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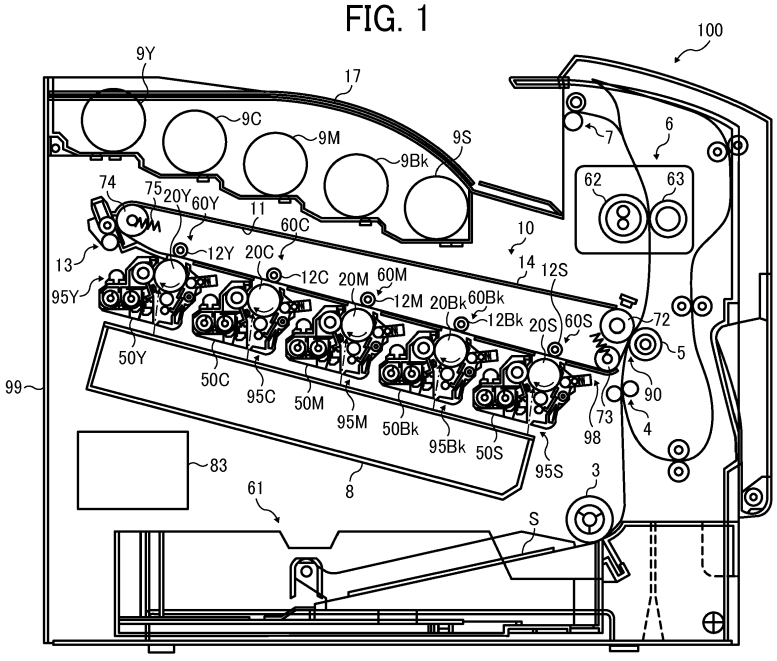
(54) **Image forming apparatus**

(57) An electrophotographic image forming apparatus (100) includes an apparatus body (99); a drive coupling (87) disposed in the apparatus body (99); a drive unit (M4) to rotate the drive coupling (87); a controller (110) to control the drive unit (M4); at least one driven member (50); a developer unit (50); a driven coupling (88) connected to the driven member (50); and a toner supply unit (80). When the developer unit (50) is attached, the driven coupling (88) engages the drive coupling (87) and the driven member (50) is driven by the drive unit (M4). The image forming apparatus (100) includes a toner ejection mode. The controller (110) controls the drive unit (M4) to cause the drive coupling (87) to stop at a predetermined rotation stop position in the toner ejection mode and controls the same to cause the drive coupling (87) to stop at a predetermined rotation stop position immediately.

FIG. 1



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Description

BACKGROUND

Technical Field

[0001] The present invention relates to an image forming apparatus.

Background Art

[0002] An image forming apparatus employing an electrophotographic method includes various driven members for performing image formation detachably attached to an apparatus body. With this structure, each of the driven members can be verified and replaced if degradation or failure occurs.

[0003] Examples of driven members include, for example, an image forming unit and a toner supply container to supply toner or a developer to the image forming unit. The image forming unit includes a plurality of rotary members, such as an image carrier, a developing roller, toner conveyance screws, and the like. These rotary members are driven by a drive unit disposed in the apparatus body.

[0004] In addition, the toner supply container is typically a toner bottle, which is laterally mounted in the apparatus body and rotates driven by the drive unit. Helical projections are formed on an interior surface of the toner bottle, so that, upon rotation of the toner bottle, the toner inside the toner bottle is moved toward the toner bottle outlet.

[0005] On the other hand, the color image forming apparatus includes image forming units for at least four colors of yellow (Y), magenta (M), cyan (C), and black (Bk), respectively. Recently, in addition to the above image forming units for the colors of Y, M, C, and Bk, a so-called special color image forming unit dedicated to pale color toner such as light cyan or light yellow, or transparent toner, has been used as disclosed in, for example, JP-2007-171498-A and JP-2007-316313-A. The special color image forming unit is used depending on the purpose of imaging, such as better image quality, glossiness, or color reproducibility.

[0006] If one image forming unit is to be added for the special color in the tandem-type color image forming apparatus using an intermediate transfer belt, a fifth station (hereinafter, a station is denoted "St") is added following the first fourth stations to which the YMCBk image forming units are mounted. The special color image forming unit that is mounted on the fifth station (5St) can be replaced with other special color image forming units depending on the purpose of imaging, and the frequency in the replacement of the special color image forming unit is higher than that of the YMCBk image forming units.

[0007] Drive transmission between the apparatus body of the image forming apparatus and the driven member is directly performed by coupling in general. The coupling includes an axial direction coupling and an orthogonal direction coupling in which engagement is performed from an orthogonal direction relative to the axial direction. In either coupling method, the rotation positions of the drive side and the driven side when coupled need to be aligned. If not, the couplings interfere with each other and the engagement is not performed well, so that the drive force cannot be transmitted properly.

[0008] Axial direction coupling is disclosed, for example, in JP-2007-304173-A (see FIGS. 11 and 12), that includes a drive coupling having a connection concave portion with a triangle cross section and a driven coupling having a connection convex portion with a triangle cross section. The driven coupling is inserted into the drive coupling from an axial direction and both couplings are engaged, so that the driving force can be transmitted with centers of rotation of both couplings aligned and adjusted.

[0009] In the axial direction coupling, even if the rotation position of the coupling for mounting to the driven member is deviated, if the drive coupling is rotated a little, each rotation position matches. One of the two couplings is spring-loaded to the other coupling, so that the two couplings are engaged and the drive transmission can be possible.

[0010] However, if the couplings are not engaged well and abut each other depending on the state of driven member when coupled together, the coupling may be damaged and broken. Accordingly, leading ends of both couplings include a tapered portion to slidably contact each other as a prevention mechanism to avoid interference with each other. With this tapered portion, a rotation position error occurring when the driven coupling receives the drive coupling in the axial direction can be adjusted.

[0011] The orthogonal direction coupling may include another interference prevention device to meet the rotation positions of both couplings. For example, JP-H04-240870-A discloses that a gear disposed at a driven shaft of the image forming unit is allowed to engage a fixed linear gear disposed on the apparatus body side immediately before the couplings are coupled together. Thus, after having been rotated at a predetermined rotation position, the driven shaft is caused to engage with the drive coupling of the apparatus body side.

