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(54) **IMAGE FORMING APPARATUS**

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G03G 15/16 (2006.01)

(52) **U.S. Cl.**
CPC ***G03G 15/162*** (2013.01)

(58) **Field of Classification Search**
CPC G03G 15/162
See application file for complete search history.

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(57) **ABSTRACT**

An image forming apparatus includes an image bearing member, an intermediate transfer belt, and a contact member. The intermediate transfer belt includes a base layer, a surface layer formed on an outside of the base layer, and an inner surface layer formed on an inner side of the base layer. A position at which the contact member and the intermediate transfer belt contact is arranged on a downstream side of the intermediate transfer belt in a rotation direction of the intermediate transfer belt. Rv>Rs1 and Rs2>Rs1, and Rs2/Rv≤40 are satisfied where Rv (Ω) is a volume resistance value of the intermediate transfer belt in a thickness direction, Rs1 (Ω) is a first surface resistance value of the inner surface layer side in a surface direction, and Rs2 (Ω) is a second surface resistance value on the surface layer side in a surface direction.

16 Claims, 9 Drawing Sheets

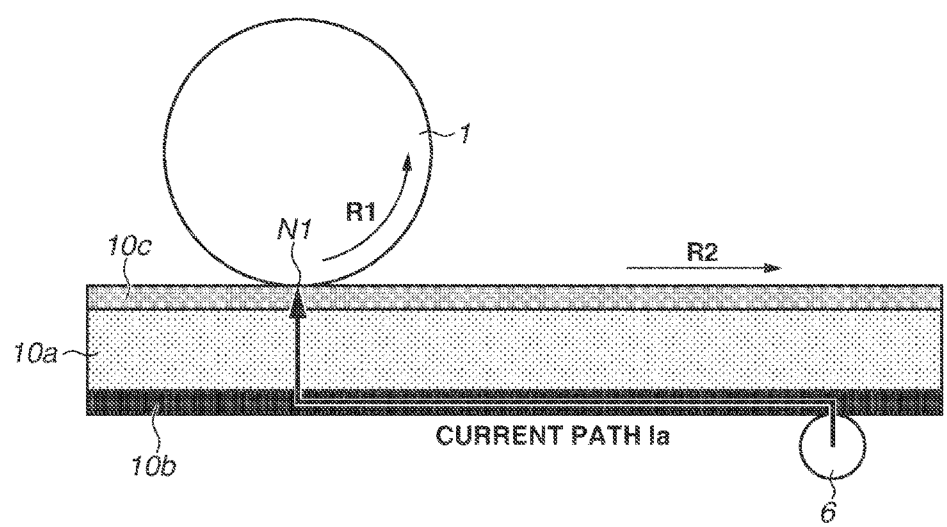


FIG.1

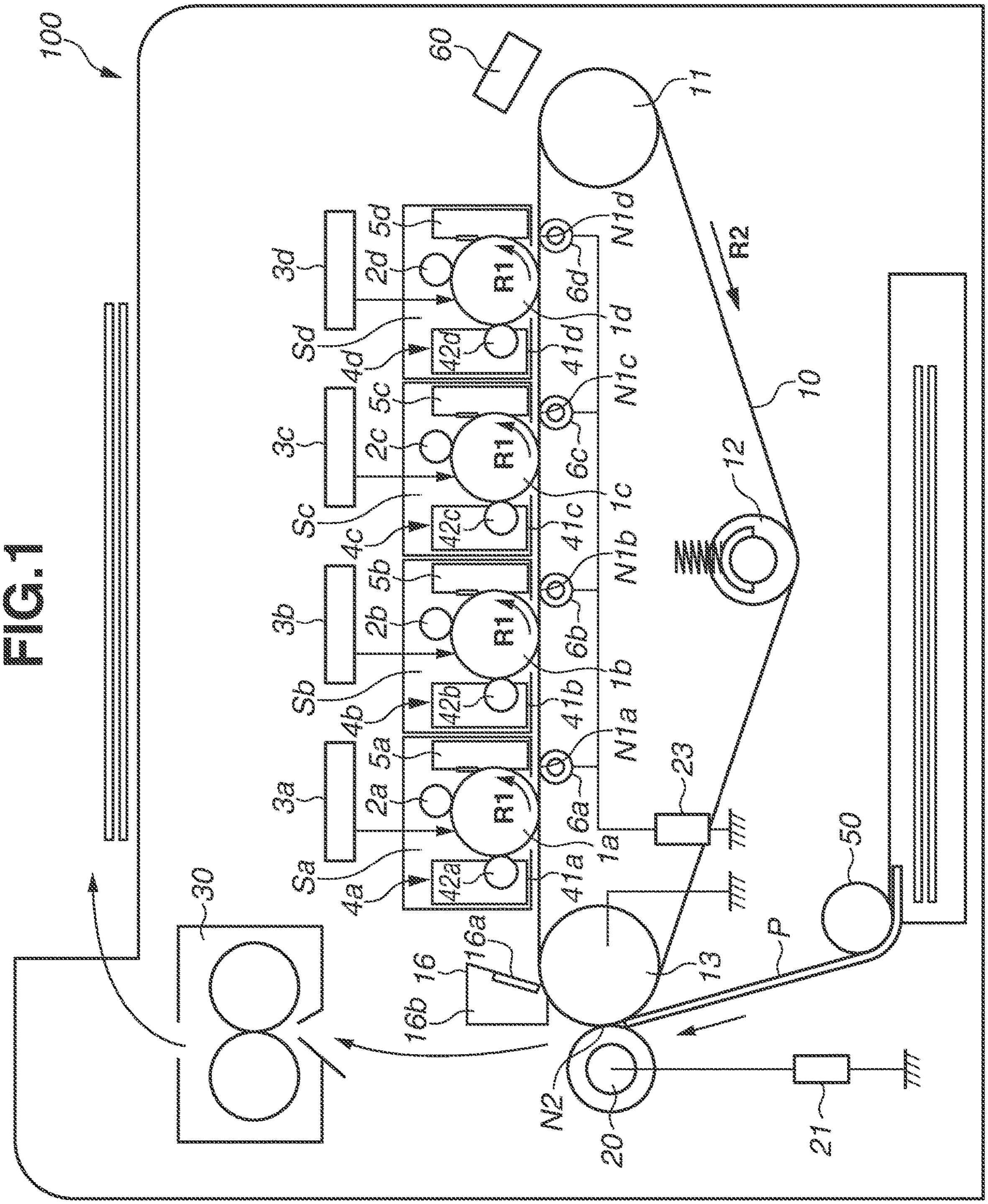

100
60
11
10
R2
12
13
16
16a
16b
20
21
23
30
50
P
N2
R1
1a
1b
1c
1d
2a
2b
2c
2d
3a
3b
3c
3d
4a
4b
4c
4d
5a
5b
5c
5d
6a
6b
6c
6d
41a
41b
41c
41d
42a
42b
42c
42d
Sa
Sb
Sc
Sd
N1a
N1b
N1c
N1d

FIG.2

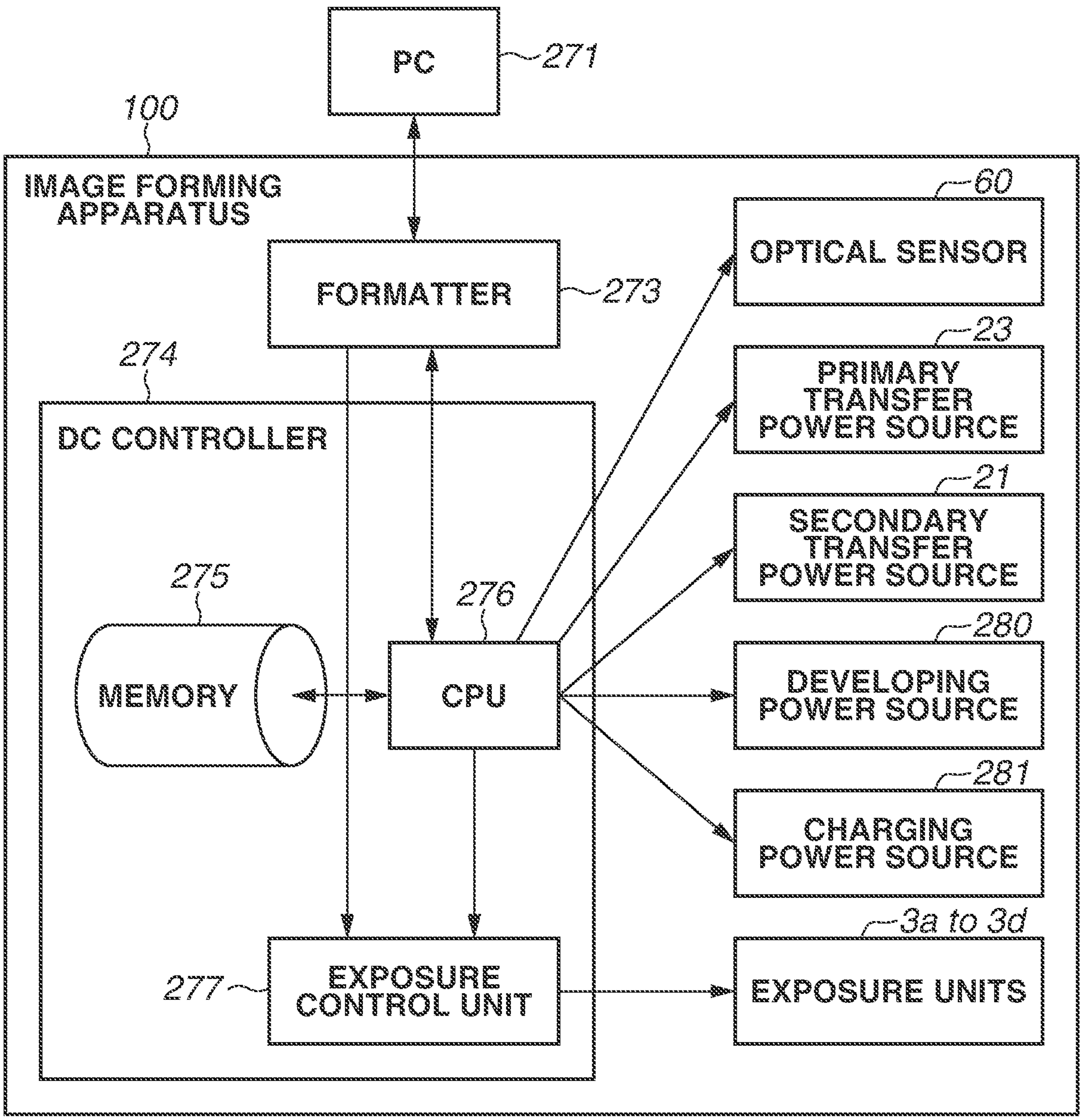

PC
271
100
IMAGE FORMING APPARATUS
FORMATTER
273
274
DC CONTROLLER
275
MEMORY
276
CPU
277
EXPOSURE CONTROL UNIT
60
OPTICAL SENSOR
23
PRIMARY TRANSFER POWER SOURCE
21
SECONDARY TRANSFER POWER SOURCE
280
DEVELOPING POWER SOURCE
281
CHARGING POWER SOURCE
3a to 3d
EXPOSURE UNITS

