate was measured using the secondary transfer bias including the DC voltage and not including the AC voltage. The result was the same as the results in the low duties that were 50%, 30%, and 10%. It is considered that this is because shortening a voltage application time to transfer the toner from the intermediate transfer belt to the recording medium prevents the overcharge of the toner and improves the transfer performance. In addition, the output waveform having the parameter Vr that has an opposite polarity of the parameter Vt surely prevents the overcharge. This is because the output waveform having both polarities generates an electric field preventing the overcharge even when the recording medium is charged.

[0121] The configurations according to the above-descried embodiments are examples, and embodiments of the present disclosure are not limited to the above-described examples. For example, the following aspects can achieve effects described below.

First Aspect

[0122] The image forming apparatus such as the color printer according to the first aspect includes the image bearer such as the intermediate transfer belt 31 and a transferor such as the secondary transfer belt 36. The transferor transfers the toner image borne on the surface of the image bearer onto the recording medium P. The image bearer includes an elastic layer such as the elastic layer 31b, a first fine particle such as the first fine particle 31c, and a second fine particle such as the second fine particle 31d. The first fine particle and the second fine particle are dispersed on the surface of the image bearer. The volume resistivity of the first fine particle is lower than the volume resistivity of the elastic layer, and the volume resistivity of the second fine particle is higher than the volume resistivity of the first fine particle.

[0123] The image bearer including the elastic layer generally includes the elastic layer as the surface layer or the elastic layer covered with a thin coating layer on the surface of the elastic layer so that the surface of the image bearer is easily deformed following the surface unevenness of rough sheet. Since the above-described image bearer generally has the surface having a high electrical resistance, the transfer bias applied to transfer the toner from the image bearer to the recording medium causes the electric discharge in the minute gap between the toner and the recording medium or the minute gap between the image bearer and the recording medium. The electric discharge may reversely charge the toner. Such reversely charged toner is not transferred from the image bearer to the recording medium. Even after the toner is transferred to the recording medium, the electric discharge may reversely charge the toner on the recording medium, and the toner may be reversely transferred to the image bearer. As a result, the electric discharge deteriorates the transfer performance. That is, using the image bearer including the elastic layer improves the transfer performance for the rough sheet but deteriorates the transfer performance for the sheet not having a rough surface.

[0124] A method to prevent the above-described deterioration in the transfer performance for the sheet not having the rough surface caused by reversely charged toner is dispersing first particles having lower volume resistivity than the volume resistivity of the elastic layer 31b of the image bearer on the surface of the image bearer. According to this method, the current easily flows between the first particles on the surface of the image bearer and between the first particles and the toner. As a result, this method prevents the occurrence of the electric discharge in the minute gap and reduces the toner reversely charged by the electric discharge. Accordingly, this method prevents the deterioration of the transfer performance for the rough sheet caused by the toner reversely charged and maintains the effect that the image bearer including the elastic layer improves the transfer performance for the rough sheet.

[0125] In the above, it is preferable to reduce the volume resistivity of the first fine particles as much as possible so as to sufficiently obtain the effect that reducing the occurrence of electric discharge in the minute gap reduces the reversely charged toner and prevents the deterioration of the transfer performance for the rough sheet. However, reducing the volume resistivity of the first fine particles tends to cause an excessive current flowing between the first fine particles on the surface of the image bearer. As a result, most of the transfer current flows between the first fine particles on the surface of the image bearer along the surface of the image bearer and reaches a non-toner adhesion portion to which no toner adheres. Most of the transfer current flows between the recording medium and the first fine particles on the surface of the image bearer without flowing to the toner. The shortage of the transfer current flowing to the toner increases the amount of toner that is not transferred from the image bearer to the recording medium and deteriorates the transfer performance.

[0126] The image bearer according to the first aspect includes not only the first fine particles but also the second fine particles having the volume resistivity higher than the volume resistivity of the first fine particles, and the first fine particles and the second fine particles are dispersed on the surface of the image bearer. Dispersing the second fine particles together with the first fine particles enables the second fine particles to block the current flowing between the first fine particles on the surface of the image bearer along the surface of the image bearer even if the volume resistivity of the first fine particles is set to be low. The above-described arrangement of the first fine particles 31c and the second fine particles 31d can reduce the current flowing along the surface of the intermediate transfer belt 31 and reaching the non-toner adhesion portion to which the toner is not adhered. In addition, a function of the first fine particles that easily flows the transfer current causes most of the transfer current to flow between the toner and the first fine particles. As a result, the above-described arrangement of the first fine particles and the second fine particles prevents the deterioration of the transfer performance caused by the low volume resistivity of the first fine particles.

[0127] Therefore, the image forming apparatus according to the first aspect can obtain the effect of the first fine particles having the low volume resistivity (the effect of reducing the reversely charged toner to improve the transfer performance) and prevent the disadvantage due to the first fine particles having the low volume resistivity (the disadvantage that the shortage of the current flowing to the toner deteriorates the transfer performance).

Second Aspect

[0128] In the second aspect, the second fine particle in the image forming apparatus according to the first aspect has a volume resistivity of 1×10^2 Ω • cm or more.

[0129] According to the second aspect, the image forming apparatus can stably obtain the effect of the second fine particles that prevents the deterioration of the transfer performance caused by the shortage of the transfer current flowing to the toner that is caused by the low volume resistivity of the first fine particles.

Third Aspect

[0130] In the third aspect, the first fine particle in the image forming apparatus according to the first aspect or the second aspect includes a core fine particle such as the base particle 31c1 and a surface layer such as the conductive layer 31c2 covering a surface of the core fine particle and having a volume resistivity from 1×10^{-6} Ω • cm to 1×10^{-4} Ω • cm. In addition, the first fine particle has a volume resistivity equal to or greater than 1×10^{-2} Ω • cm.

[0131] According to the third aspect, the image forming apparatus can stably obtain the effect of the second fine particles that prevents the occurrence of the abnormal image caused by the low volume resistivity of the first fine particles.

Fourth Aspect

[0132] In the fourth aspect, the surface layer of the first fine particle in the image forming apparatus according to the third aspect has a thickness of 100 nm or less.

[0133] According to the fourth aspect, it is easy to adjust the volume resistivity of the first fine particles to a desired value.

Fifth Aspect

[0134] According to a fifth aspect, the image forming apparatus according to any one of the first to fourth aspects includes the first fine particle having a volume average particle diameter of 100 μm or less and the second fine particle having a volume average particle diameter of 100 μm or less.