[0012] If the coupling method disclosed in JP-2007-304173-A (see FIGS. 11 and 12) is employed, a driven coupling strikes the drive coupling strongly depending on the attachment of the image forming unit as a driven member. If the coupling is broken due to this impact, the rotary drive force cannot be transmitted.

[0013] Not just breakage but also damage of the coupling may adversely affect adjusting the axial core even though the rotary drive force transmission is possible, so that the rotation of the image carrier or the developing roller will be fluctuated, thereby causing an defective image to be generated. In addition, if an interference prevention mechanism such as a tapered portion is provid-

ed, the coupling will be large in size and the cost will be increased, and further, more restrictions are imposed on the design.

[0014] Moreover, if the interference prevention device as disclosed in JP-H04-240870-A is provided, the apparatus becomes large in size due to the space needed for the gear, and the cost will increase due to an increased number of parts.

[0015] Another approach is to keep the rotation stop position of the drive coupling constant in both coupling methods of the axial direction coupling and the orthogonal direction coupling, so that the detachable attachment of the driven coupling relative to the drive coupling is smoothed as disclosed in JP-2005-292676-A (see paragraph [0008]).

[0016] However, the above method will prolong the standby time until the end of the stop control. In particular, after the driven member is detached once for maintenance and is then reattached, the rotation positions of the couplings of the drive side and the driven side in the reattachment are not changed from the detachment time of the driven member. As a result, because the reattachment is possible without the rotation stop position control, the thus-incurred standby time is pointless.

SUMMARY

[0017] Described herein below are embodiments of an image forming apparatus employing an electrophotographic method. The electrophotographic image forming apparatus includes an apparatus body; a drive coupling disposed in the apparatus body of the image forming apparatus; a drive unit to rotate the drive coupling; a controller to control the drive unit; at least one driven member; a developer unit detachably attachable to the apparatus body of the image forming apparatus; a driven coupling connected to the driven member; and a toner supply unit to supply toner or developer to the developer unit. When the developer unit is attached to the apparatus body of the image forming apparatus, the driven coupling engages the drive coupling and the driven member is driven by the drive unit; the image forming apparatus includes a toner ejection mode to discharge the toner contained inside the toner supply unit; the controller controls the drive unit to cause the drive coupling to stop at a predetermined rotation stop position in the toner ejection mode; and in a mode other than the toner ejection mode, the controller controls the drive unit to cause the drive coupling to stop at a predetermined rotation stop position immediately when the drive coupling is rotating.

[0018] In the toner ejection mode in which there is a high possibility that the outstanding developing device is replaced with a different developing device, the rotation stop position control of the drive unit of the apparatus body side enables positional alignment of the rotation stop position between the drive coupling of the apparatus body side and the driven coupling of the developing device.

[0019] As a result, the engagement between the couplings when the different developing device is attached can be performed smoothly. Moreover, due to the positional alignment of the rotation stop position, the interference prevention device need not be provided for the drive coupling and the driven coupling, thereby reducing the cost of the image forming apparatus and saving the space.

[0020] On the other hand, in the non-toner ejection mode in which there is a high possibility that the same developing device is reattached, the rotation stop position control on the drive coupling of the apparatus body side is not performed, thereby reducing the standby time.

[0021] These and other objects, features, and advantages of the present invention will become apparent upon consideration of the following description of the preferred embodiments of the present invention when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022]

FIG. 1 is a schematic configuration of an image forming apparatus according to an embodiment of the present invention;

FIG. 2 is a schematic configuration of an image forming unit in the image forming apparatus shown in FIG. 1;

FIG. 3A is a perspective view of a developer unit of the image forming unit;

FIG. 3B is a plan view of the developer unit illustrating toner conveyance screws disposed inside the developer unit;

FIG. 3C is a perspective view of the toner conveyance screws;

FIG. 4A is a perspective view of a drive coupling disposed on an apparatus body side of the image forming apparatus;

FIG. 4B is an enlarged perspective view of the drive coupling in FIG. 4A;

FIG. 4C is a front view of the drive coupling;

FIG. 4D is a front view of a driven coupling of a process unit;

FIG. 5 is a schematic view of a toner supply mechanism from a toner bottle to the developer unit;

FIG. 6 illustrates a view of a control panel;

FIG. 7 is a block diagram of a controller of the image forming apparatus;

FIG. 8 is a flowchart of steps in a process of replacement of a special color toner;

FIG. 9 is a flowchart of steps in operation of a toner ejection mode;

FIG. 10 is a flowchart of steps in a home position stop control of a developing motor in the toner ejection mode; and

FIG. 11 is a flowchart of steps in the home position stop control of the developing motor.

DETAILED DESCRIPTION

[0023] With reference to drawings, an image forming apparatus according to an embodiment of the present invention will be described. In each figure illustrating an embodiment of the present invention, the same reference numeral will be applied to a part or component having the same function or shape, and once explained, a redundant description thereof will be omitted.

<Overview of image forming apparatus>

[0024] FIG. 1 is a schematic view of an image forming apparatus illustrating an embodiment of the present invention. The image forming apparatus 100 is a color laser printer capable of forming a color image. The image forming apparatus 100, however, may be another type of electrophotographic image forming apparatus, such as a copier, a printer, a facsimile machine, and a multifunction apparatus having one or more capabilities of the above devices.

[0025] The image forming apparatus 100 performs image forming processes based on image signals corresponding to image data received from external devices. Such image forming apparatuses are preferably of the type capable of employing, as a recording medium on which image formation is performed, a regular sheet of paper used for copying in general, an OHP sheet, thick sheet such as a card and a postcard, or an envelope.

[0026] The image forming apparatus 100 includes photoconductor drums 20Y, 20C, 20M, 20Bk, and 20S, each as an image carrier to form an image of a color corresponding to a color decomposed from a print-target image into yellow, cyan, magenta, black, and a special color. The photoconductor drums 20Y, 20C, 20M, 20Bk, and 20S are disposed side by side in a so-called tandem arrangement. Herein, suffixes Y, C, M, Bk, and S of each reference numeral indicates a part or component of yellow, cyan, magenta, black, and special color units, respectively.