FIG.3

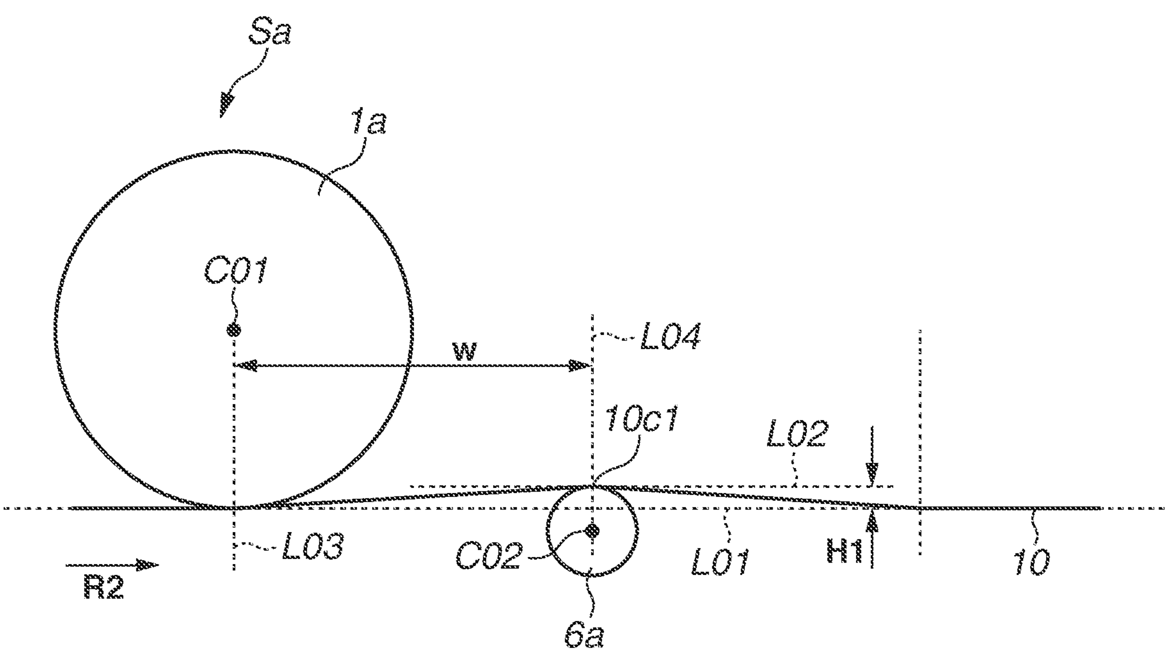


FIG.4

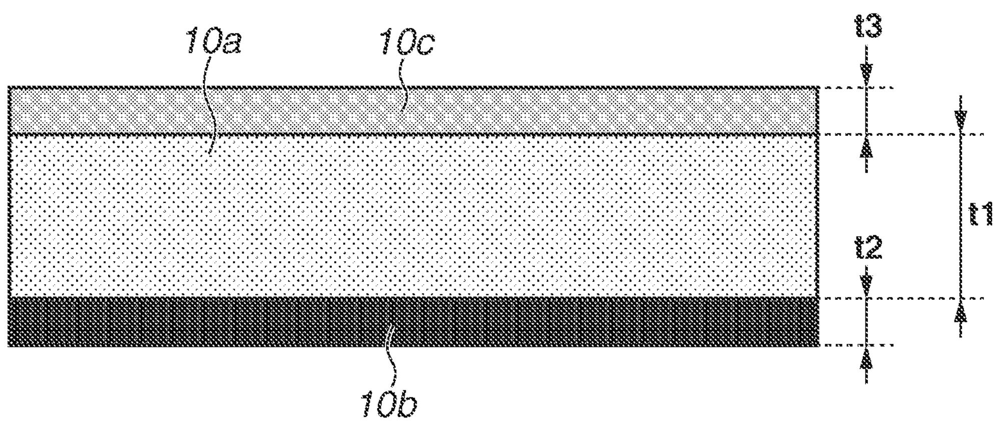


FIG.5A

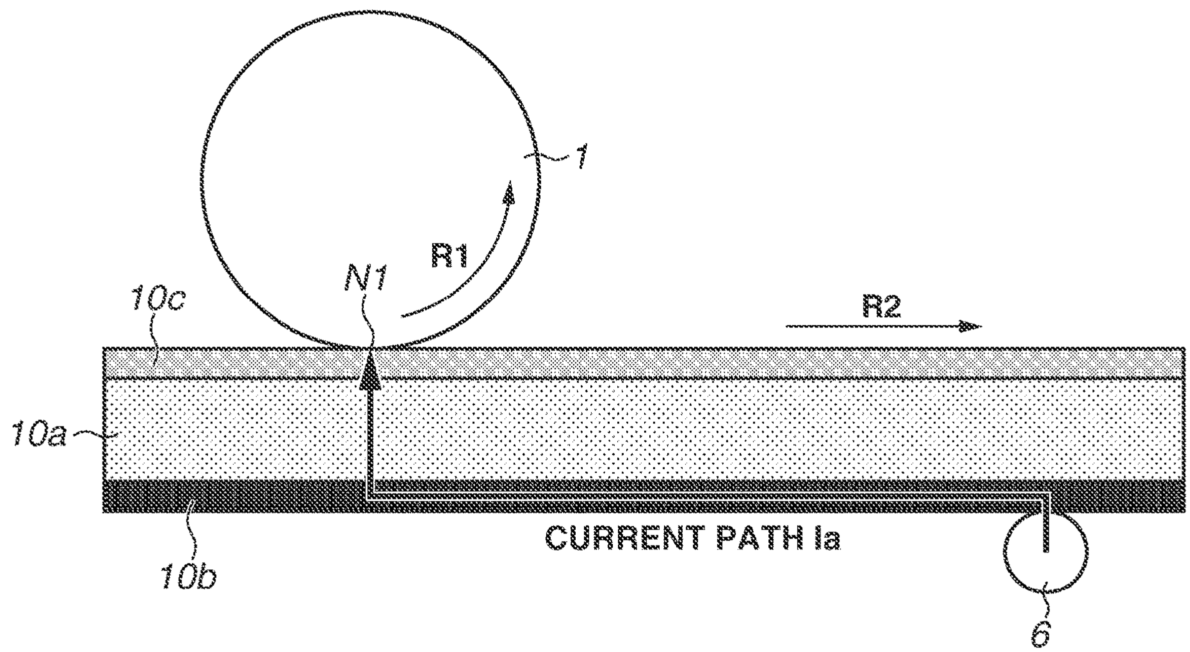

1
R1
N1
10c
R2
10a
10b
CURRENT PATH Ia
6

FIG.5B

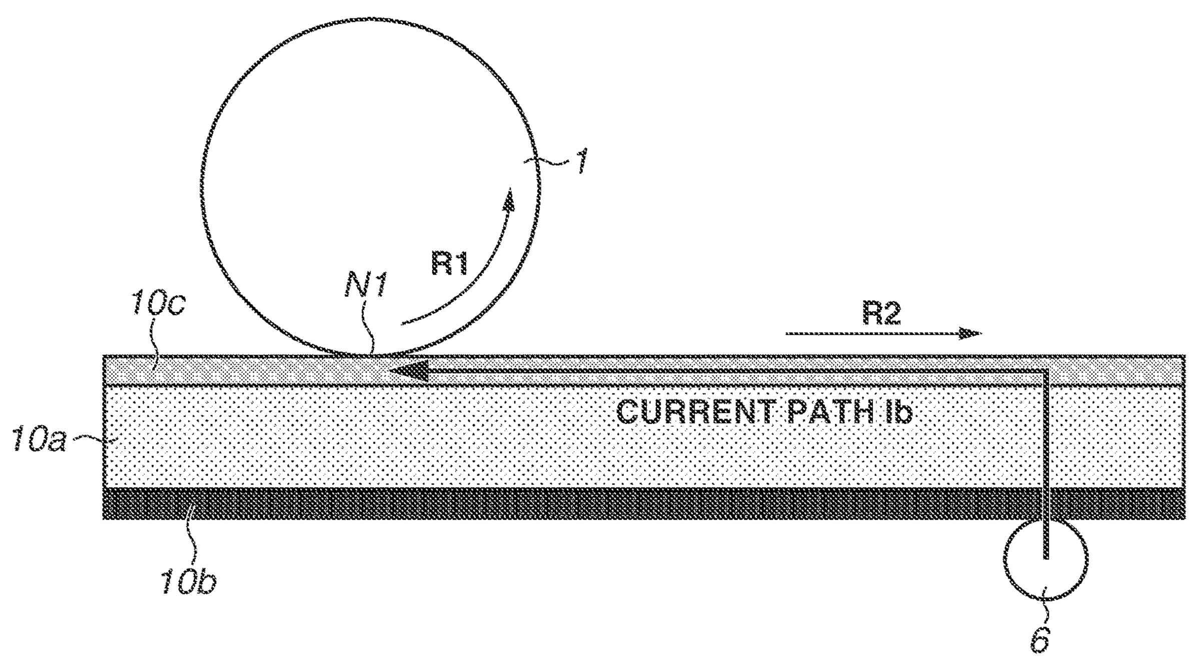

1
R1
N1
10c
R2
CURRENT PATH Ib
10a
10b
6

FIG.6

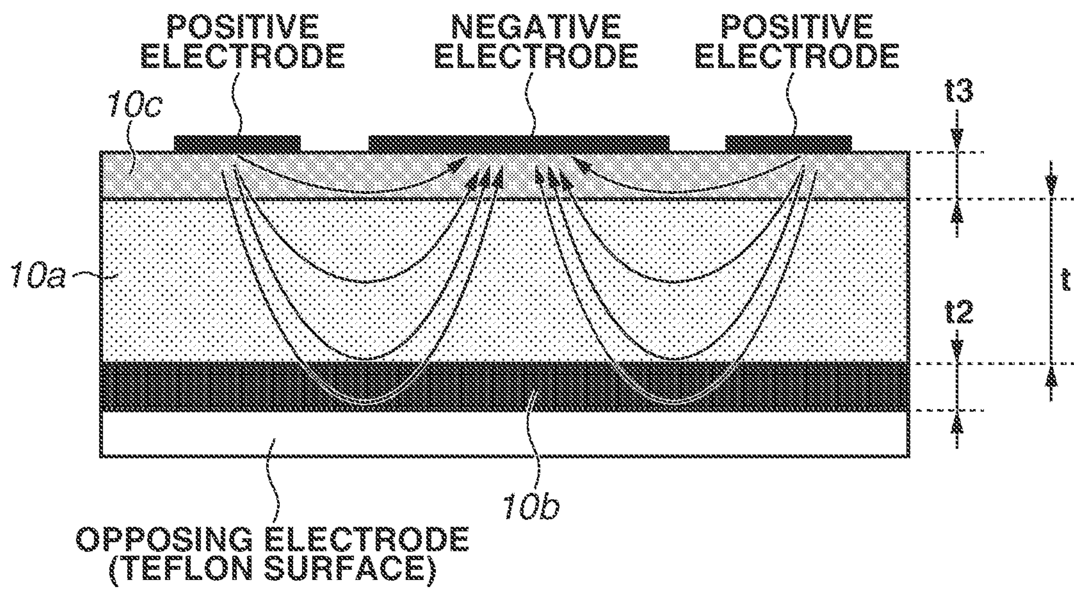
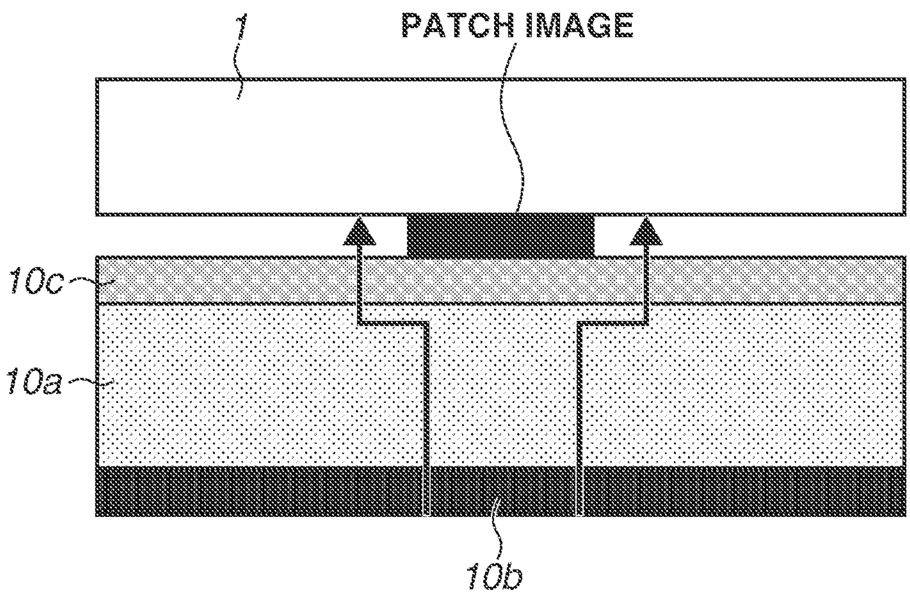