[0135] Even if the first fine particles and the second fine particles are densely dispersed on the surface of the image bearer, recesses are formed between the particles. The toner may be physically caught in the recesses. In this case, the toner is not transferred to the recording medium, and the transfer performance is deteriorated. The first fine particles and the second fine particles each having the volume average particle diameter according to the fifth aspect form the recesses between the particles having the size which the toner is not caught and prevents the deterioration of the transfer performance.

Sixth Aspect

[0136] In the sixth aspect, the image forming apparatus according to any one of the first to fifth aspects further includes a transfer bias power source such as the secondary transfer bias power source 39. The transfer bias power source is configured to output a transfer bias having the transfer bias waveform that satisfies the following condition.

$$\text{Duty} = (B - A) / B \times 100\% > 50\%,$$

where A is the duration time of the transfer-side peak waveform to transfer the toner image from the image bearer to the recording medium, and B is the period of the transfer bias waveform.

[0137] According to the sixth aspect, the image forming apparatus including the image bearer having the elastic layer can improve the halftone transfer rate.

[0138] The above-described embodiments are illustrative and do not limit the present invention. Thus, numerous additional modifications and variations are possible in light of the above teachings. For example, elements and/or features of different illustrative embodiments may be combined with each other and/or substituted for each other within the scope of the present invention.

Claims

1. An image bearer (31) comprising:

   an elastic layer (31b);
   first fine particles (31c) having a volume resistivity lower than a volume resistivity of the elastic layer (31b), the first fine particles (31c) dispersed on a surface of the image bearer (31); and
   second fine particles (31d) having a volume resistivity lower than the volume resistivity of the first fine particles (31c), the second fine particles (31d) dispersed on the surface of the image bearer (31).

2. The image bearer (31) according to claim 1,
   wherein the volume resistivity of the second fine particles (31d) is equal to or greater than $1 \times 10^{2}\ \Omega \cdot \mathrm{cm}$.

3. The image bearer (31) according to claim 1 or 2,

   wherein each of the first fine particles (31c) includes a core fine particle (31c1) and a surface layer (31c2) covering a surface of the core fine particle (31c1),
   wherein a volume resistivity of a material of the surface layer (31c2) is equal to or greater than $1 \times 10^{-6}\ \Omega \cdot \mathrm{cm}$ and equal to or smaller than $1 \times 10^{-4}\ \Omega \cdot \mathrm{cm}$, and
   wherein the volume resistivity of the first fine particles (31c) is equal to or greater than $1 \times 10^{-2}\ \Omega \cdot \mathrm{cm}$.

4. The image bearer (31) according to claim 3,
   wherein a thickness of the surface layer (31c2) is equal to or smaller than 100 nm.

5. The image bearer (31) according to any one of claims 1 to 4,
   wherein each of a volume average particle diameter of the first fine particles (31c) and a volume average particle diameter of the second fine particles (31d) is equal to or smaller than 100 μm.

6. The image forming apparatus (500) comprising:

   the image bearer (31) according to any one of claims 1 to 5; and
   a transferor (36) configured to transfer a toner image borne on the surface of the

7. The image forming apparatus (500) according to claim 6, further comprising a transfer bias power source (39) configured to output a transfer bias having a transfer bias waveform that satisfies

$$\mathrm{Duty} = (B - A) / B \times 100\% > 50\%,$$

   where A is a duration time of a transfer-side peak waveform to transfer the toner image from the image bearer (31) to the recording medium, and B is a period of the transfer bias waveform.

FIG. 1

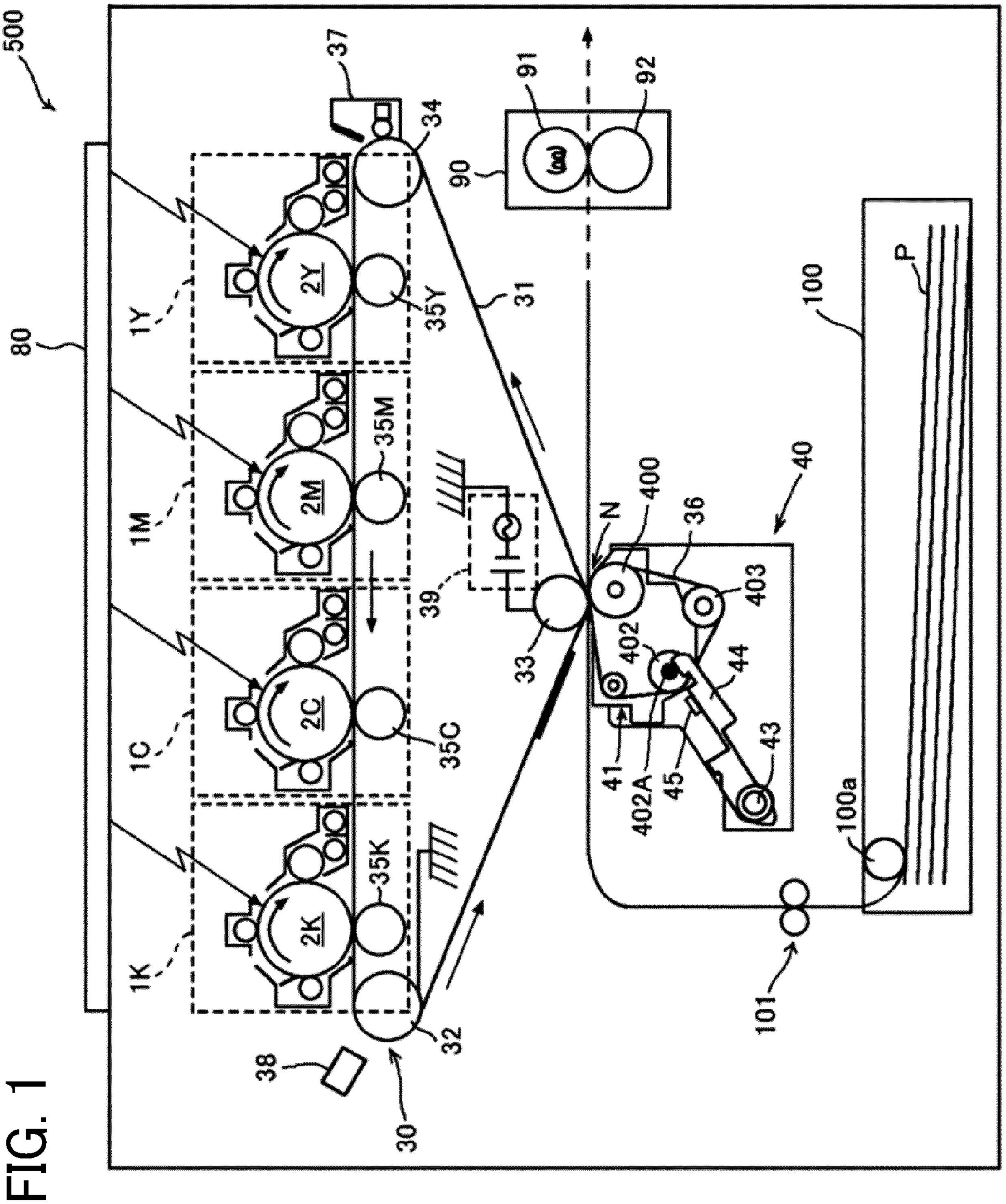

500
80
1K
1C
1M
1Y
2K
2C
2M
2Y
35K
35C
35M
35Y
37
34
31
32
30
38
33
39
N
400
36
403
402
44
43
45
402A
41
40
90
91
92
100
P
100a
101