[0027] An intermediate transfer belt 11 is an endless belt disposed inside an apparatus body 99 of the image forming apparatus 100 at a substantially center of the apparatus body 99. The intermediate transfer belt 11 serves as an intermediate transfer member. The photoconductor drums 20Y, 20C, 20M, 20Bk, and 20S are disposed at an outer circumferential surface of the intermediate transfer belt 11, that is, an image forming surface side of the belt.

[0028] The intermediate transfer belt 11 is movable to a position opposite each of the photoconductor drums 20Y, 20C, 20M, 20Bk, and 20S, in a direction of arrow A1 as illustrated in FIG. 2. Each of the photoconductor drums 20Y, 20C, 20M, 20Bk, and 20S is disposed in that order from upstream to downstream in the A1 direction.

[0029] Each visible image formed on each photoconductor drum 20Y, 20C, 20M, 20Bk, or 20S is so transferred to the intermediate transfer belt 11 as to be superimposed on the same position on the intermediate transfer belt 11 while the intermediate transfer belt 11 is moving in the A1 direction, and the images are then transferred en bloc to a transfer sheet S as a recording medium. Accordingly, the image forming apparatus 100 is defined as an image forming apparatus using the intermediate transfer method.

[0030] A lower surface of the intermediate transfer belt 11 is opposed to each of the photoconductor drums 20Y, 20C, 20M, 20Bk, and 20S, and each opposed portion forms a transfer section 98 at which a toner image on each of the photoconductor drums 20Y, 20C, 20M, 20Bk, and 20S is transferred to the intermediate transfer belt 11.

[0031] In the superimposed image transfer to the intermediate transfer belt 11, the toner image formed on each of the photoconductor drums 20Y, 20C, 20M, 20Bk, and 20S is transferred to the same position of the intermediate transfer belt 11, while the intermediate transfer belt 11 is moving in the Arrow A1 direction. In addition, primary transfer rollers 12Y, 12C, 12M, 12Bk, and 12S are disposed opposite the photoconductor drums 20Y, 20C, 20M, 20Bk, and 20S, respectively, with the intermediate transfer belt 11 sandwiched therebetween. These primary transfer rollers 12Y, 12C, 12M, 12Bk, and 12S apply electric voltage, so that the superimposed image transfer is performed upstream to downstream in theA1 direction.

[0032] The intermediate transfer belt 11 includes a base layer formed of a material having low elasticity, and a coating formed of a high smoothness covering the base layer. Thus, the intermediate transfer belt 11 has a multilayer structure including the coating overlaid on the base layer. Preferred materials for the base layer include, for example, fluorine resins, polyvinylidene (PVD) sheet, and polyimide resins. Preferred materials for the coating include, for example, fluorine resins.

[0033] The intermediate transfer belt 11 includes a guide at its end portion. The guide prevents the intermediate transfer belt 11 from slanting to either direction orthogonal to a sheet surface in FIG. 1 when the intermediate transfer belt 11 rotates in the A1 direction. The guide of the present embodiment is made of urethane rubber, but may employ various rubber materials such as silicone rubber.

[0034] Each of the photoconductor drums 20Y, 20C, 20M, 20Bk, and 20S is mounted in a corresponding image forming unit 60Y, 60C, 60M, 60Bk, or 60S serving as a toner image forming station that forms images of the colors yellow, cyan, magenta, black, and special, respectively.

[0035] The image forming apparatus 100 includes five image forming units 60Y, 60C, 60M, 60Bk, and 60S, and a transfer belt unit 10. The transfer belt unit 10 includes the intermediate transfer belt 11 and is disposed opposite and above each of the photoconductor drums 20Y, 20C, 20M, 20Bk, and 20S.

[0036] A secondary transfer roller 5 disposed opposite the intermediate transfer belt 11 at an edge of the transfer

belt unit 10 serves as a transfer member driven accompanied by the intermediate transfer belt 11. Further, a scanner 8, a writing unit, is disposed opposite and below the image forming units 60Y, 60C, 60M, 60Bk, and 60S.

[0037] A sheet feeder 61 is a sheet tray on which transfer sheets S are stacked and is disposed below the scanner 8. A sheet feed roller 3, a timing roller pair 4, and a sensor are disposed at a proximal side of the sheet feeder 61. The sensor detects whether a leading end of the transfer sheet S reaches the timing roller pair 4 or not.

[0038] The transfer sheet S conveyed from the sheet feeder 61 is sent, via the timing roller pair 4, to a secondary transfer portion 90 at a predetermined time matched with the toner image formed by the image forming units 60Y, 60C, 60M, 60Bk, and 60S.

[0039] The image forming apparatus 100 further includes a fixing device 6 employing a roller fixing method and fixing the toner image transferred on the transfer sheet S, and a sheet ejection roller pair 7 that discharges the transfer sheet S on which the toner image is fixed thereon, toward outside the apparatus body 99. Toner bottles 9Y, 9C, 9M, 9Bk, and 9S each containing toner of one of colors yellow, cyan, magenta, black, and special are disposed above the transfer belt unit 10.

[0040] A sheet ejection tray 17 is disposed above the apparatus body 99, and the transfer sheet S discharged outside the apparatus body 99 by the ejection roller 7 is stacked on the sheet ejection tray 17. In addition, foreign objects such as waste toner are collected in a waste toner tank 83.

[0041] The image forming apparatus 100 includes a toner supply mechanism 80 as a toner supply means as illustrated in FIGS. 3A and 5. The toner supply mechanism 80 feeds toner inside the toner bottles 9Y, 9C, 9M, 9Bk, and 9S to developer units 50Y, 50C, 50M, 50Bk, and 50C, each disposed in the image forming units 60Y, 60C, 60M, 60Bk, and 60S, respectively.

[0042] The image forming apparatus 100 includes a control panel 160 (see FIG. 6) as an input means for inputting various settings to the image forming apparatus 100; and a controller 110 (see FIG. 7) including a CPU, a memory, and the like, which controls operation of the image forming apparatus 100 as a whole.

[0043] The transfer belt unit 10 includes the primary transfer rollers 12Y, 12C, 12M, 12Bk, and 12S in addition to the intermediate transfer belt 11. The intermediate transfer belt 11 is wound around a drive roller 72 as a drive member, a transfer entrance roller 73, and a cleaning opposite roller 74. The cleaning opposite roller 74 is biased by a spring 75 as a biasing means in a direction to increase a tensile force of the intermediate transfer belt 11.