POSITIVE ELECTRODE
NEGATIVE ELECTRODE
POSITIVE ELECTRODE
10c
t3
10a
t1
t2
10b
OPPOSING ELECTRODE (TEFLON SURFACE)

FIG.7



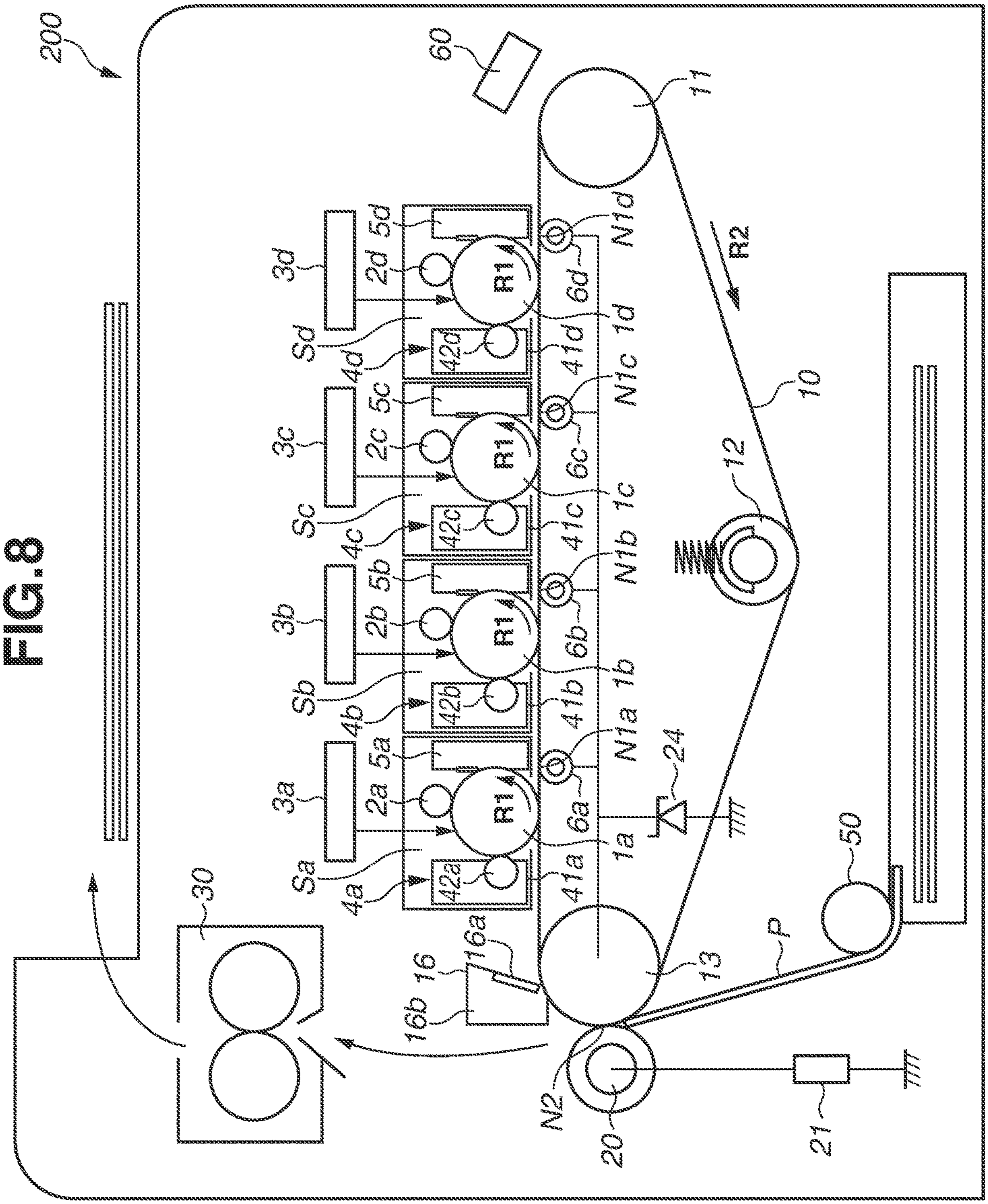

200
60
11
R2
10
12
50
P
13
16
16a
16b
30
N2
20
21
24
Sa
Sb
Sc
Sd
1a
1b
1c
1d
2a
2b
2c
2d
3a
3b
3c
3d
4a
4b
4c
4d
5a
5b
5c
5d
6a
6b
6c
6d
41a
41b
41c
41d
42a
42b
42c
42d
N1a
N1b
N1c
N1d
R1

FIG.8

FIG.9

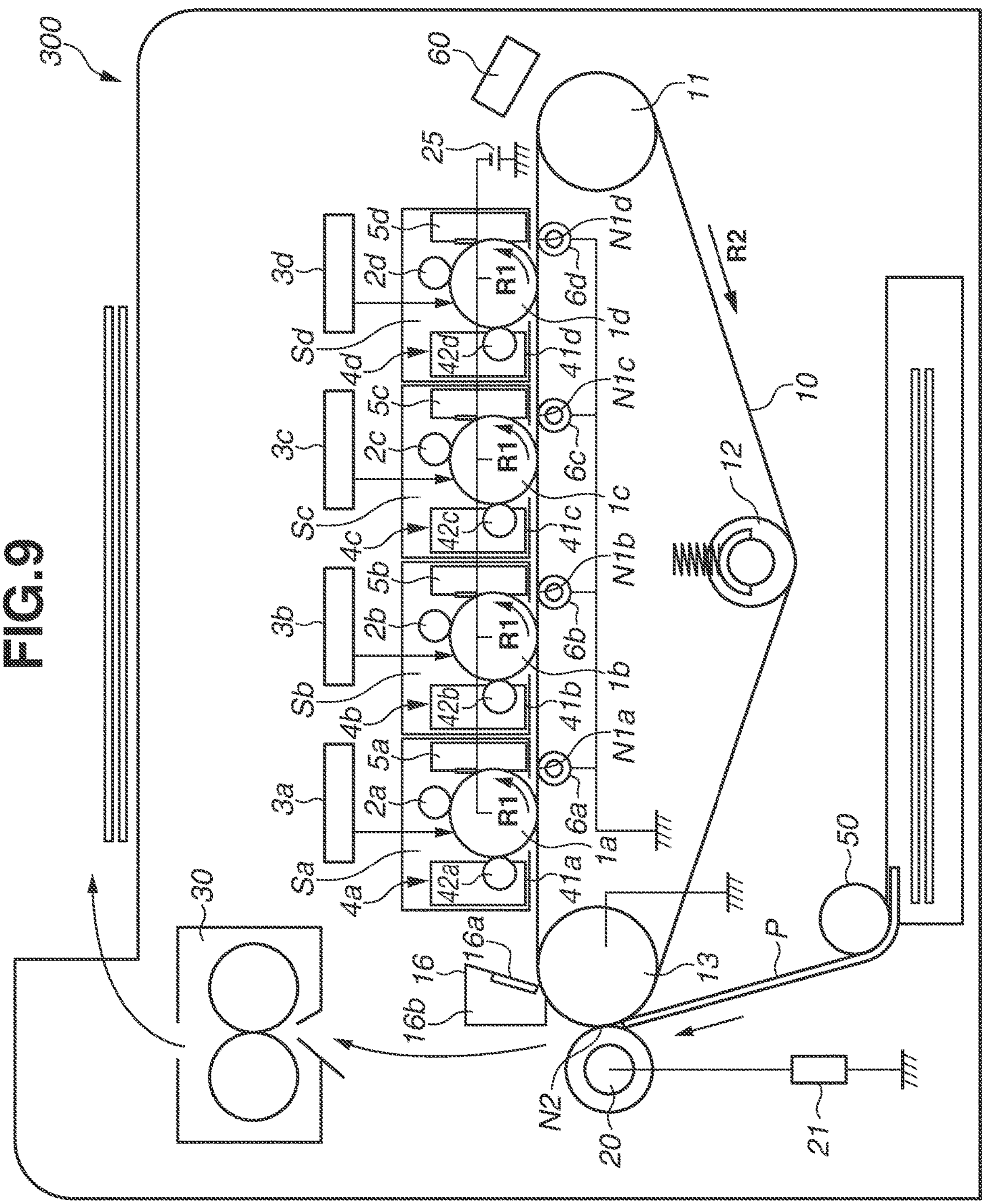

300
60
11
25
3d
2d
5d
Sd
4d
42d
R1
1d
6d
41d
N1d
R2
3c
2c
5c
Sc
4c
42c
1c
6c
41c
N1c
10
12
3b
2b
5b
Sb
4b
42b
1b
6b
41b
N1b
3a
2a
5a
Sa
4a
42a
1a
6a
41a
N1a
50
30
16a
16
16b
13
P
N2
20
21

IMAGE FORMING APPARATUS

BACKGROUND

Field

The present disclosure relates to an image forming apparatus, such as a laser printer, a copying machine, and a facsimile machine, employing an electrophotographic method.

Description of the Related Art

Heretofore, an image forming apparatus including an intermediate transfer member has been known.

In such the image forming apparatus, in a primary transfer process, a toner image formed on a surface of a photosensitive drum is primarily transferred onto an intermediate transfer member by applying a voltage to a primary transfer member disposed facing the photosensitive drum (primary transfer portion). Further, a toner image of a plurality of colors is formed on the surface of the intermediate transfer member by repeating the primary transfer process for toner images of the plurality of colors.

Then, in a secondary transfer process, the toner images of the plurality of colors formed on the surface of the intermediate transfer member are collectively transferred onto the surface of a recording medium such as a paper sheet by applying a voltage to a secondary transfer member. The toner image transferred onto the surface of the recording medium is then fixed onto the recording medium by a fixing unit to form a color image.

Japanese Patent Application Laid-open No. 2018-036624 discusses a configuration in which, to improve transferability, a low resistance layer is formed on an inner circumferential surface of a base layer of an intermediate transfer belt and a primary transfer voltage is applied to cause an electrical current to flow in a circumferential direction of the intermediate transfer belt from the first transfer member.