FIG. 2

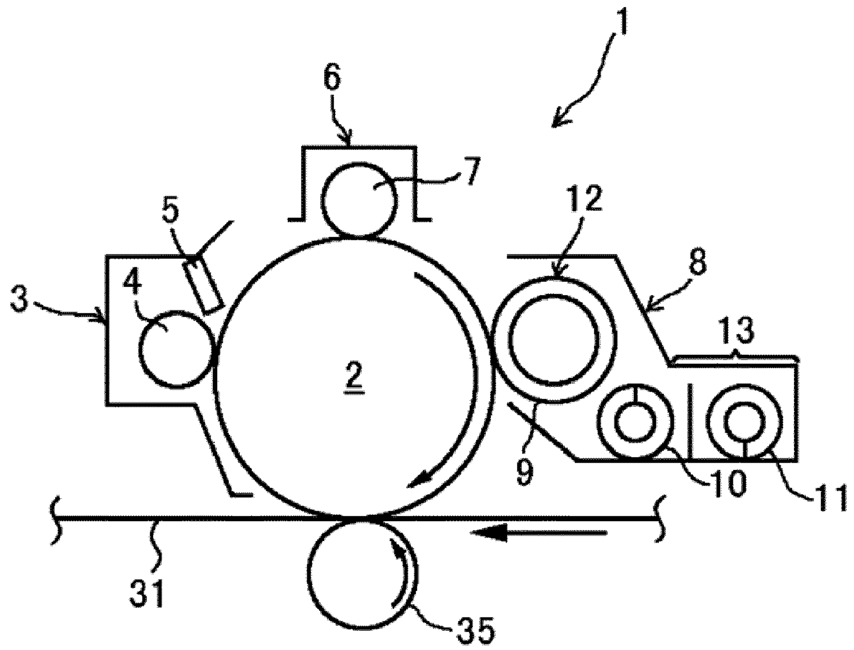


FIG. 3

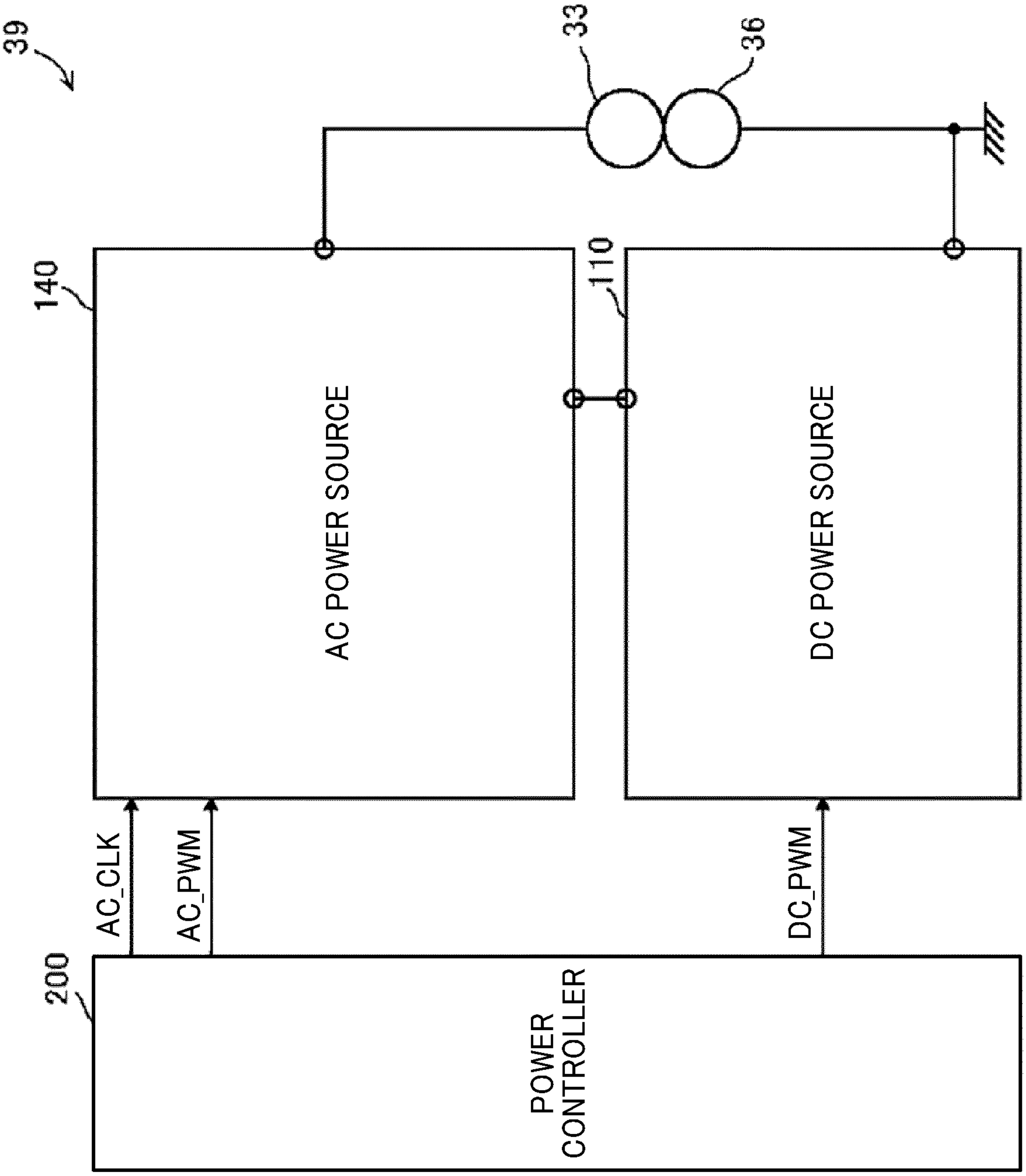

39
33
36
140
110
AC POWER SOURCE
DC POWER SOURCE
AC_CLK
AC_PWM
DC_PWM
200
POWER
CONTROLLER

FIG. 4