[0044] The transfer belt unit 10 further includes an intermediate transfer belt case 14 as a chassis of the intermediate transfer belt 11. The intermediate transfer belt case 14 is detachably supported to the apparatus body 99. The intermediate transfer belt case 14 holds the drive roller 72, the transfer entrance roller 73, the cleaning opposite roller 74, and the spring 75 therein. In addition, a belt cleaner 13 configured to clean the surface of the intermediate transfer belt 11 is disposed integrally with the intermediate transfer belt case 14. The belt cleaner 13 is disposed opposite the intermediate transfer belt 11 and cleans the surface of the intermediate transfer belt 11.

[0045] The transfer belt unit 10 includes a drive system to rotate the drive roller 72 and a power supply and a bias controller as a primary transfer bias applicator to apply the primary transfer bias to the primary transfer rollers 12Y, 12C, 12M, 12Bk, and 12S.

[0046] The transfer entrance roller 73 and the cleaning opposite roller 74 are driven rollers driven by the drive roller 72 and rotate following the intermediate transfer belt 11 that is driven to rotate as well. The primary transfer rollers 12Y, 12C, 12M, 12Bk, and 12S press a rear surface of the intermediate transfer belt 11 toward the photoconductor drums 20Y, 20C, 20M, 20Bk, and 20S, so that the pressed portion is formed as a primary transfer nip.

[0047] The primary transfer nip is formed on a portion of the intermediate transfer belt 11 stretched between the transfer entrance roller 73 and the cleaning opposite roller 74. The transfer entrance roller 73 and the cleaning opposite roller 74 include a function to stabilize the primary transfer nip.

[0048] A primary transfer electric field is formed at each primary transfer nip by the primary transfer bias, between the photoconductor drums 20Y, 20C, 20M, 20Bk, and 20S and the primary transfer rollers 12Y, 12C, 12M, 12Bk, and 12S, respectively. The toner images of each color formed on the photoconductor drums 20Y, 20C, 20M, 20Bk, and 20S are primarily transferred onto the intermediate transfer belt 11 via the primary transfer electric field and a nip pressure.

[0049] The drive roller 72 contacts the secondary transfer roller 5 via the intermediate transfer belt 11, to thereby form the secondary transfer portion 90. The cleaning opposite roller 74 serves as a tension roller to give a predetermined tensile force suitable for transferring image to the intermediate transfer belt 11 under an effect of the spring 75.

[0050] The belt cleaner 13 is disposed opposite the intermediate transfer belt 11 at a left side of the cleaning opposite roller 74 in FIG. 1. The belt cleaner 13 includes a cleaning brush and a cleaning blade both disposed to be opposed to and contact the intermediate transfer belt 11. Foreign materials such as residual toner on the intermediate transfer belt 11 are scratched and removed by the cleaning brush and blade, and the intermediate transfer belt 11 is to be cleaned accordingly. Foreign objects such as the waste toner thus removed by the belt cleaner are collected in a waste toner tank 83 via a waste toner path.

[0051] The sheet feeder 61 is disposed below the apparatus body 99 and contains a plurality of transfer sheets S in a state of a stacked bundle. The sheet feeder 61

includes the sheet feed roller 3 to contact and feed a topmost transfer sheet S. When the sheet feed roller 3 rotates in a counterclockwise direction, the topmost transfer sheet S is conveyed to the timing roller pair 4.

[0052] An outer circumferential surface of the timing roller pair 4 is precisely dimensioned to meet an image forming speed, that is, a moving speed of the intermediate transfer belt 11 with a speed of the conveyed sheet. The tolerance of the outer circumferential surface is within 0.03 mm.

[0053] A secondary transfer electric field is formed at the secondary transfer portion 90 by the secondary transfer bias between the drive roller 72 and the intermediate transfer belt 11 and the secondary transfer roller 5. The toner images formed on the intermediate transfer belt 11 are secondarily transferred onto the transfer sheet S by the secondary transfer electric field and a nip pressure. The drive roller 72 serves also as a secondary transfer opposite roller.

[0054] The fixing device 6 includes a fixing roller 62 with a build-in heat source, and a pressure roller 63 pressed by the fixing roller 62. When the transfer sheet S on which the toner image is carried passes through the fixing portion that is pressed by the fixing roller 62 and the pressure roller 63, the carried toner image is fixed on the surface of the transfer sheet S with heat and pressure.

[0055] A predetermined amount of toner of one of colors yellow, cyan, magenta, black, and special contained in the toner bottles 9Y, 9C, 9M, 9Bk, and 9S is replenished to the developer units 50Y, 50C, 50M, 50Bk, and 50S, respectively. The toner bottles 9Y, 9C, 9M, 9Bk, and 9S are consumables that are replaced when the toner replenished inside is used up. When the toner is exhausted, the toner bottle is detached from the apparatus body 99 and is replaced with a new one.

[0056] The belt cleaner 13 and the cleaning opposite roller 74 move downward with the primary transfer rollers 12Y, 12C, 12M, and 12S when a monochrome printing process is performed, so that the intermediate transfer belt 11 is configured to be apart from the photoconductor drums 20Y, 20C, 20M, and 20S.

[0057] Various information input from the control panel is recognized and identified by the controller 110. The information inputted from the control panel includes, for example, reference values used to detect retention of the developer by a retention sensor. The control panel includes a display, and the controller 110 controls the control panel to allow the display to indicate predetermined values.

[0058] As to the image forming units 60Y, 60C, 60M, 60Bk, and 60S, one of the image forming unit 60Y including the photoconductor drum 20Y is taken as a representative and will be described. The other image forming units 60C, 60M, 60Bk, and 60S are structurally the same as the image forming unit 60Y, and therefore, a duplicated description of the other units will be omitted in the description below.

<Image forming unit>

[0059] As illustrated in FIG. 2, as to the image forming unit 60Y including the photoconductor drum 20Y, various parts including a primary transfer roller 12Y are disposed in the periphery of the photoconductor drum 20Y. Specifically, along a clockwise rotation direction B1 of FIG. 2, the primary transfer roller 12Y, a cleaning unit 40Y, a charger 30Y, and the developer unit 50Y are disposed. The developer unit 50Y serves as the image forming unit.