SUMMARY

The present disclosure is directed to an image forming apparatus capable of suppressing occurrence of image defects while achieving excellent primary transferability of an intermediate transfer belt including three or more layers.

According to an aspect of the present disclosure, an image forming apparatus includes an image bearing member configured to bear a toner image, an intermediate transfer belt configured to contact the image bearing member and to which the toner image is to be transferred from the image bearing member, wherein the intermediate transfer belt is endless and conductive and includes a base layer, a surface layer formed on an outer circumferential surface side of the base layer, and an inner surface layer formed on an inner circumferential surface side of the base layer, and a contact member configured to contact the intermediate transfer belt from an opposite side of the image bearing member contacting the intermediate transfer belt, wherein, with respect to a rotation center of the image bearing member and as seen from a rotation shaft direction of the image bearing member, a position at which the contact member and the intermediate transfer belt contact is arranged on a downstream side of the intermediate transfer belt in a rotation direction of the intermediate transfer belt, and wherein Rv>Rs1 and Rs2>Rs1, and Rs2/Rv≤40 are satisfied where Rv (Ω) is a volume resistance value of the intermediate transfer belt in a thickness direction, Rs1 (Ω) is a first surface resistance value of the inner surface layer side in a surface direction, and Rs2 (Ω) is a second surface resistance value on the surface layer side in a surface direction.

Further features of the present disclosure will become apparent from the following description of exemplary embodiments with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross-section diagram schematically illustrating an image forming apparatus according to a first exemplary embodiment of the present disclosure.

FIG. **2** is a control block diagram of the image forming apparatus according to the first exemplary embodiment of the present disclosure.

FIG. **3** is a cross-section diagram schematically illustrating a primary transfer portion of the image forming apparatus according to the first exemplary embodiment of the present disclosure.

FIG. **4** is a cross-section diagram schematically illustrating an intermediate transfer belt of the image forming apparatus according to the first exemplary embodiment of the present disclosure.

FIGS. **5**A and **5**B are diagrams schematically illustrating primary transfer current paths Ia and Ib of the image forming apparatus according to the first exemplary embodiment of the present disclosure, respectively.

FIG. **6** is diagram schematically illustrating a current path when a surface resistivity on a surface side of the intermediate transfer belt of the image forming apparatus according to the first exemplary embodiment of the present disclosure is measured.

FIG. **7** is a diagram schematically illustrating a primary transfer current path in a comparative example 6 relative to the first exemplary embodiment of the present disclosure.

FIG. **8** is a cross-section diagram schematically illustrating an image forming apparatus according to a second exemplary embodiment of the present disclosure.

FIG. **9** is a cross-section diagram schematically illustrating an image forming apparatus according to a third exemplary embodiment of the present disclosure.

DESCRIPTION OF THE EMBODIMENTS

Exemplary embodiments of the present disclosure will be described in detail with reference to the attached drawings. Note that dimensions, materials, and shapes of components, and relative arrangements thereof described in the following exemplary embodiments should be changed as appropriate depending on configurations and various conditions of apparatuses to which the present disclosure is applied, and not intended to limit the scope of the present disclosure within the following exemplary embodiments.

1. Image Forming Apparatus

FIG. **1** a cross-section diagram schematically illustrating an image forming apparatus according to a first exemplary embodiment.

More specifically, FIG. **1** is a longitudinal section illustrating a configuration of an image forming apparatus **100** according to the present exemplary embodiment.

As illustrated in FIG. **1**, the image forming apparatus **100** is a so-called tandem type image forming apparatus including a plurality of image forming units (stations) Sa, Sb, Sc, and Sd. The first image forming unit Sa, the second image forming unit Sb, the third image forming unit Sc, and the fourth image forming unit Sd form respective images using yellow (Y) toner, magenta (M) toner, cyan (C) toner, and black (Bk) toner.

These four image forming units Sa, Sb, Sc, and Sd are disposed in a line with predetermined intervals, and the image forming units Sa, Sb, Sc, and Sd have substantially the same configuration except for colors of stored toners. For this reason, the image forming apparatus **100** according to the first exemplary embodiment (also second exemplary embodiment and third exemplary embodiment) will be described mainly using the first image forming unit Sa.

The first image forming unit Sa includes a photosensitive drum **1***a*, which is a photosensitive member with a drum shape, a charging roller **2***a*, which is a charging member, a developing unit **4***a*, and a drum cleaning unit **5***a*.

The photosensitive drum **1***a* is an image bearing member for bearing a toner image, and is rotationally driven in an arrow R**1** direction at a predetermined process speed (200 mm/sec in the first exemplary embodiment). The developing unit **4***a* includes a developer container **41***a* for containing yellow toner, and a developing roller **42***a* serving as a developing member for bearing the yellow toner supplied from the developer container **41***a* to develop a yellow toner image on the photosensitive drum **1***a*.

The drum cleaning unit **5***a* is a unit for collecting toner adhering to the photosensitive drum **1***a*. The drum cleaning unit **5***a* includes a cleaning blade to contact the photosensitive drum **1***a*, and a waste toner box for containing toner removed from the photosensitive drum **1***a* by the cleaning blade.

When a DC controller **274** (see FIG. **2**) serving as a controller receives an image signal to start an image forming operation, the photosensitive drum **1***a* is rotationally driven. In a rotation process of the photosensitive drum **1***a*, the photosensitive drum **1***a* is uniformly charged by the charging roller **2***a* with a predetermined polarity (negative polarity in the first exemplary embodiment) at a predetermined potential (dark portion potential Vd), and is exposed by an exposure unit **3***a* based on the image signal.

In this way, an electrostatic latent image corresponding to a yellow color component image of a target color image is formed.

Next, the electrostatic latent image is developed by the developing roller **42***a* at a developing position, and is visualized as a yellow toner image (hereinbelow, just referred to as a toner image). The developing roller **42***a* rotates in the same direction as the photosensitive drum **1***a* at a speed of 300 mm/sec, which is 1.5 times that of the photosensitive drum **1***a* in speed, to perform development on the photosensitive drum **1***a* stably.

At this time, in the present exemplary embodiment, the normal charging polarity of the toner contained in the developing unit **4***a* is negative. The developing roller **42***a* performs reversal development of the electrostatic latent image by the toner charged with the same polarity as the photosensitive drum **1***a* charged by the charging roller **2***a*. However, the present disclosure is applicable to an image forming apparatus configured to perform normal development of an electrostatic latent image using the toner charged with a polarity opposite to the charging polarity of the photosensitive drum **1***a*.

An endless movable intermediate transfer belt **10** serving as an intermediate transfer member is arranged at a position to contact the photosensitive drums **1***a* to **1***d* of the image forming units Sa to Sd, and is stretched around three axes including a driving roller **11**, a stretching roller **12**, and a secondary transfer opposing roller **13** each serving as a stretching member. The intermediate transfer belt **10** is stretched with a total tensile force of 60 N by the stretching roller **12**, and is moved in an arrow R**2** direction by the rotation of the secondary transfer opposing roller **13** rotated by receiving a driving force.

The toner image formed on the photosensitive drum **1***a* is primarily transferred onto the intermediate transfer belt **10** by applying a voltage with a positive polarity from a primary transfer power source **23** to a primary transfer roller **6***a*, in a process in which the toner image passes through a primary transfer nip N**1***a* at which the photosensitive drum **1***a* and the intermediate transfer belt **10** contact. Then, the toner remaining on the photosensitive drum **1***a* without being primarily transferred onto the intermediate transfer belt **10** is collected by the drum cleaning unit **5***a* to be removed from the surface of the photosensitive drum **1***a*.

In the present exemplary embodiment, at a primary transfer time, an electrical current is caused to flow from a contact member contacting the intermediate transfer belt **10** to the intermediate transfer belt **10**. With this electrical current, a primary transfer potential is formed at the primary transfer portion of each of the image forming units Sa to Sd (image forming stations), of the intermediate transfer belt **10**.

In addition, a generation method of the primary transfer potential of the image forming apparatus **100** according to the present exemplary embodiment will be described in detail below.

Similar to the yellow (first color) toner image, the magenta (second color) toner image, the cyan (third color) toner image, and the black (fourth color) toner image are formed and sequentially transferred onto the intermediate transfer belt **10** in an overlapped manner. In this way, four color toner images corresponding to a target color image are formed on the intermediate transfer belt **10**. Then, the four color toner images born by the intermediate transfer belt **10** pass through a secondary transfer nip N**2** formed by a secondary transfer roller **20** and the intermediate transfer belt **10** contacting each other. In a process of passing through the secondary transfer nip N**2**, the four color toner images are collectively secondarily transferred onto a transfer medium (recording medium) P such as a paper sheet or an overhead projector sheet fed from a paper feed unit **50**.

The secondary transfer roller **20** is a roller with an external diameter of 18 mm, and formed of nickel-plated steel bar with an external diameter of 8 mm covered by a foamed sponge material that is adjusted to have a volume resistivity of 10^8 Ω·cm and thickness of 5 mm mainly including nitrile-butadiene rubber (NBR) and epichlorohydrin rubber. In addition, the rubber hardness of the foamed sponge material is 30 degrees with a load of 500 g measured using an ASKER hardness meter C type. The secondary transfer roller **20** is in contact with an outer circumferential surface of the intermediate transfer belt **10** and forms the secondary transfer nip N**2** by being pressed with a pressing force of 50 N to the secondary transfer opposing roller **13** disposed facing the secondary transfer roller **20** via the intermediate transfer belt **10**.

The secondary transfer roller **20** is rotationally driven by the intermediate transfer belt **10** and a voltage is applied from a secondary transfer power source **21**. Thereby, an electrical current flows from the secondary transfer roller **20** toward the secondary transfer opposing roller **13**. In this way, the toner image born by the intermediate transfer belt **10** is secondarily transferred at the secondary transfer nip N**2** to the transfer medium P.

When the toner image on the intermediate transfer belt **10** is secondarily transferred onto the transfer medium P, the voltage to be applied to the secondary transfer roller **20** from the secondary transfer power source **21** is controlled to cause the electrical current to flow constantly from the secondary transfer roller **20** toward the secondary transfer opposing roller **13** via the intermediate transfer belt **10**. Further, the magnitude of the electrical current to perform the secondary transfer is determined in advance based on a surrounding environment, in which the image forming apparatus **100** is installed, and types of the transfer medium P.

The secondary transfer power source **21** is connected to the secondary transfer roller **20** to apply a transfer voltage to the secondary transfer roller **20**. Further, the secondary transfer power source **21** can output a range of voltage from 100 V to 4000 V.

The transfer medium P onto which the toner image of four colors is transferred by the secondary transfer is then heated and pressed with a fixing unit **30**. As a result, the four colors of toner are melted and mixed to be fixed onto the transfer medium P. On the other hand, the toner remaining on the intermediate transfer belt **10** after the secondary transfer is removed and cleaned by a belt cleaning unit **16** (collection unit) provided on the downstream side of the secondary transfer nip N2 in the moving direction of the intermediate transfer belt **10**.

The belt cleaning unit **16** includes a cleaning blade **16***a* and a waste toner container **16***b*. The cleaning blade **16***a* serving as a contact member contacts an outer circumferential surface of the intermediate transfer belt **10** at a position facing the secondary transfer opposing roller **13**, and the waste toner container **16***b* contains the toner collected by the cleaning blade **16***a*. Hereinbelow, the cleaning blade **16***a* is simply referred to as a blade **16***a*.