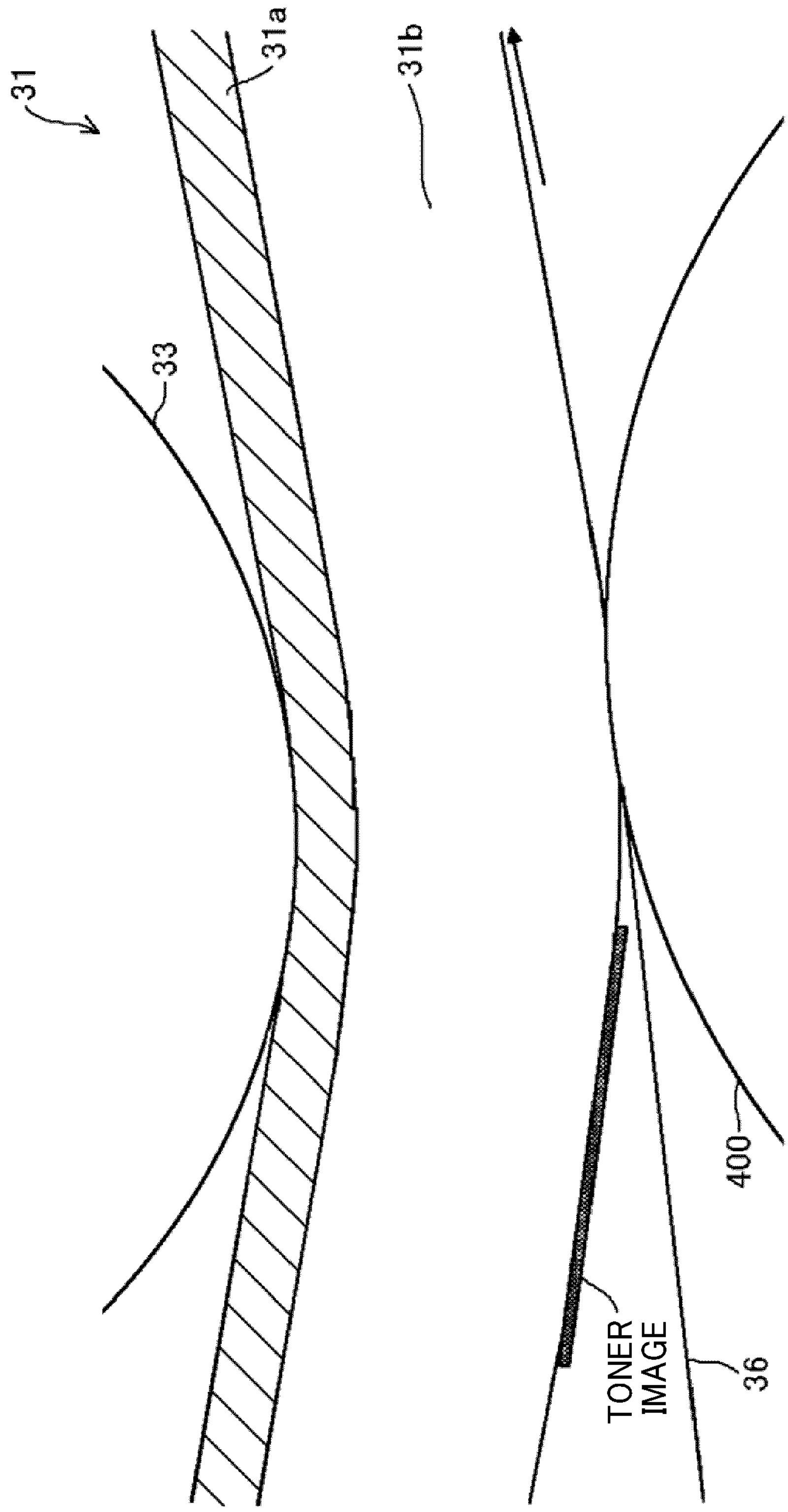


FIG. 5

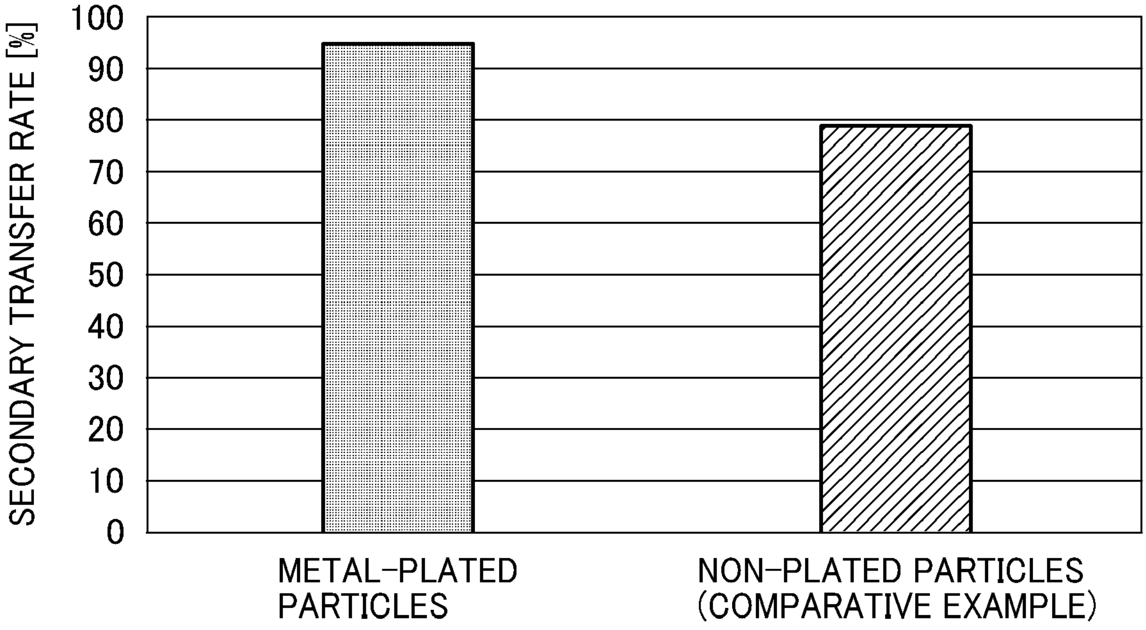

SECONDARY TRANSFER RATE [%]
100
90
80
70
60
50
40
30
20
10
0
METAL-PLATED PARTICLES
NON-PLATED PARTICLES (COMPARATIVE EXAMPLE)