[0060] The charger 30Y includes a charging roller 31Y driven to rotate while contacting a surface of the photoconductor drum 20Y and a cleaning roller 32Y driven to rotate while contacting the charging roller 31Y. Means to apply DC voltage to which bias voltage of AC component is superimposed is connected to the charging roller 31Y. With this structure, the surface of the photoconductor drum 20Y is discharged at a charged area opposed to the charging roller 31Y and is charged at a predetermined polarity at the same time.

[0061] The cleaning roller 32Y rotates driven by the charging roller 31Y, thereby cleaning a surface of the charging roller 31Y. Thus, the present embodiment employs a charging system using a contact roller; however, the charging system employing a nearby roller may be employed, and alternatively, a corotron method may be applied.

[0062] The developer unit 50Y includes a developing roller 51Y disposed near and opposite the photoconductor drum 20Y. Yellow toner electrostatically transfers onto the electrostatic latent image formed on a surface of the photoconductor drum 20Y at a developing area between the developing roller 51Y and the photoconductor drum 20Y, so that the electrostatic latent image is rendered visible as a yellow toner image. A detailed description of the developer unit 50Y is deferred.

[0063] A primary transfer bias applicator applies a predetermined voltage suitable for the primary transfer from a power source to the primary transfer roller 12Y in accordance with bias controller.

[0064] The scanner 8 as illustrated in FIG. 1 emits optically modulated laser beams L to an area between the charged area and the developing area of the photoconductor drum 20Y, thereby exposing the surface of the photoconductor drum 20Y charged by the charging roller 31Y so that the electric potential of the exposed area is reduced and a potential difference is produced electrostatically on the surface of the photoconductor drum 20Y, forming an electrostatic latent image. The developer unit 50Y supplies yellow toner to the area where the potential is reduced, and the yellow toner is adhered thereon and is rendered visible as a yellow toner image.

[0065] The cleaning unit 40Y includes a cleaning case 43Y that includes an opening at a portion opposite the photoconductor drum 20Y. A cleaning roller 45Y is disposed at the cleaning case 43Y. The cleaning roller 45Y contacts the photoconductor drum 20Y to clean it by scraping off foreign materials such as residual toner, car-

rier particles, paper dust, and the like remaining on the photoconductor drum 20Y.

[0066] A cleaning blade 41Y is disposed at the cleaning case 43Y. The cleaning blade 41Y contacts the photoconductor drum 20Y at downstream of the cleaning roller 45Y in the rotation direction B1 of the photoconductor drum 20Y and scrapes the foreign materials off from the surface of the photoconductor drum 20Y.

[0067] The cleaning unit 40Y further includes an ejection screw 42Y that is rotatably disposed in the cleaning case 43Y. The ejection screw 42Y conveys the foreign materials such as the waste toner scraped off and removed by the cleaning roller 45Y and the cleaning blade 41Y toward the waste toner tank 83. The ejection screw 42Y forms part of the waste toner path.

[0068] The image forming unit 60Y is constructed of the photoconductor drum 20Y, the primary transfer roller 12Y, the cleaning unit 40Y, the charger 30Y, and the developer unit 50Y. As illustrated in FIG. 2, a process unit 95Y is defined as the image forming unit 60Y excluding the primary transfer roller 12Y.

[0069] Specifically, the process unit 95Y includes the photoconductor drum 20Y, the cleaning unit 40Y, the charger 30Y, and the developer unit 50Y, which are integrally formed in the process unit 95Y. The process unit 95Y is therefore detachably attachable to the apparatus body 99 of the image forming apparatus 100 as a unit toward a proximal side in FIG. 1.

[0070] In addition, the photoconductor drum 20Y is independently detachably attachable to the apparatus body 99 of the image forming apparatus 100 toward the proximal side in FIG. 1. The process unit 95Y excluding the photoconductor drum 20Y, that is, the unit including the cleaning unit 40Y, the charger 30Y, and the developer unit 50Y is to be referred to as a developing unit 70Y. The developing unit 70Y is detachably attachable to the apparatus body 99 of the image forming apparatus 100 toward the proximal side in FIG. 1.

[0071] The developer unit 50Y is independently detachably attachable to the apparatus body 99 of the image forming apparatus 100 for replacement of the developer or the developing agent. Further, the process unit 95Y excluding the developer unit 50Y forms a unit that includes the photoconductor drum 20Y, the cleaning unit 40Y, and the charger 30Y. This unit is detachably attachable to the apparatus body 99 of the image forming apparatus 100 as a unit.

(Basic operation of the image forming apparatus)

[0072] When a signal to form a color image is input to the thus-constructed image forming apparatus 100, the drive roller 72 is driven so that the intermediate transfer belt 11, the transfer entrance roller 73, and the cleaning opposite roller 74 are driven to rotate as well. At the same time, the photoconductor drum 20Y, 20C, 20M, 20Bk, and 20S are driven to rotate in the B1 direction in FIG. 2.

[0073] The charger roller 31Y uniformly charges the surface of the photoconductor drum 20Y while the drum 20Y is rotating in the B1 direction. Then, by exposure of the scanning laser beams L from the scanner 8, the electrostatic latent image corresponding to yellow color is formed.

[0074] The electrostatic latent image is rendered visible by the developer unit 50Y with yellow toner. The primary transfer roller 12Y primarily transfers the thus-obtained yellow monochrome toner image onto the intermediate transfer belt 11 that moves in the A1 direction. The foreign objects including residual toner remaining on the surface of the photoconductor drum 20Y after transfer are removed by the cleaning unit 40Y, so that the cleaned surface of the photoconductor drum 20Y is ready for a next discharging and charging by the charging roller 31Y.

[0075] Other photoconductor drums 20C, 20M, 20Bk, and 20S form a toner image of each color similarly to the photoconductor drum 20Y, and the formed monochrome toner image of each color is sequentially, primarily transferred on the same position of the intermediate transfer belt 11 that moves in the A1 direction via the primary transfer rollers 12C, 12M, 12Bk, and 12S. The toner image superimposed on the intermediate transfer belt 11 moves to the secondary transfer portion 90 disposed opposite the secondary transfer roller 5 in accordance with the rotation of the intermediate transfer belt 11 in the A1 direction, and is secondarily transferred onto the transfer sheet S in the secondary transfer portion 90.