In the image forming apparatus **100** according to the first exemplary embodiment, a full color print image is formed as described above.

2. Control of Image Forming Operation

Next, control of the image forming operation according to the first exemplary embodiment will be described with reference to a control block diagram.

FIG. **2** is a block diagram illustrating control blacks of the image forming apparatus according to the first exemplary embodiment.

More specifically, FIG. **2** illustrates the control blocks for controlling the operation of the image forming apparatus **100**.

As illustrated in FIG. **2**, a personal computer (PC) **271** serving as a host computer issues a print instruction to a formatter **273** serving as a conversion unit included in the image forming apparatus **100** to transmit image data of a print image to the formatter **273**.

The formatter **273** receives from the PC **271** red/green/blue (RGB) image data or cyan/magenta/yellow/black (CMYK) image data and converts the received image data into CMYK exposure data following the mode designated by the PC **271**. The exposure data converted at this time has 600 dots per inch (dpi) resolution. The modes designated from the PC **271** include a mode regarding image quality, in addition to a paper type and a paper size.

On the other hand, the formatter **273** transfers the converted exposure data to an exposure control unit **277** serving as an exposure control device included in the DC controller **274**. The exposure control unit **277** controls exposure units **3***a* to **3***d* following an instruction from a central processing unit (CPU) **276**.

In the image forming apparatus **100** illustrated in FIG. **2**, halftone control is performed by adjusting on and off areas of the exposure data. The CPU **276** starts an image forming sequence upon receiving the print instruction from the formatter **273**.

The DC controller **274** includes the CPU **276**, a memory **275**, and the like, and performs a preprogrammed operation. The CPU **276** controls a charging high-voltage (charging power source **281**), a developing high-voltage (developing power source **280**), and a transfer high-voltage (primary transfer power source **23** and secondary transfer power source **21**) to form an electrostatic latent image, and also controls a developed toner image transfer and the like to form an image.

Further, the CPU **276** also performs processing of receiving a signal from an optical sensor **60** serving as a detection unit used in a case where a correction control is performed to correct a position and a density of an image to be formed by the image forming apparatus **100**. In the image correction control, an amount of reflection light reflected from a test patch (toner image used for detection) formed on an outer circumferential surface of the intermediate transfer belt **10** at a position facing the optical sensor **60** is measured by the optical sensor **60**.

In addition, the detection signal detected by the optical sensor **60** is analog-to-digital (AD) converted via the CPU **276**, and then stored in the memory **275**. The DC controller **274** performs calculation using the detection result of the optical sensor **60** and performs various kinds of corrections.

3. Stretching Configuration for Intermediate Transfer Belt

Next, a description will be given of the intermediate transfer belt **10**, and the driving roller **11**, the stretching roller **12**, and the secondary transfer opposing roller **13**, which are stretching members for the intermediate transfer belt **10**, and the primary transfer rollers **6***a* to **6***d*, used in the image forming apparatus **100** according to the present exemplary embodiment.

As illustrated in FIG. **1**, the intermediate transfer belt **10** is arranged as an intermediate transfer member at a position facing each of the image forming units Sa to Sd. The intermediate transfer belt **10** is an endless belt formed by adding a conducting agent to a resin material to add conductivity thereto. The intermediate transfer belt **10** is stretched by three axes including the driving roller **11**, the stretching roller **12**, the secondary transfer opposing roller **13**, which are the stretching members. In this way, the intermediate transfer belt **10** is stretched by the stretching roller **12** with a total tensile force of 60 N.

Further, as illustrated in FIG. **1**, the primary transfer rollers **6***a* to **6***d* are disposed on the respective downstream sides of the photosensitive drums **1***a*, **1***b*, **1***c*, and **1***d* in a moving direction of the intermediate transfer belt **10**. The primary transfer rollers **6***a* to **6***d* are contact members contacting the inner circumferential surface of the intermediate transfer belt **10**.

FIG. **3** is a cross-section diagram schematically illustrating the primary transfer portion of the image forming apparatus **100** according to the present exemplary embodiment. Since the image forming units Sa, Sb, Sc, and Sd have substantially the same configuration, the image forming apparatus **100** according to the first exemplary embodiment will be described mainly using the first image forming unit Sa.

More specifically, FIG. **3** illustrates an arrangement relationship between the photosensitive drum **1***a* and the primary transfer roller **6***a*.

As illustrated in FIG. **3**, in the image forming unit Sa, the primary transfer roller **6***a* is disposed on the downstream side of the photosensitive drum **1***a* in the rotation direction

R2 of the intermediate transfer belt **10**. More specifically, a perpendicular line L**04** perpendicular to the intermediate transfer belt **10** is located on the downstream side of a perpendicular line L**03** perpendicular to the intermediate transfer belt **10** in the rotation direction R2 of the intermediate transfer belt **10**. The perpendicular line L**04** passes through a rotation center C**02** of the primary transfer roller **6***a*, and the perpendicular line L**03** passes through a rotation center C**01** of the photosensitive drum **1***a*.

Further, the primary transfer roller **6***a* is arranged at a position entering the surface of the intermediate transfer belt **10** so that a "wound amount" of the intermediate transfer belt **10** around the photosensitive drum **1***a* can be secured in the image forming unit Sa. In addition, a dotted line L**01** in FIG. **3** illustrates a position of the surface of the intermediate transfer belt **10** before the primary transfer roller **6***a* enters the surface of the intermediate transfer belt **10**. On the other hand, a dotted line L**02** in FIG. **3** illustrates a position of a vertex **10***c***1** of the surface of the intermediate transfer belt **10** after the primary transfer roller **6***a* enters the surface of the intermediate transfer belt **10**. In the present exemplary embodiment, the vertex **10***c***1** is a position at which the intermediate transfer belt **10** and the primary transfer roller **6***a* are brought into contact.

In the present exemplary embodiment, the primary transfer roller **6***a* is a metal roller configured of a straight nickel-plated round bar formed of Steel Use Stainless (SUS) with an external diameter of 6 mm. The primary transfer roller **6***a* is rotated along with the rotation of the intermediate transfer belt **10**. On the other hand, in the first exemplary embodiment, an external diameter of the photosensitive drum **1***a* is 24 mm. The primary transfer roller **6***a* is in contact with the intermediate transfer belt **10** over a predetermined area in a lengthwise direction (width direction) orthogonal to the moving direction of the intermediate transfer belt **10**.

In addition, the distance between the perpendicular line L**03** drawn from the rotation center C**01** of the photosensitive drum **1***a* and the perpendicular line L**04** drawn from the rotation center C**02** of the primary transfer roller **6***a* is defined as W, and a lifting height of the intermediate transfer belt **10** by the primary transfer roller **6***a* (i.e., distance between dotted lines L**01** and L**02**) is defined as H1. At this time, in the first exemplary embodiment, W=10 mm and H1=2 mm.

In addition, a voltage is applied from the primary transfer power source **23** to the primary transfer roller **6***a*, and is supplied as a primary transfer current (described below) that passes through the inner circumferential surface conductive layer of the intermediate transfer belt **10**. In the first exemplary embodiment, 300 V is applied as the primary transfer voltage.

4. Intermediate Transfer Belt

Next, the intermediate transfer belt **10**, which is a feature point of the first exemplary embodiment, will be described.

FIG. **4** is a cross-section diagram schematically illustrating the intermediate transfer belt **10** of the image forming apparatus **100** according to the first exemplary embodiment.

More specifically, FIG. **4** illustrates a vertical cross-section view in a thickness direction of the intermediate transfer belt **10** used in the first exemplary embodiment.

In the present exemplary embodiment, the intermediate transfer belt **10** has a peripheral length of 700 mm and a thickness of 90 μm, and has a three-layer configuration including a base layer **10***a*, an inner surface layer **10***b* formed on an inner circumferential surface of the base layer **10***a*, and a surface layer **10***c* formed on an outer circumferential surface of the base layer **10***a*.

The base layer **10***a* is an endless layer formed of polyethylene naphthalate (PEN) with an ion conductive material mixed as a conducting agent. Further, the inner surface layer **10***b* is a layer formed of acrylic resin with carbon mixed as a conducting agent. The surface layer **10***c* is a layer formed of acrylic resin with metal oxide mixed as a conducting agent.

More specifically, the inner surface layer **10***b* is a layer formed on the inner side (stretching axis side) of the base layer **10***a*. Assuming that the polyvinylidene fluoride layer, which is the base layer **10***a*, is t1 in thickness, the acrylic resin layer, which is the inner surface layer **10***b*, is t2 in thickness, and the acrylic resin layer, which is the surface layer **10***c*, is t3 in thickness, t1=87 μm, t2=2 μm, and t3=3 μm.

In addition, in the present exemplary embodiment, PEN is used as the material of the base layer **10***a* of the intermediate transfer belt **10**. However, other materials may be used. For example, a material such as polyester or acrylonitrile butadiene styrene (ABS) copolymer, or mixed resin thereof may be used.

Further, in the present exemplary embodiment, acrylic resin is used as the material of the inner surface layer **10***b* of the intermediate transfer belt **10**. However, other materials may be used. For example, a material such as polyester may be used.

Further, in the present exemplary embodiment, acrylic resin is used as the material of the surface layer **10***c* of the intermediate transfer belt **10**. However, other materials may be used. For example, a material such as polyester may be used.

In the present exemplary embodiment (experimental examples 1 to 9), a preferable resistance value of the intermediate transfer belt **10** is set as a resistance value of the intermediate transfer belt **10**, using a volume resistivity measured from the surface layer **10***c* side, a surface resistivity measured from the surface layer **10***c* side, and a surface resistivity measured from the inner surface layer **10***b* side.

In addition, the volume resistivity is measured using a ring probe of type UR (MCP-HTP12) attached to Hiresta-UP (MCP-HT450) of Mitsubishi Chemical Corporation. As a probe opposing electrode, a metallic surface of a register table UFL is used.

On the other hand, the surface resistivity is measured using a ring probe of type UR **100** (MCP-HTP16) attached to a measurement device that is the same as that used for the volume resistivity. As a probe opposing electrode, a surface of polytetrafluoroethylene, such as a Teflon® surface, of a register table UFL is used.

Further, the measurement of the volume resistivity is performed under the conditions that the probe presses from the front surface side of the intermediate transfer belt **10** with a pressing force 1 kg, an application voltage is 250 V, and a measurement time is 10 s. The measurement of the volume resistivity is a measurement of a resistance value of the intermediate transfer belt **10** in a thickness direction, and corresponds to the measurement of a resistance value of the base layer **10***a*. If the application voltage is too high, it is hard to detect the change of the volume resistivity. On the other hand, if the application voltage is too low, the repetitive reproducibility of the measured value decreases due to the influence of the surface shape of the surface layer **10***c* or the influence of the foreign substances adhering to the probe.

Taking these conditions into consideration, the application voltage is determined to be 250 V in the first exemplary embodiment.

The measurement of the surface resistivity of the inner surface layer **10**b is performed under the conditions that the probe presses from the inner surface side of the intermediate transfer belt **10** with a pressing force 1 kg, an application voltage is 10 V, and a measurement time is 10 s.

Further, the measurement of the surface resistivity of the surface layer **10**c is performed under the conditions that the probe presses from the inner surface side of the intermediate transfer belt **10** with a pressing force 1 kg, an application voltage is 100 V, and a measurement time is 10 s.