FIG. 6

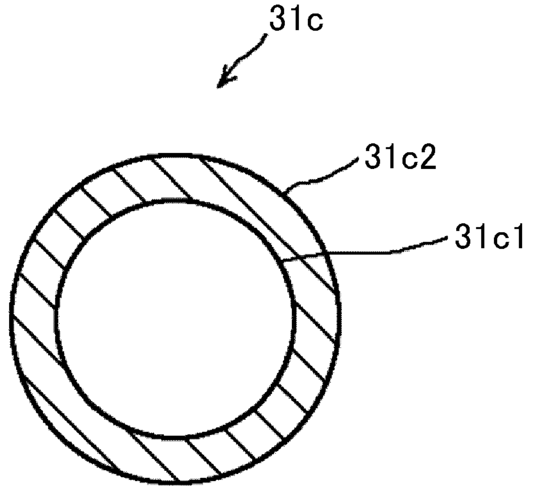

31c
31c2
31c1

FIG. 7

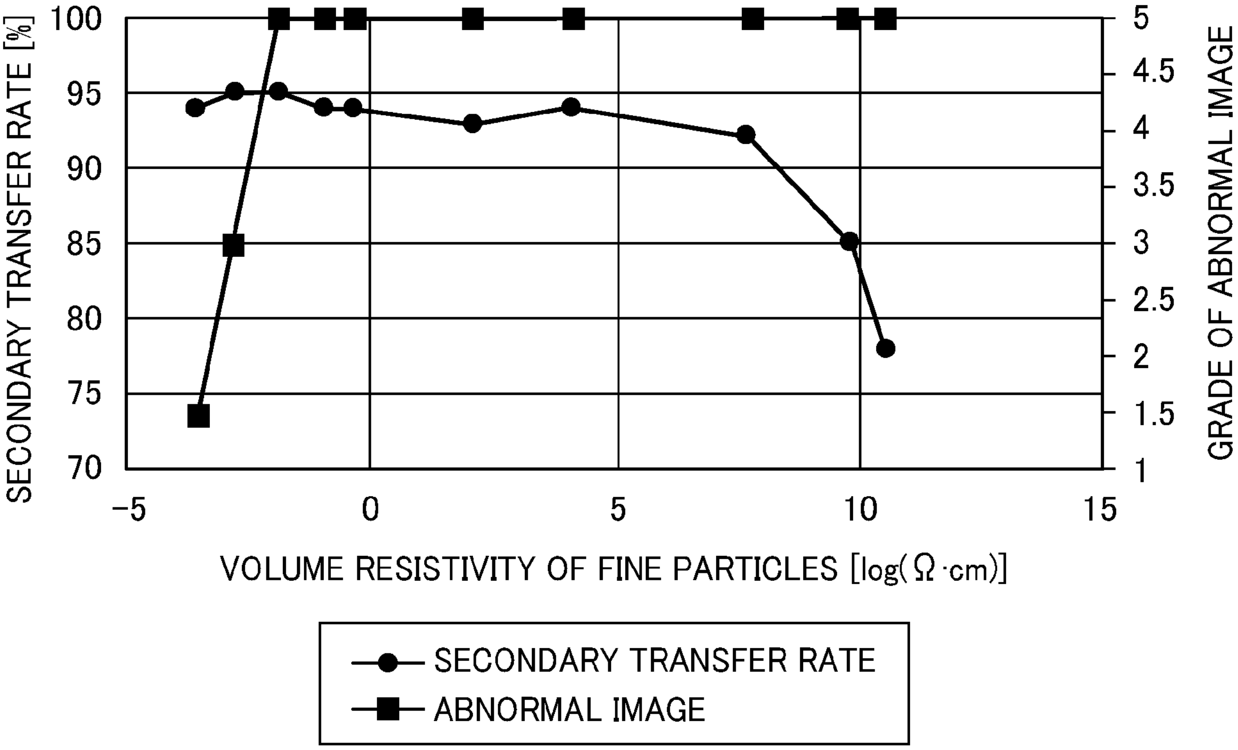

100
95
90
85
80
75
70
SECONDARY TRANSFER RATE [%]
5
4.5
4
3.5
3
2.5
2
1.5
1
GRADE OF ABNORMAL IMAGE
−5
0
5
10
15
VOLUME RESISTIVITY OF FINE PARTICLES [log(Ω·cm)]
SECONDARY TRANSFER RATE
ABNORMAL IMAGE