[0076] The transfer sheet S conveyed from the sheet feeder 61 by the sheet feed roller 3 is conveyed at a predetermined timing by the timing roller pair 4 to a portion between the intermediate transfer belt 11 and the secondary transfer roller 5. The above timing depends on the detection signal from a sensor to detect that the leading end of the transfer sheet S reaches the timing roller pair 4 and a position of the toner image on the intermediate transfer belt 11.

[0077] The transfer sheet S carries transferred toner images of all colors thereon and moves on to the fixing device 6. When the transfer sheet S passes through the fixing portion between the fixing roller 62 and the pressure roller 63, the carried toner image is fixed onto the surface of the transfer sheet S with heat and pressure, so that a synthesized color image is formed/fixed on the transfer sheet S.

[0078] The fixed transfer sheet S passing through the fixing device 6 is conveyed via the sheet ejection roller 7, and is stacked on the sheet ejection tray 17 disposed on an upper part of the apparatus body 99. On the other hand, the intermediate transfer belt 11 after the secondary transfer is cleaned by the cleaning brush and the cleaning blade of the belt cleaner 13 and becomes ready for the next charging and developing processes.

<Developer unit and toner supply mechanism>

[0079] In the image forming process as described above, toner of each one of the colors yellow, cyan, ma-

genta, black, and a special color is consumed in a respective one of the developer units 50Y, 50C, 50M, 50Bk, and 50S, respectively. As a result, the toner supply mechanism 80 as illustrated in FIGS. 3A and 5 supplies a predetermined, necessary amount of toner from the toner bottles 9Y, 9C, 9M, 9Bk, and 9S to each of the developer units 50Y, 50C, 50M, 50Bk, and 50S, respectively.

[0080] The developer units 50Y, 50C, 50M, 50Bk, and 50S cause each color of toner to be charged so as to develop each electrostatic latent image formed on the photoconductor drums 20Y, 20C, 20M, 20Bk, and 20S with each color of toner.

[0081] As to the structure of the developer units 50Y, 50C, 50M, 50Bk, and 50C, one of the developer units 50Y is taken as a representative and will be described. The other developer units 50C, 50M, 50Bk, and 50S are structurally the same as the developer unit 50Y, and therefore redundant description of the other units will be omitted in the description below.

[0082] As illustrated in FIG. 2, the developer unit 50Y includes the developing roller 51Y, a developer case 55Y, and a developing blade 52Y. The developer case 55Y is a casing serving as a developer container including an opening at a portion opposite the photoconductor drum 20Y. The developing blade 52Y regulates a developer or developing agent deposited on the developing roller 51Y at a predetermined height.

[0083] The developer unit 50Y is disposed below and opposite the developer case 55Y and includes a first toner conveyance screw 53Y and a second toner conveyance screw 54Y, each serving as a toner conveying part while circulating the developer or developing agent.

[0084] The second toner conveyance screw 54Y rotates in the same direction associating with the first toner conveyance screw 53Y via engagement toothed gears disposed at an end of rotary shafts 83Y and 84Y and idle gears disposed between both toothed gears.

[0085] The developer unit 50Y further includes a toner density sensor 92Y to detect density of the toner contained in the developer case 55Y. Further, means to apply developing bias having a DC component is disposed. Furthermore, a drive unit to rotate the first toner conveyance screw 53Y and the second toner conveyance screw 54Y in the same direction is disposed.

[0086] The developer unit 50Y performs development using a two-component developer including non-magnetic yellow toner and magnetic carrier particles mainly formed of iron powder. The developer is contained in the developer case 55Y.

[0087] The developing roller 51Y is disposed near and opposite the photoconductor drum 20Y via the opening of the developer case 55Y. As illustrated in FIG. 2, the developing roller 51Y includes a developing sleeve 56Y, which is rotatable, includes a surface to carry the developer, and has a thin cylinder shape formed of non-magnetic aluminum. In addition, a magnet 57Y to generate magnetic field is disposed inside the developing sleeve 56Y so as to be covered by the developing sleeve 56Y so that the developing sleeve 56Y carries the developer.

[0088] As illustrated in FIG. 2, the developer case 55Y includes a developer chamber 58Y in which the first toner conveyance screw 53Y is disposed; and an agitation chamber 59Y in which the second toner conveyance screw 54Y is disposed. The developer chamber 58Y and the agitation chamber 59Y are partitioned by a partition wall 81Y. The developer case 55Y includes a supply port 91Y. The yellow toner is supplied from the toner bottle 9Y (see FIG. 1) to the supply port 91Y via the toner supply mechanism 80 as illustrated in FIG. 3A.

[0089] As illustrated in FIGS. 2 and 3A, the first toner conveyance screw 53Y is disposed opposite the developing roller 51Y so that the first toner conveyance screw 53Y supplies the developer to the developing roller 51Y, and therefore, the developer chamber 58Y is positioned nearer to the developing roller 51Y than the developer chamber 58Y is.

[0090] The developer case 55Y is virtually illustrated to have an opening at an upper part thereof to simplify the description in FIGS. 3A and 3B. In actuality, as illustrated in FIG. 2, excluding the opening of the developer case 55Y through which the developing roller 51Y opposes to the photoconductor drum 20Y, the developer case 55Y is tightly sealed lest the developer leak.

[0091] As illustrated in FIG. 3B or FIG. 3C, the first toner conveyance screw 53Y and the second toner conveyance screw 54Y include a rotary shaft 83Y and a rotary shaft 84Y, respectively, each defines a rotary center. A screw portion 85Y and a screw portion 86Y each include a spiral, concave shape and disposed on each of the rotary shafts.

[0092] The screw portion 85Y and the screw portion 86Y are helical and reversely formed to each other. The first toner conveyance screw 53Y and the second toner conveyance screw 54Y are parallel to each other and with the developing roller 51Y. The toothed gears are disposed at each end of the rotary shafts 83Y and 84Y and idle gears are engaged between both toothed gears. As a result, when one of the rotary shaft 83Y and the rotary shaft 84Y rotates, the other rotary shaft rotates in the same direction.