The measurement of the surface resistivity of the surface layer **10**c corresponds to the measurement of a resistance value of the surface layer **10**c. If the application voltage is too high, the amount of current passing through the base layer **10**a and the inner surface layer **10**b increases. On the other hand, if the application voltage is too low, there may be a case where a resistance value cannot be measured because current does not flow between the probe electrodes, and a case where the repetitive reproducibility of the measured value decreases due to the influence of the surface shape of the surface layer **10**c or the influence of foreign substances adhering to the probe. For this reason, the application voltage is determined to be 100 V in the first exemplary embodiment, taking these conditions into consideration.

In addition, in the present exemplary embodiment, the indoor temperature is set to 23° C. and the indoor humidity is set to 50% as a measurement environment of the resistance value.

The above-described "volume resistivity" and "surface resistivity" are defined by Japanese Industrial Standards (JIS) K 6911, and are expressed by the following formulas (1) and (2).

$$\text{volume resistivity } \rho v\ (\Omega\cdot\text{cm}) = R(\Omega)\times RCFv\times t\ (\text{cm}) \quad (1)$$

$$\text{surface resistivity } \rho s(\Omega/\text{square}) = R(\Omega)\times RCFs \quad (2)$$

RCFv in the formula (1) and RCFs in the formula (2) are resistivity correction coefficients and are constants set for each probe used for measurement.

In the present exemplary embodiment, a ring probe of type UR (MCP-HTP12) is used to measure the "volume resistivity", and RCFv is 2.011 in this case.

Further, a ring probe of type UR100 (MCP-HTP16) is used to measure the "surface resistivity", and RCFs is 100 in this case.

Further, "t" in the formula (1) is a thickness of the intermediate transfer belt **10**.

In the present exemplary embodiment, the resistance values calculated from the formulas (1) and (2) will be described to compare resistance values (R) in a thickness direction and a surface direction.

In the following description, a resistance value obtained by converting the volume resistivity (ρv) using the formula (1) is referred to as a "volume resistance value (Rv)", and a resistance value obtained by converting the surface resistivity (ρs) using the formula (2) is referred to as a surface resistance value (Rs). In an experimental example 1 of the first exemplary embodiment, as described in a table 1 below, the intermediate transfer belt **10** has 1.62×10^7 (Ω) as the volume resistance value, 1.10×10^5 (Ω) as the surface resistance value of the inner surface layer **10**b, and 3.55×10^7 (Ω) as a surface resistance value of the surface layer **10**c. Accordingly, in the "experimental example 1", assuming that the volume resistance value is Rv, the surface resistance value of the inner surface layer **10**b is Rs1, and the surface resistance value of the surface layer **10**c is Rs2, the value of Rs1 is lower than the values of Rv and Rs2, and Rs2/Rv is 2.19.

Next, with reference to FIGS. **5**A and **5**B, a description will be given of a reason why the surface resistance value Rs1 of the inner surface layer **10**b is set to be lower than, for example, the surface resistance value Rs2 of the surface layer **10**c, in the present exemplary embodiment.

FIGS. **5**A and **5**B are respective schematic diagrams illustrating a primary transfer current path Ia and a primary transfer current path Ib of the image forming apparatus **100** according to the first exemplary embodiment of the present disclosure.

More specifically, FIGS. **5**A and **5**B schematically illustrate a state where the current supplied from the primary transfer roller **6** flows in two different current paths including the current path Ia and the current path Ib.

As illustrated in FIG. **5**A, in the current path Ia, the primary transfer current supplied from the primary transfer roller **6** flows mainly in the inner surface layer **10**b in an opposite direction of the rotation direction R**2** of the intermediate transfer belt **10**. Further, the primary transfer current reaches the primary transfer nip **N1** that is a contact point of the photosensitive drum **1** and the intermediate transfer belt **10**, and flows to the photosensitive drum **1**.

On the other hand, as illustrated in FIG. **5**B, as for the current path Ib, the primary transfer current flows mainly in the surface layer **10**c. More specifically, in a case where the inner surface layer **10**b, the base layer **10**a, and the surface layer **10**c have similar resistance values, the primary transfer current passes through the base layer **10**a or the surface layer **10**c as a current path from the primary transfer roller **6** to the primary transfer nip **N1**.

In this case, in a case of the "current path Ib" as illustrated in FIG. **5**B, the surface layer **10**c has a positive polarity and there is a possibility that discharge current may be generated between the intermediate transfer belt **10** and the photosensitive drum **1** on the downstream side of the primary transfer nip **N1** in the direction R**2**. As a result, there is a possibility that an image defect with a discharge pattern may occur in the corresponding image forming unit at a transfer time, or a so-called "re-transfer" may occur. The re-transfer is a phenomenon in which toner primarily transferred onto the intermediate transfer belt **10** is transferred onto the photosensitive drum **1** at the station disposed on the downstream side of the intermediate transfer belt **10** in the rotation direction R**2**.

Accordingly, it is necessary to bypass the "current path Ib" illustrated in FIG. **5**B to suppress the discharge current generated on the downstream side of the primary transfer nip **N1** in the direction R**2**, and to prevent the re-transfer. Thus, in the present exemplary embodiment, the resistance value of the inner surface layer **10**b is made sufficiently smaller than those of the base layer **10**a and the surface layer **10**c to achieve a configuration in which the primary transfer current mainly passes through the inner surface layer **10**b to reach the primary transfer nip **N1**. In other words, the "current path Ia" illustrated in FIG. **5**A is achieved.

Next, a preferable relationship between the volume resistance value Rv and the surface resistance value Rs2 on the surface layer **10**c side will be described.

FIG. **6** is diagram schematically illustrating a current path when the surface resistance value Rs2 on the surface layer

10*c* side of the intermediate transfer belt **10** of the image forming apparatus **100** according to the first exemplary embodiment is measured.

As illustrated in FIG. **6**, the surface resistance value Rs2 on the surface layer **10***c* side is obtained by measuring a current flowing from a positive electrode to a negative electrode contacting the surface layer **10***c*.

Since the thickness "t3" of the surface layer **10***c* is thin (3 μm), when the surface resistance value Rs2 of the surface layer **10***c* is measured, the current flowing between the electrodes of the probe also passes through the base layer **10***a* in addition to the surface layer **10***c* to reach the negative electrode from the positive electrode. Further, since the intermediate transfer belt **10** according to the first exemplary embodiment includes the inner surface layer **10***b*, part of the current flowing between the electrodes of the probe passes through the inner surface layer **10***b*. As a result, the surface resistance value Rs2 of the surface layer **10***c* is measured as if it is lower than the actual resistance value.

In a case where the surface resistance value Rs2 of the surface layer **10***c* is high, for example, when a voltage is applied to the secondary transfer roller **20**, a discharge current may be generated between the secondary transfer roller **20** and the intermediate transfer belt **10**, influenced by the pattern of the toner image or the unevenness of the paper. With the discharge current, electric charge is accumulated on the surface layer **10***c* of the intermediate transfer belt **10** to form a potential as a potential memory. In this way, the potential may be held on the surface layer **10***c*. If a primary transfer is performed in this state, a discharge current is generated between the photosensitive drum **1** and the intermediate transfer belt **10** on the upstream side of the primary transfer nip N**1** in the rotation direction R**2** of the intermediate transfer belt **10**.

With this discharge current, a phenomenon called pre-transfer occurs. This phenomenon is a phenomenon in which the primary transfer toner on the photosensitive drum **1** is transferred onto the intermediate transfer belt **10** at a gap between the photosensitive drum **1** and the intermediate transfer belt **10** on the upstream side of the primary transfer nip N**1**. Due to such a primary transfer failure, an image defect, in which a formed image is deteriorated in quality or a discharge trail is formed as a toner image, may occur.

In the present exemplary embodiment, to prevent such a primary transfer failure, the surface resistance value Rs2 of the surface layer **10***c* of the intermediate transfer belt **10** was studied so as to have a preferable surface resistance value, taking into consideration the amount of passing current into the inner surface layer **10***b*. Further, since the preferable primary transfer voltage changes depending on the volume resistance value, the surface resistance value Rs2 of the surface layer **10***c* is set so as to be able to suppress the image defect caused by the above-described discharge current, taking the volume resistance value into consideration.

<Evaluation>

Next, an evaluation about the first exemplary embodiment will be described.

The table 1 describes comparison results of experimental examples 1 to 9 according to the first exemplary embodiment and comparative examples 1 to 6 for the first exemplary embodiment obtained by changing the volume resistance value Rv and the surface resistance value Rs2 of the surface layer **10***c* of the intermediate transfer belt **10** used in the first exemplary embodiment.

More specifically, the table 1 includes the volume resistance value Rv, the surface resistance value Rs1 of the inner surface layer side, the surface resistance value Rs2 on the surface layer side, Rs2/Rv, and image evaluation results of (A) to (F), for each of the intermediate transfer belts **10** of the experimental examples 1 to 9 and the comparative examples 1 to 6.

In addition, the comparative examples 1 to 6 are different from the experimental examples 1 to 9 only in resistance value of the intermediate transfer belt **10** of the first exemplary embodiment, and other configurations are the same as those of the experimental examples 1 to 9.

The intermediate transfer belts **10** in the experimental examples 1 to 9 of the first exemplary embodiment and the comparative examples 1 to 6 have the same materials and shapes in the base layer **10***a*, the inner surface layer **10***b*, and the surface layer **10***c*. The resistance values thereof are adjusted by adjusting the amounts of conducting agents to be added to respective layers.

Next, with reference to the table 1, a description will be given of the evaluation of the "image quality" of each of the evaluation images (A) to (F) according to the first exemplary embodiment.

The table 1 includes resistance values of intermediate transfer belts **10** in the experimental examples 1 to 9 according to the first exemplary embodiment and the comparative examples 1 to 6, measured in the ambient temperature 23° C. and the humidity 50%, and the transferability of the image formed in the ambient temperature 23° C. and the humidity 50% at the primary transfer portion for each of the intermediate transfer belts **10**.

In addition, for the "evaluation images (A) to (E)" illustrated in the table 1, A4 size sheets GF-0081 (produced by CANON) of 81.4 g/m^2 in grammage are used.

More specifically, as the evaluation image (E), a full-page solid (Solid in the table 1) image with an average density of 100% of yellow, magenta, cyan, and black is printed and evaluated.

Further, as the evaluation image (D), a solid patch image with 10 mm×10 mm square patches for each color being discretely arranged is printed and evaluated.

Further, as the evaluation images (B) and (C), respective full-page halftone (HT in the table 1) images with average densities of 20% and 50% are printed and evaluated.

Further, as the evaluation image (F), an full-page ary (secondary) color (Ary Color in the table 1) image of red, green, blue with an average density 200% is printed and evaluated.

Further, as the evaluation image (A), a text image including yellow, magenta, cyan, black texts each with an average density 100% is printed and evaluated.

First, the evaluation results of the experimental examples 1 to 9 of the intermediate transfer belts **10** according to the first exemplary embodiment will be described.

As illustrated in the table 1, in the present exemplary embodiment, the volume resistance value Rv of the intermediate transfer belt **10** of each of the experimental examples 1 to 9 resides in a range from 2.60×10^6 (Ω) to 3.51×10^7 (Ω), and the surface resistance value Rs1 of the inner surface layer **10***b* resides in a range from 1.10×10^3 (Ω) to 1.10×10^5 (Ω).

In the present exemplary embodiment, the surface resistance value Rs2 of the surface layer **10***c* of the intermediate transfer belt **10** of each of the experimental examples 1 to 9 resides in a range from 3.55×10^7 (Ω) to 6.41×10^8 (Ω), and Rs2/Rv resides in a range from 2.186 to 38.740.