FIG. 8

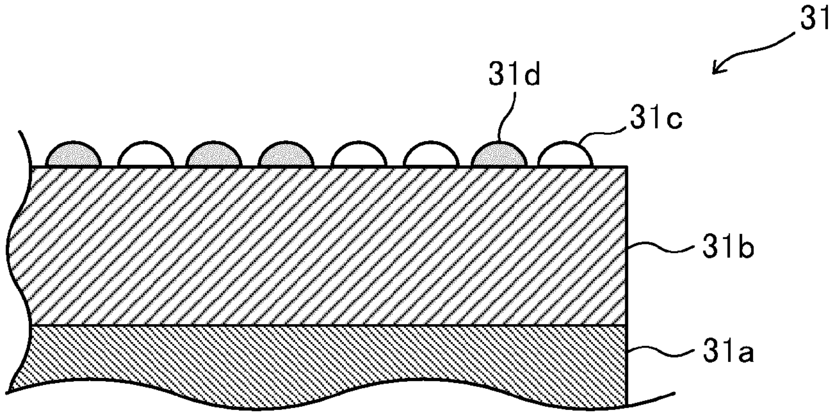

31
31d
31c
31b
31a

FIG. 9

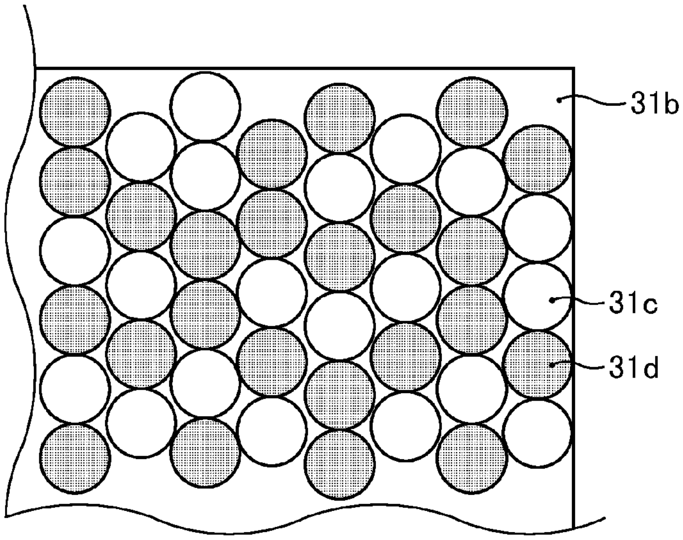

31b
31c
31d

FIG. 10

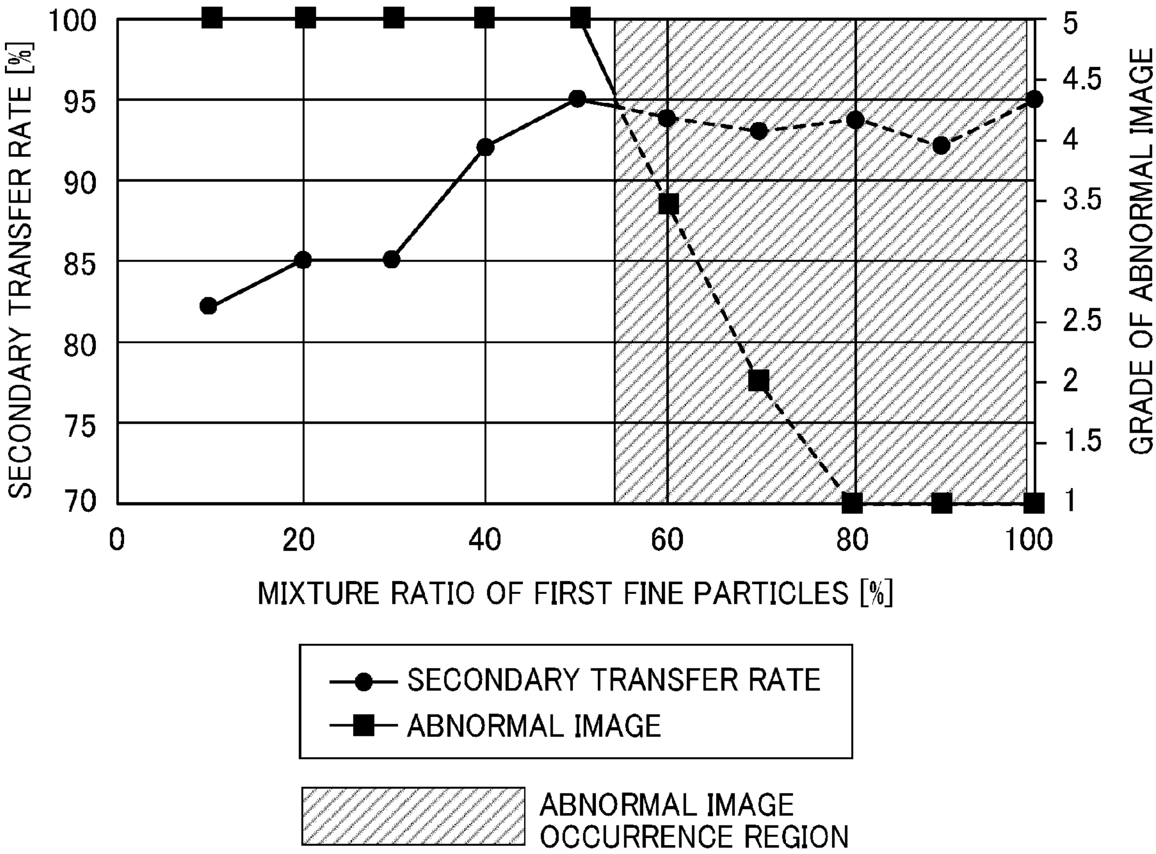

100
95
90
85
80
75
70
SECONDARY TRANSFER RATE [%]
5
4.5
4
3.5
3
2.5
2
1.5
1
GRADE OF ABNORMAL IMAGE
0
20
40
60
80
100
MIXTURE RATIO OF FIRST FINE PARTICLES [%]
SECONDARY TRANSFER RATE
ABNORMAL IMAGE
ABNORMAL IMAGE OCCURRENCE REGION

FIG. 11

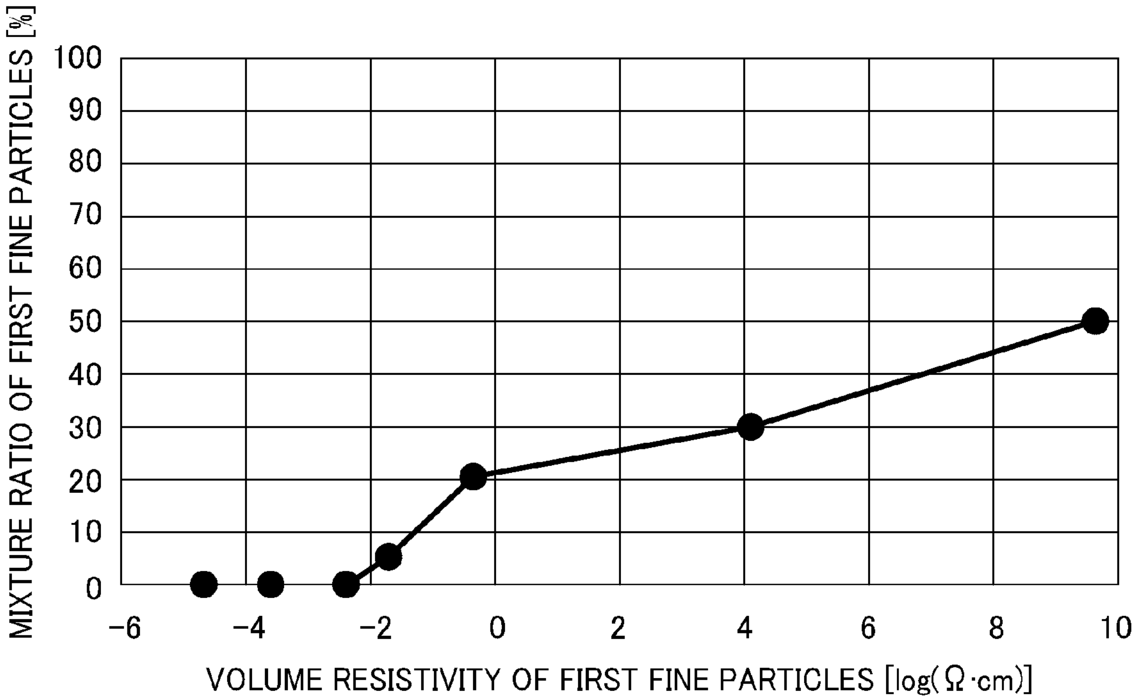

MIXTURE RATIO OF FIRST FINE PARTICLES [%]
100
90
80
70
60
50
40
30
20
10
0
−6
−4
−2
0
2
4
6
8
10
VOLUME RESISTIVITY OF FIRST FINE PARTICLES [log(Ω·cm)]