[0093] Furthermore, the drive unit drives to rotate the rotary shaft 83Y and the rotary shaft 84Y in the same direction, so that the first toner conveyance screw 53Y and the second toner conveyance screw 54Y rotate in the same direction. Via rotation about the rotary shaft 83Y and the rotary shaft 84Y, the screw portion 85Y and the screw portion 86Y serve to convey the developer in a direction of the rotary shaft, that is, along the rotary shaft 83Y and the rotary shaft 84Y.

[0094] More specifically, each of the first and second toner conveyance screws 53Y, 54Y conveys the developer in the following direction. The first toner conveyance screw 53Y conveys the developer in the developer chamber 58Y in a distal side in FIG. 2 and leftward in FIG. 3B, which is referred to as a first direction. The second toner conveyance screw 54Y conveys the developer in the ag-

itation chamber 59Y toward a proximal side in FIG. 2 and rightward in FIG. 3B, which is referred to as a second direction.

[0095] Although the developer chamber 58Y and the agitation chamber 59Y are partitioned by the partition wall 81Y, there are spaces at both lateral ends of the partition wall 81Y inside a side wall of the developer case 55Y, so that the developer chamber 58Y and the agitation chamber 59Y are communicated in those spaces.

[0096] As a result, the developer moves from the developer chamber 58Y to the agitation chamber 59Y and from the agitation chamber 59Y to the developer chamber 58Y in the communicating spaces due to the rotation of the first and second toner conveyance screws 53Y, 54Y. With this structure, the developer is circulated and conveyed constantly in a counterclockwise direction in the developer chamber 58Y and the agitation chamber 59Y as illustrated in FIG. 3B.

[0097] The developer chamber 58Y forms a first section in which the developer is supplied to the developing roller 51Y while being conveyed in the first direction. The agitation chamber 59Y forms a second section in which the developer is conveyed from the developer chamber 58Y. The agitation chamber 59Y also serves as a third section in which the developer is conveyed in the second direction and is replenished to the developer chamber 58Y.

[0098] The second section and the third section form a common space as the agitation chamber 59Y; however, these sections may be disposed separately as long as the developer can be circulated. The first direction and the second direction are parallel to each other in the present embodiment; however, they may not be in parallel in a case, for example, where the second section and the third section each are formed as separate spaces and are bent.

[0099] The drive unit enables to change each rotational speed of the first toner conveyance screw 53Y and the second toner conveyance screw 54Y via the control of a controller, so that the conveyance speed of the developer can be changed by changing the rotational speed of the first toner conveyance screw 53Y and the second toner conveyance screw 54Y.

[0100] The toner density sensor 92Y detects magnetic permeability of the developer inside the developer case 55Y and obtains the density of the toner contained in the developer by correlating the detected permeability value to toner density. The toner density sensor 92Y is disposed below the second toner conveyance screw 54Y. Alternatively, as will be described later, the toner density sensor 92Y may be disposed below the first toner conveyance screw 53Y, and the density of the toner may be obtained by detecting the density of toner included in the developer upon the developer falls from the developing roller 51Y.

[0101] The toner supply mechanism 80 includes a toner conveyance screw 136 and a motor M3 as will be described later referring to FIG. 5. The motor M3 is driven to rotate a coil when it is determined that the density of the toner is low from the detection by the toner density sensor 92Y detecting that the density of the toner included in the developer inside the developer case 55Y is reduced to a value less than the predetermined value of the density. With this, a predetermined amount of yellow toner is replenished to the developer inside the developer unit 50Y from the toner bottle 9Y via the supply port 91Y.

[0102] The toner replenished inside the developer unit 50Y via the supply port 91Y falls on the second toner conveyance screw 54Y inside the agitation chamber 59Y as the second section. Specifically, the supply port 91Y is disposed at a position to supply toner to the second toner conveyance screw 54Y.

[0103] The yellow toner replenished from the supply port 91Y is agitated and mixed with the developer by the first toner conveyance screw 53Y and the second toner conveyance screw 54Y, so that the agitated and mixed developer is supplied to the developing roller 51Y.

[0104] Because agitation and mixture of the developer with the newly replenished toner is performed mainly in the agitation chamber 59Y as the second section, the agitation chamber 59Y as the second section serves as a toner density adjustment space. The newly replenished toner receives, during agitation and mixture, electrical charging by friction between toner particles and between the toner and the carrier particles. The toner is then electrically charged.

[0105] The first toner conveyance screw 53Y and the second toner conveyance screw 54Y each serve as a developer agitator to agitate the developer inside the developer case 55Y. When the developer moves along the screw portions 85Y, 86Y, the developer is agitated vertically, so that the agitation effect is obtained.

[0106] In the developer unit 50Y, the developer inside the developer chamber 58Y is carried on the developing sleeve 56Y in an ears form due to the magnetic force of the magnet 57Y The developing roller 51Y serves as a developer carrier to carry the developer stored inside the developer case 55Y. The carried amount of the developer by the developing sleeve 56Y is regulated by the developing blade 52Y.

[0107] The layered developer with a regulated amount carried on the developing sleeve 56Y is conveyed to a development area between the developing roller 51Y and the photoconductor drum 20Y according to the rotation of the developing sleeve 56Y in a direction indicated by an arrow C 1.

[0108] The yellow toner charged by agitation of the first toner conveyance screw 53Y and the second toner conveyance screw 54Y included in the developer electrostatically transfers onto the electrostatic latent image formed on the surface of the photoconductor drum 20Y by the effect of the developing bias of the bias applicator, so that the electrostatic latent image is rendered visible as a yellow toner image.

[0109] Thus, by developing the electrostatic latent image on the surface of the photoconductor drum 20Y, the

yellow toner is consumed. The developer of which the density of the yellow toner is reduced is further conveyed by the rotation of the developing sleeve 56Y in the C1 direction, separates from the surface of the developing sleeve 56Y at a part with less magnetic force and falls, and is mixed and agitated with other developer.

[0110] In the present embodiment, the bias applicator is configured to impress the developing bias of a DC component; however, the developing bias may be formed of an AC component, and alternatively, the DC component with the AC component superimposed can be employed.

[0111] As described heretofore, the developer is agitated to electrically charge the toner included in the developer; however, the toner is gradually degraded through agitation. On the other hand, when an image having a low image area ratio is printed continuously, the toner tends to be degraded before being consumed, fluidity of the toner reduces, the toner accumulates without being agitated, and the developing property is degraded because such an image does not consume a lot of toner.