On the other hand, the volume resistance value Rv of the intermediate transfer belt **10** of each of the comparative examples 1 to 5 resides in a range from 1.56×10^6 (Ω) to 1.42×10^8 (Ω), and the surface resistance value Rs1 of the inner surface layer **10***b* is 1.10×10^5 (Ω). The surface resistance value Rs2 of the surface layer **10***c* of the intermediate transfer belt **10** of each of the comparative examples 1 to 5 resides in a range from 1.23×10^8 (Ω) to 6.04×10^{10} (Ω), and Rs2/Rv resides in a range from 53.564 to 424.523.

Further, in the intermediate transfer belt **10** of the comparative example 6, the volume resistance value Rv is 1.98×10^6 (Ω), the surface resistance value Rs1 of the inner surface layer **10***b* is 1.10×10^5 (Ω), the surface resistance value Rs2 of the surface layer **10***c* is 2.18×10^6, and Rs2/Rv is 1.103.

As illustrated in the table 1, an image defect (evaluation result "NG") is not observed for each of the evaluation images (A) to (F) of the experimental examples 1 to 9 according to the first exemplary embodiment. In the table 1, "AA" means excellent, "A" means good, "B" means small image defect, and "NG" means image defect.

Next, a description will be given of a reason why excellent images can be obtained in the intermediate transfer belts **10** of the experimental examples 1 to 9 according to the first exemplary embodiment.

First, the excellent images were obtained even for the full-page halftone 20% image (B) and the full-page halftone 50% image (C) in which the discharge images are easily noticed, because the intermediate transfer belts **10** are configured not to have excessively high surface resistance values on the surface layer **10***c* side, taking the fact that the inner surface layer **10***b* is formed into consideration.

On the other hand, by setting the volume resistance value Rv and the surface resistance value Rs2 of the surface layer **10***c* to have close values, even if a primary transfer voltage enough to obtain a desired primary transfer current is applied, a potential memory phenomenon of the surface layer **10***c* does not occur and the discharge current on the upstream side of the primary transfer nip **N1** is suppressed. More specifically, if $Rs2/Rv \leq 40$ is satisfied, the volume resistance value Rv and the surface resistance value Rs2 of the surface layer **10***c* becomes close to each other, to effectively suppress the discharge current. Further, since the surface resistance value Rs1 on the inner surface layer **10***b* side is set to be sufficiently small, the primary transfer voltage applied to the primary transfer roller **6** hardly attenuated before reaching the primary transfer nip **N1**. Thus, the excellent transferability was obtained even for the images that need sufficient transfer currents, such as the full-page solid image (E) and the full-page secondary color image (F).

Further, since the surface resistance value Rs2 of the surface layer **10***c* is high, also in the solid patch image (D), it was possible to restrain the occurrence of the transfer failure generated due to a reason that the primary transfer current does not pass through the solid patch image to be described below.

In addition, since the potential memory phenomenon of the surface layer **10***c*, in general, tends to occur easily, as the surface resistance value Rs2 of the surface layer **10***c* becomes larger, it is preferable to set the surface resistance value Rs2 to be 1.00×10^9 (Ω) or lower, in the present exemplary embodiment. Further, it is more preferable to set the surface resistance value Rs2 of the surface layer **10***c* to be 6.41×10^8 (Ω) or lower, to reduce the influence of the potential memory phenomenon.

Next, evaluation results of the intermediate transfer belts **10** in the comparative examples 1 to 5 will be described.

The intermediate transfer belt **10** of the comparative example 1 has a high surface resistance value Rs2 of the surface layer **10***c* relative to the volume resistance value Rv, and the value of Rs2/Rv is 53.564. With the intermediate transfer belt **10** of the comparative example 1, a minor discharge trail was observed on each of the images of full-page halftone 20% image (B) and the full-page halftone 50% image (C), which are images for which a discharge trail is easy to be noticed, as a result of the occurrence of the potential memory phenomenon of the surface layer **10***c*.

Further, the intermediate transfer belt **10** of each of the comparative examples 2 and 3 has a value of Rs2/Rv in a range from 120.001 to 195.914 and larger than that of the comparative example 1, and the potential memory phenomenon of the surface layer **10***c* may occur more easily.

As a result, the discharge trails were easier to be noticed in the comparative examples 2 and 3, and a minor discharge trail was observed on the full-page halftone 20% image (B), and a noticeable discharge trail was observed on the full-page halftone 50% image (C).

Further, each of the intermediate transfer belts **10** in the comparative examples 4 and 5 has a value of Rs2/Rv in a range from 408.413 to 424.523, which is larger than that of the comparative examples 2 and 3, and a minor discharge trail was observed on the full-page halftone 20% image (B), and a noticeable discharge trail was observed on the full-page halftone 50% image (C) and the full-page solid image (E).

On the other hand, with the intermediate transfer belt **10** of the comparative example 6, a transfer failure caused by the toner image on the photosensitive drum **1** not being sufficiently transferred onto the intermediate transfer belt **10** due to the lack of the primary transfer current on the solid patch image (D), was generated.

More specifically, the intermediate transfer belt **10** of the comparative example 6 has 1.103 as a value of Rs2/Rv, the surface resistance value Rs2 on the surface layer **10***c* side is almost equivalent to the volume resistance value Rv, and the surface resistance value Rs2 on the surface layer **10***c* side is low like 2.18×10^6 (Ω), even though the potential memory phenomenon of the surface layer **10***c* does not occur. Compared with the comparative example 6, any of the experimental examples 1 to 9 according to the first exemplary embodiment has 3.00×10^7 (Ω) or more as the surface resistance value Rs2. Thus, no image defect was observed on the solid patch image (D) without lack of the primary transfer current.

Next, in the intermediate transfer belt **10** of the comparative example 6, a description will be given of a mechanism in which the transfer failure occurs on the solid patch image (D) in a case where the surface resistance value Rs2 on the surface layer **10***c* side is small.

FIG. **7** is a diagram schematically illustrating a primary transfer current path in the comparative example 6 relative to the first exemplary embodiment according to the present disclosure.

More specifically, FIG. **7** illustrates a state of current at the primary transfer in the configuration of the comparative example 6.

In addition, the direction from the front side to the back side in FIG. **7** corresponds to the rotation direction R**2** of the intermediate transfer belt **10**.

As illustrated in FIG. **7**, with the intermediate transfer belt **10** of the comparative example 6, the surface resistance value Rs2 of the surface layer **10***c* is small, and the primary transfer current easily flows to the photosensitive drum **1** bypassing the patch image.

More specifically, as a current path of the primary transfer current, there is a path through which a primary transfer current flows to the photosensitive drum **1** from the intermediate transfer belt **10** through the toner image. On the other hand, as illustrated in FIG. **7**, there is another path through which a primary transfer current directly flows to the photosensitive drum **1** from the intermediate transfer belt **10** not through the toner image. In the configuration illustrated in FIG. **7**, the path through which a current flows through (passing through) the toner image normally has a larger resistance value than the path not through the toner image.

However, in a case where the surface resistance value Rs2 of the surface layer **10***c* is small, the difference of the resistance values between the current path through the toner image and the current path not through the toner image becomes large. For this reason, as illustrated in FIG. **7**, in the comparative example 6, a large amount of the primary transfer current flows directly from the intermediate transfer belt **10** to the photosensitive drum **1** not through the toner image.

Thus, since the primary transfer is performed by the toner image being moved on the current passing path, with the configuration illustrated in the comparative example 6, if the ratio of the current flowing through the path not via the toner image increases, a sufficient amount of the transfer current cannot be supplied to the toner image, which may cause the transfer failure.

In addition, as for the text image (A), no image defect was observed in any of the intermediate transfer belts **10** of the experimental examples 1 to 9 according to the first exemplary embodiment and the comparative examples 1 to 6.

As described above, with the intermediate transfer belt **10** configured of three layers including the base layer **10***a*, the inner surface layer **10***b*, and the surface layer **10***c*, to obtain a good transferability, the primary transfer current supplied from the primary transfer roller **6** needs to reach the primary transfer nip N**1** through the inner surface layer **10***b*. In addition, it is necessary to adjust the resistance values of the base layer **10***a* and the surface layer **10***c* to have a specific relationship so as to restrain the discharge trail and the pre-transfer to obtain good transferability.

More specifically, in the present exemplary embodiment, the volume resistance value Rv of the base layer **10***a* of the intermediate transfer belt **10**, and the surface resistance value (second surface resistance value) Rs2 of the surface layer **10***c* need to be larger than the surface resistance value (first surface resistance value) Rs1 of the inner surface layer **10***b*. In addition, Rs2/Rv≤40 needs to be satisfied, and the surface resistance value (second surface resistance value) Rs2 needs to be 3.00×10^7 (Ω) or more.

In the present exemplary embodiment, as illustrated in the table 1, each of the volume resistance values Rv was set to be a value in a range from 2.60×10^6 (Ω) to 3.51×10^7 (Ω) as the resistance values of the intermediate transfer belts **10** of the experimental examples 1 to 9 according to the first exemplary embodiment. In other words, it is preferable to set the volume resistance value Rv in this range. In addition, it is more preferable to set the volume resistance value Rv to a value in a range from 4.57×10^6 (Ω) to 1.83×10^7 (Ω).

Further, in the present exemplary embodiment, the surface resistance value Rs1 of the inner surface layer **10***b* is set to be a value in a range from 1.10×10^3 (Ω) to 1.10×10^5 (Ω). In other words, the surface resistance value Rs1 of the inner surface layer **10***b* is desirably set in this range.

Thus, in the present exemplary embodiment, the surface resistance value Rs2 of the surface layer **10***c* is set to be a value in a range from 3.55×10^7 (Ω) to 6.41×10^8 (Ω). In other words, the surface resistance value Rs2 of the surface layer **10***c* is desirably set to be 3.55×10^7 (Ω) or more. On the other hand, considering the influence of the potential memory, the surface resistance value Rs2 of the surface layer **10***c* is desirably set to be 6.41×10^8 (Ω) or smaller.

Further, in the present exemplary embodiment, Rs2/Rv is set to be a value in a range from 2.186 to 38.740. Thus, Rs2/Rv≤40 is satisfied.

In this way, according to the present exemplary embodiment, it is possible to restrain the potential memory phenomenon of the surface layer **10***c* while a sufficient primary transfer voltage to perform the primary transfer is applied by setting Rv, Rs1, and Rs2 as described above, to obtain the intermediate transfer belt **10** for obtaining a good image quality with the discharge trail and the density unevenness caused by the pre-transfer being suppressed.

On the other hand, with the intermediate transfer belt **10** of each of the comparative examples 1 to 6, Rs2/Rv is 53.564 or more, and the image defect caused by the discharge trail of the intermediate transfer belt **10** was observed.

In order to restrain the potential memory phenomenon of the surface layer **10***c*, the surface resistivity ρs2 on the surface layer **10***c* side is desirably smaller than those of other layers, and Rs2/Rv needs to be 40 or smaller. In addition, it is preferable to set Rs2/Rv to be 21.859 or smaller, in order to effectively restrain the occurrence of the image defect under the condition in which the image defect due to the discharge trail is easy to occur, for example, when the usage environment at the image forming time is in low-temperature and low-humidity, or toner deteriorates. The reason is, as the Rs2/Rv is larger, the potential memory phenomenon of the surface layer **10***c* tends to occur more easily.