FIG. 12

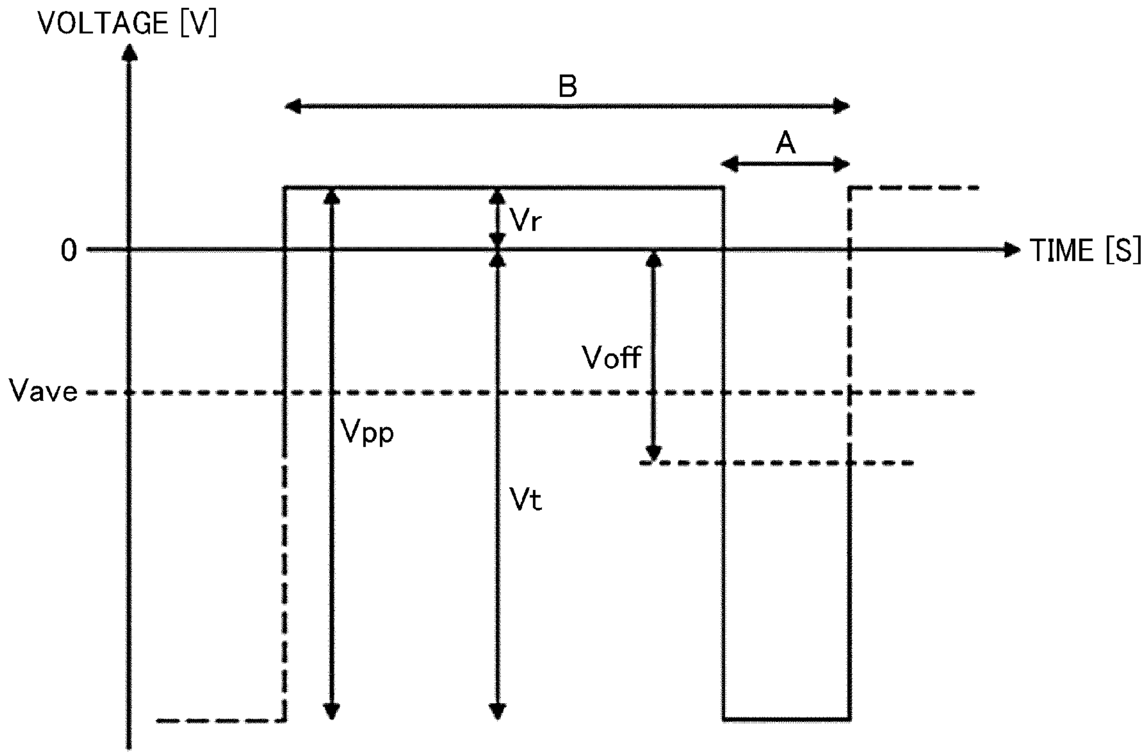

VOLTAGE [V]
B
A
Vr
0
TIME [S]
Voff
Vave
Vpp
Vt

FIG. 13

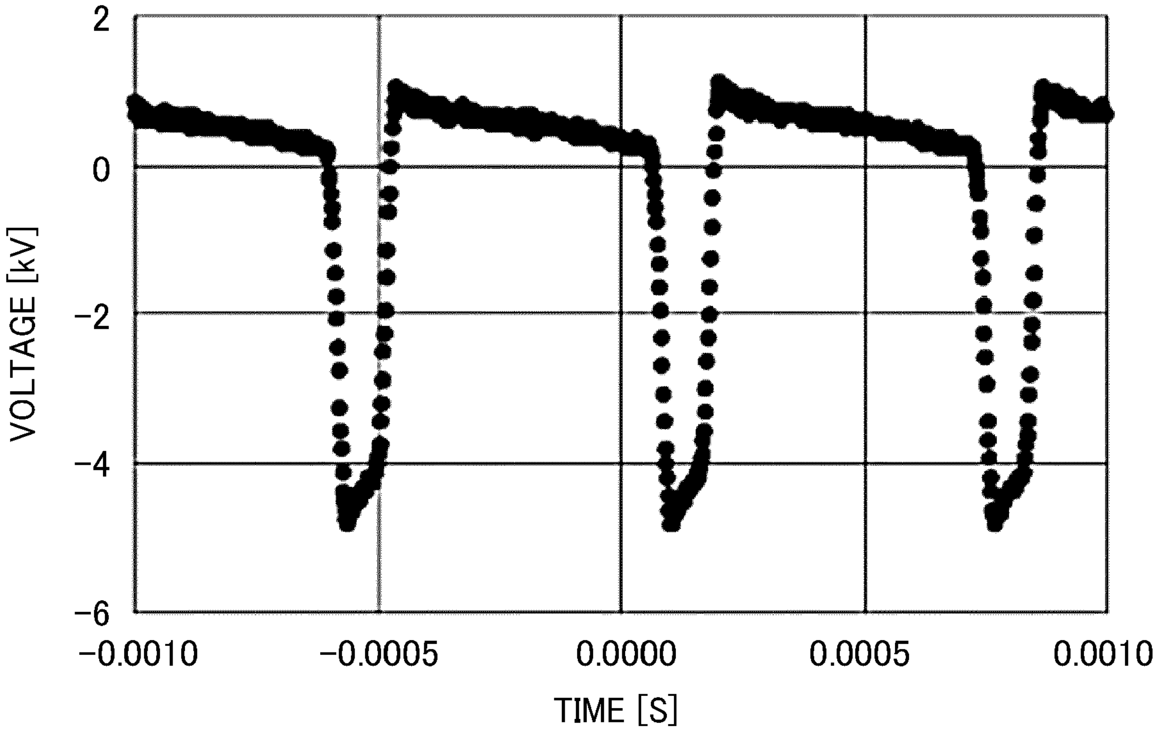


FIG. 14A

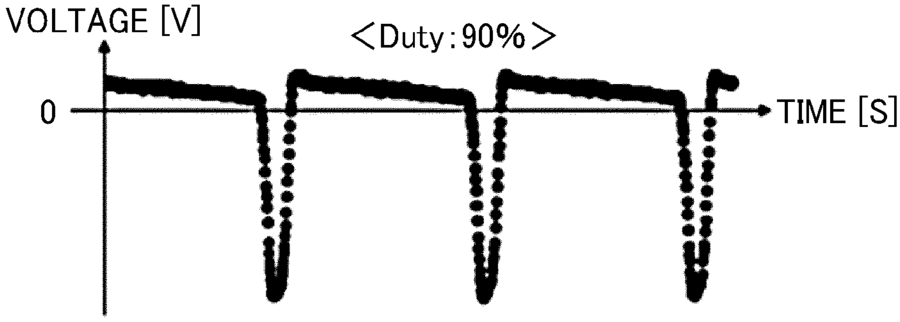


FIG. 14B

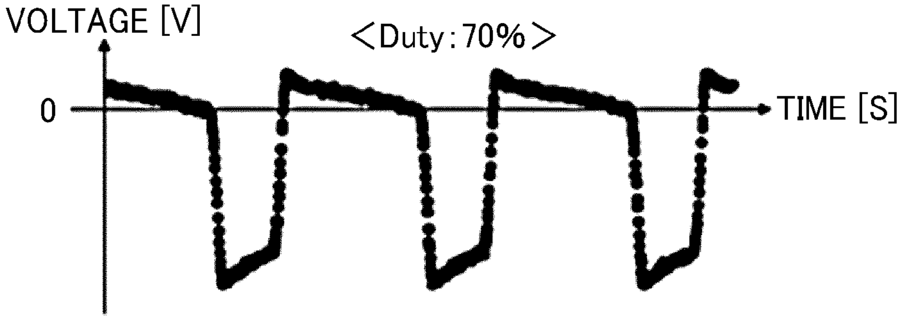


FIG. 14C

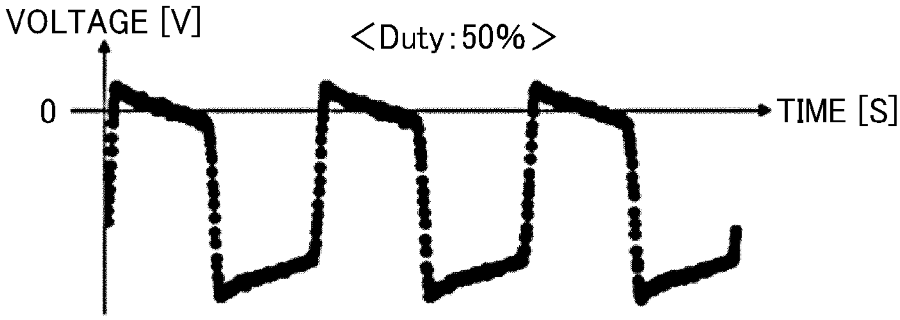


FIG. 14D

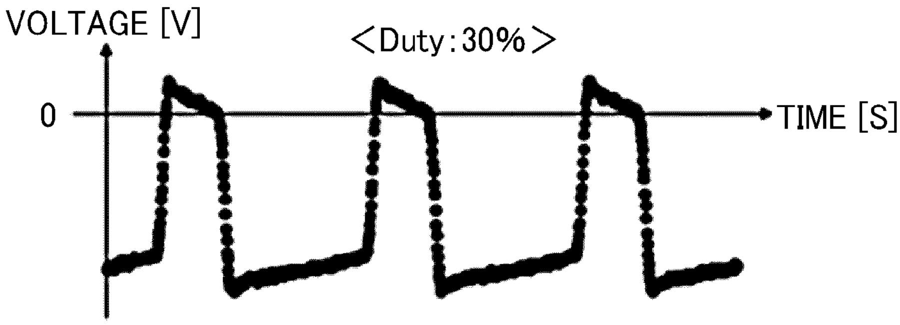
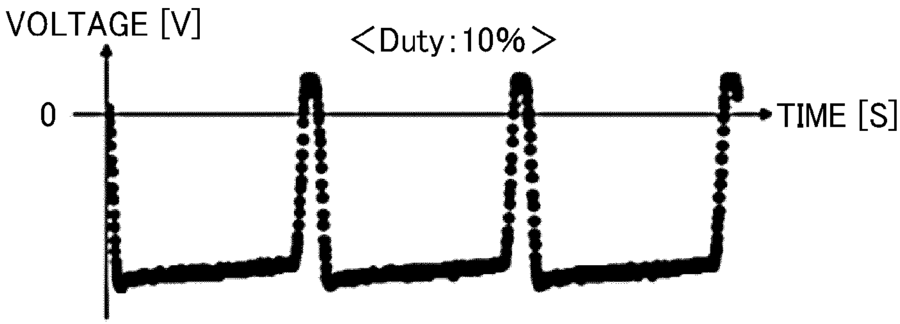


FIG. 14E



Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 21 20 9098

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	JP 2005 156636 A (RICOH PRINTING SYS LTD) 16 June 2005 (2005-06-16) * paragraph [0019] - paragraph [0078]; figures 1-5 *	1-6 7	INV. G03G15/16
A	EP 0 768 576 A1 (CANON KK [JP]) 16 April 1997 (1997-04-16) * column 2, line 30 - line 39 * * column 5, line 56 - column 6, line 6 *	1-7	
X,D Y	JP 2018 200407 A (RICOH CO LTD) 20 December 2018 (2018-12-20) * paragraph [0009] - paragraph [0146]; figures 1-17 *	1-7 7	
X Y	EP 3 518 048 A1 (RICOH CO LTD [JP]) 31 July 2019 (2019-07-31) * paragraph [0010] - paragraph [0138]; figures 1-6 *	1-6 7	