Further, as is understood from the comparative example 6, in order to effectively restrain the occurrence of the primary transfer failure for the solid patch image (D), it is necessary to reduce the resistance value difference between the resistance value of the current path formed from the intermediate transfer belt **10** to the photosensitive drum **1**, and the resistance value of the current path formed from the intermediate transfer belt **10** to the photosensitive drum **1** via the toner image. Thus, in the present exemplary embodiment, the surface resistance value Rs2 on the surface layer **10***c* side is to be set 3.00×10^7 (Ω) or more.

TABLE 1

	Rv (Ω)	Rs1 (Ω)	Rs2 (Ω)	Rs2/Rv	(A) Text	(B) HT (20%)	(C) HT (50%)	(D) Solid Patch	(E) Solid	(F) Ary Color
Experimental Example 1	1.62×10^7	1.10×10^5	3.55×10^7	2.1859	AA	AA	AA	A	AA	AA
Experimental Example 2	1.66×10^7	1.10×10^4	7.36×10^7	4.4442	AA	AA	AA	AA	AA	AA
Experimental Example 3	5.13×10^6	1.10×10^5	3.55×10^7	6.9123	AA	AA	AA	A	AA	AA

TABLE 1-continued

	Rv (Ω)	Rs1 (Ω)	Rs2 (Ω)	Rs2/Rv	(A) Text	(B) HT (20%)	(C) HT (50%)	(D) Solid Patch	(E) Solid	(F) Ary Color
Experimental Example 4	4.57×10^{6}	1.10×10^{4}	4.00×10^{7}	8.7435	AA	AA	AA	A	AA	AA
Experimental Example 5	9.15×10^{6}	1.10×10^{5}	1.00×10^{8}	10.9293	AA	AA	AA	AA	AA	AA
Experimental Example 6	2.60×10^{6}	1.10×10^{5}	3.77×10^{7}	14.4828	AA	A	AA	A	AA	AA
Experimental Example 7	3.51×10^{7}	1.10×10^{3}	6.41×10^{8}	18.2440	AA	A	A	A	AA	AA
Experimental Example 8	1.62×10^{7}	1.10×10^{5}	3.55×10^{8}	21.8587	AA	A	A	A	AA	AA
Experimental Example 9	9.16×10^{6}	1.10×10^{5}	3.55×10^{8}	38.7397	AA	A	A	A	A	A
Comparative Example 1	2.29×10^{6}	1.10×10^{5}	1.23×10^{8}	53.5639	AA	B	B	A	A	A
Comparative Example 2	2.47×10^{6}	1.10×10^{5}	2.97×10^{8}	120.0006	AA	B	NG	A	A	A
Comparative Example 3	1.95×10^{6}	1.10×10^{5}	3.82×10^{8}	195.9141	AA	B	NG	A	A	A
Comparative Example 4	1.56×10^{6}	1.10×10^{5}	6.39×10^{8}	408.4125	AA	NG	NG	A	NG	A
Comparative Example 5	1.42×10^{8}	1.10×10^{5}	6.04×10^{10}	424.5226	AA	NG	NG	A	NG	A
Comparative Example 6	1.98×10^{6}	1.10×10^{5}	2.18×10^{6}	1.1031	AA	A	A	NG	A	A

An image forming apparatus according to a second exemplary embodiment of the present disclosure is basically similar to that according to the first exemplary embodiment, and thus different portions thereof will be described.

FIG. **8** is a cross-section diagram schematically illustrating the image forming apparatus **200** according to the second exemplary embodiment of the present disclosure.

As illustrated in FIG. **8**, in the configuration of the second exemplary embodiment, the driving roller **11** and the primary transfer rollers **6***a*, **6***b*, **6***c*, and **6***d* are electrically connected to the secondary transfer opposing roller **13**, to be a same potential. Since the image forming units Sa, Sb, Sc, and Sd have substantially a same configuration, the image forming apparatus **200** according to the second exemplary embodiment will be described mainly using the first image forming unit Sa.

More specifically, the secondary transfer opposing roller **13**, the primary transfer rollers **6***a*, **6***b*, **6***c*, and **6***d* are grounded via a Zener diode **24**, which is a voltage support element. In this way, a voltage is supplied to the primary transfer roller **6***a* by the Zener voltage generated at a cathode of the Zener diode **24** by the current supplied from the secondary transfer roller **20** serving as a current supply member.

Further, the primary transfer current supplied from the primary transfer roller **6***a* passes through the inner surface layer **10***b* and reaches the primary transfer nip N**1***a*, and then is supplied to the photosensitive drum **1***a*. To obtain a desired primary transferability, the Zener voltage is set to be "300 V" in the present exemplary embodiment.

In the second exemplary embodiment, similar to the first exemplary embodiment, a preferable primary transfer performance can be obtained in the intermediate transfer belt **10** configured of three layers including a base layer, an inner surface layer, and a surface layer.

Further, in the second exemplary embodiment, in place of the primary transfer power source **23** in the first exemplary embodiment illustrated in FIG. **1**, the primary transfer voltage is generated using the Zener diode **24** connected to the secondary transfer opposing roller **13** and the primary transfer roller **6***a*. In this way, the second exemplary embodiment has an advantage compared with the first exemplary embodiment that a good primary transfer performance can be obtained with simpler configuration.

An image forming apparatus according to a third exemplary embodiment of the present disclosure is basically the same as that of the first exemplary embodiment or the second exemplary embodiment, and thus different portions will be described below.

FIG. **9** is a cross-section diagram schematically illustrating an image forming apparatus **300** according to the third exemplary embodiment of the present disclosure.

In the first and the second exemplary embodiments described above, by applying the primary transfer voltage to form the potential difference between the surface potential of the photosensitive drum **1***a* and the potential of the intermediate transfer belt **10**, the toner on the surface of the photosensitive drum **1***a* is primarily transferred to the intermediate transfer belt **10**. It is a feature point of the third exemplary embodiment that the primary transfer rollers **6***a* to **6***d* are grounded and a drum power source **25** serving as a negative power source common to the photosensitive drums **1***a* to **1***d* is provided.

More specifically, in the third exemplary embodiment, the drum power source **25** is connected to supply a voltage to each of drum element tubes of the photosensitive drums **1***a* to **1***d*. Hereinbelow, the voltage applied to the drum element tubes by the drum power source **25** is referred to as a "drum voltage".

In the third exemplary embodiment, the potential difference between the surface potential of the photosensitive drum **1***a* and the surface potential of the intermediate transfer belt **10** is formed by adjusting the drum voltage. The configurations except the configuration for performing the primary transfer are the same as those of the first exemplary embodiment and the second exemplary embodiment.

In the third exemplary embodiment, similar to the first and second exemplary embodiments, a good primary transfer performance can be obtained in the intermediate transfer belt

10 configured of three layers including a base layer, an inner surface layer, and a surface layer.

In addition, in the third exemplary embodiment, the primary transfer rollers 6*a* to 6*d* can be grounded instead of arranging the drum power source 25 connected to the drum element tubes of the photosensitive drums 1*a* to 1*d*. In this way, the third exemplary embodiment has an advantage that a stretching unit with a simpler configuration to stretch the intermediate transfer belt 10 can be obtained while obtaining a good primary transfer performance, compared with the first exemplary embodiment and the second exemplary embodiment.

While the present disclosure has been described with reference to exemplary embodiments, it is to be understood that the disclosure is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

This application claims the benefit of Japanese Patent Application No. 2021-146410, filed Sep. 8, 2021, and Japanese Patent Application No. 2022-045081, filed Mar. 22, 2022, which are hereby incorporated by reference herein in their entirety.

What is claimed is:

1. An image forming apparatus comprising:
- an image bearing member configured to bear a toner image;
- an intermediate transfer belt configured to contact the image bearing member and to which the toner image is to be transferred from the image bearing member, wherein the intermediate transfer belt is endless and conductive and includes a base layer, a surface layer formed on an outer circumferential surface side of the base layer, and an inner surface layer formed on an inner circumferential surface side of the base layer; and
- a contact member configured to contact the intermediate transfer belt from an opposite side of the image bearing member contacting the intermediate transfer belt,
- wherein, with respect to a rotation center of the image bearing member and as seen from a rotation shaft direction of the image bearing member, a position at which the contact member and the intermediate transfer belt contact is arranged downstream from the image bearing member in a rotation direction of the intermediate transfer belt,
- wherein Rv>Rs1 and Rs2>Rs1, and Rs2/Rv≤40 are satisfied where Rv (Ω) is a volume resistance value of the intermediate transfer belt in a thickness direction, Rs1 (Ω) is a first surface resistance value of the inner surface layer side in a surface direction, and Rs2 (Ω) is a second surface resistance value on the surface layer side in a surface direction, and
- wherein the volume resistance value Rv is a value in a range from 2.60×10^{6} (Ω) to 3.51×10^{7} (Ω).

2. The image forming apparatus according to claim 1, wherein the second surface resistance value Rs2 is 3.00×10^{7} (Ω) or more.

3. The image forming apparatus according to claim 1, wherein the volume resistance value Rv and the second surface resistance value Rs2 satisfies Rs2/Rv≤22.

4. The image forming apparatus according to claim 1, wherein the second surface resistance value Rs2 is a value of 7.00×10^{7} (Ω) or more.

5. The image forming apparatus according to claim 1, wherein the volume resistance value Rv is a value in a range from 4.57×10^{6} (Ω) to 1.83×10^{7} (Ω).

6. The image forming apparatus according to claim 1, wherein the second surface resistance value Rs2 is 6.41×10^{8} (Ω) or less.

7. The image forming apparatus according to claim 1, wherein the base layer is a thickest layer of a plurality of layers included in the intermediate transfer belt in the thickness direction.

8. The image forming apparatus according to claim 1, wherein the surface layer is provided in contact with a surface of the base layer on the outer circumferential surface side.

9. The image forming apparatus according to claim 8, wherein a surface of the surface layer opposite to a surface in contact with the base layer is configured to contact the image bearing member.

10. The image forming apparatus according to claim 1, wherein the inner surface layer is provided in contact with a surface of the base layer on the inner circumferential surface side.

11. The image forming apparatus according to claim 10, wherein a surface of the inner surface layer opposite to a surface in contact with the base layer contacts the contact member.

12. The image forming apparatus according to claim 1, wherein, to cause the intermediate transfer belt to wind around a surface of the image bearing member, the contact member presses the intermediate transfer belt in the thickness direction of the intermediate transfer belt toward a side on which the image bearing member is present from a side on which the contact member is present.

13. The image forming apparatus according to claim 1, further comprising a power source connected to the contact member,
- wherein, by the power source applying to the contact member a voltage with an opposite polarity opposite to a normal charge polarity of toner of the toner image, the toner image born by the image bearing member is transferred to the intermediate transfer belt.

14. The image forming apparatus according to claim 13, wherein the contact member is a rotatable metal roller.

15. The image forming apparatus according to claim 13, wherein, by the power source applying to the contact member a voltage, a current flows from the contact member to the image bearing member, and the current flows from the inner surface layer in the thickness direction of the intermediate transfer belt toward the image bearing member via the base layer and the surface layer after flowing through the inner surface layer in a circumferential direction.

16. The image forming apparatus according to claim 1, further comprising a power source connected to the image bearing member,
- wherein the toner image born by the image bearing member is transferred to the intermediate transfer belt, by the power source applying a voltage with a polarity that is the same as a normal charge polarity of toner of the toner image to the image bearing member.

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