X Y	US 2017/269513 A1 (KUBO HIDETAKA [JP] ET AL) 21 September 2017 (2017-09-21) * paragraph [0022] - paragraph [0215]; figures 1-8 *	1-6 7	TECHNICAL FIELDS SEARCHED (IPC) G03G
X Y	JP 2014 145817 A (RICOH CO LTD) 14 August 2014 (2014-08-14) * paragraph [0019] - paragraph [0127]; figures 1-7 *	1-6 7	

The present search report has been drawn up for all claims

3

Place of search	Date of completion of the search	Examiner
Munich	21 March 2022	Billmann, Frank

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
....
& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 21 20 9098

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

21-03-2022

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2005156636 A	16-06-2005	NONE	
EP 0768576 A1	16-04-1997	CN 1155103 A	23-07-1997
		DE 69613787 T2	22-11-2001
		EP 0768576 A1	16-04-1997
		HK 1012052 A1	23-07-1999
		KR 970022591 A	30-05-1997
		US 5700617 A	23-12-1997
JP 2018200407 A	20-12-2018	NONE	
EP 3518048 A1	31-07-2019	EP 3518048 A1	31-07-2019
		US 2019227463 A1	25-07-2019
US 2017269513 A1	21-09-2017	NONE	
JP 2014145817 A	14-08-2014	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2018200407 A **[0003]**