[0112] Then, the developer units 50Y, 50C, 50M, and 50Bk are configured to detect reduction of fluidity of the developer by the accumulation. When the accumulation is detected, the density of the toner included in the developer is adjusted, so that the inconvenience is prevented or restricted. Means and structure for detecting the accumulation are disposed to each developer unit 50Y, 50C, 50M, and 50Bk in the similar manner.

<Drive coupling of the apparatus body side>

[0113] As illustrated in FIGS. 4A and 4B, an end plate 93a is disposed at the apparatus body 99 of the image forming apparatus 100, to which the process unit 95Y for drive coupling of the apparatus body 99 of the image forming apparatus 100 is attached. The end plate 93a is positioned at a distal side in an inserting direction of the process unit 95Y when inserted in the apparatus body 99 of the image forming apparatus 100. The drive coupling to drive each rotary shaft of the photoconductor drum 20Y, the cleaning unit 40Y, the charger 30Y, and the developer unit 50Y that are disposed in the process unit 95Y protrudes from the end plate 93a.

[0114] Hereinafter, the drive coupling to drive the rotary shaft of the developer unit 50Y, which corresponds to the unit excluding the photoconductor drum 20Y from the process unit 95Y, will be explained.

[0115] As illustrated in FIG. 4B, a support plate 93b is disposed outboard of the end plate 93a, and a rotary shaft 96 to drive the second toner conveyance screw 54Y of the developer unit 50Y is held by the support plate 93b. The rotary shaft 96 is driven by a drive motor disposed at a rear side of the end plate 93a to the apparatus body 99. The drive motor can be implemented as a stepping motor in addition to the normal general purpose motors.

[0116] A drive coupling 87 is disposed at an end of the rotary shaft 96. The drive coupling 87 rotates together with a fan-shaped feeler 101 attached to the rotary shaft 96. An optical sensor 102 is so disposed as to straddle the feeler 101, so that the optical sensor 102 detects absence and presence of the feeler 101 through detecting light transmission and blocking, respectively.

[0117] As illustrated in FIG. 4C, the drive coupling 87 includes a tripod-shaped female part formed inside an inner periphery of a cylindrical body with spacings provided at intervals of 120 degrees (θ = 120 degrees), serving as a connection concave portion. In addition, as illustrated in FIG. 4D, a driven coupling 88 disposed at the apparatus body 99 of the image forming apparatus 100 includes a tripod-shaped male part formed around the rotary shaft with projections provided at intervals of 120 degrees (θ = 120 degrees), serving as a connection convex portion. When the developer unit 50Y is mounted to the apparatus body 99 of the image forming apparatus 100, the female part of the drive coupling 87 detachably engages the male part of the driven coupling 88.

[0118] The aforementioned shape of the coupling is an example, and the shape is not limited to the above example. Instead, any coupling shape and joint shape can be employed so long as those shapes can transmit a rotary drive force appropriately.

[0119] The home position of the drive coupling 87 is not limited to a particular point in the rotary direction of 360 degrees as a rotation stop position. Specifically, when the drive coupling 87 has a shape repeating in the peripheral direction at intervals of 120 degrees, each of three particular points with intervals of 120 degrees can be made a rotation stop position.

<Toner supply mechanism>

[0120] As illustrated in FIGS. 1 and 5, toner bottles 9Y, 9C, 9M, 9Bk, and 9S are disposed upstream of the toner supply mechanism 80 and inside the apparatus body 99 of the image forming apparatus 100. FIG. 5 illustrates the toner supply mechanism 80 in which special color toner is supplied from the special color toner bottle 9S; however, toner of the other colors can be supplied from the Y, C, M, and Bk toner bottles in the same manner.

[0121] The special color toner bottle 9S is horizontally disposed at a predetermined position in an upper portion of the apparatus body 99. The special color toner bottle 9S is horizontally disposed detachably attachable to the apparatus body 99 in a direction as indicated by a double-headed arrow in FIG. 5. A bottle drive motor M1 is detachably coupled to a bottom side surface of the special color toner bottle 9S.

[0122] A diaphragm pump P is a type of powder air pump and is disposed apart from the special color toner bottle 9S. The special color toner bottle 9S and the diaphragm pump P are connected via a toner conveyance tube 94. One end of the toner conveyance tube 94 is connected to an outlet of the special color toner bottle 9S. The other end of the toner conveyance tube 94 is connected to a suction port P1 of the diaphragm pump P.

[0123] A diaphragm pump drive motor M2 is disposed on the diaphragm pump P. The diaphragm pump P includes an eccentric shaft mounted to a rotary shaft of the diaphragm pump drive motor M2. Via the rotation of the eccentric shaft, the diaphragm inside the diaphragm pump P is bent and deformed repeatedly, so that an internal cubic volume of the diaphragm pump P is increased or decreased.

[0124] With this structure, the special color toner is moved from the suction port P1 of the diaphragm pump P to an outlet P2. Alternatively, the diaphragm pump P may be implemented as other pumps that can vacuum up powdery objects, such as a Mono pump, a suction type, single-axis eccentric screw pump, and the like.

[0125] A sub-hopper 120 that extends horizontally is disposed below the diaphragm pump P. An inlet 120a formed on an upper part of the sub-hopper 120 is connected to the outlet P2 of the diaphragm pump P. An outlet 120b formed on a bottom part of the sub-hopper 120 is connected to the developer unit 50S. A toner end sensor 137 is disposed on a wall surface of the sub-hopper 120.

[0126] The toner conveyance screw 136 is horizontally disposed inside the sub-hopper 120. The toner conveyance screw 136 is driven by the motor M3. A clutch CL, gears 130 to 133, and a rotary shaft 140 are disposed between the sub-hopper 120 and the motor M3. The rotational force of the motor M3 is sequentially transmitted from the gear 130, to the gear 131, rotary shaft 140, gear 132, gear 133, and to the clutch CL in this order.

[0127] Upon the toner end sensor 137 detecting dropping of the level of toner, the diaphragm pump drive motor M2 is driven to supply special color toner to the sub-hopper 120. Upon the clutch CL being connected, the toner conveyance screw 136 of the sub-hopper 120 is rotated. When the toner conveyance screw 136 rotates, the special color developer unit 50S is replenished from the outlet 120b with the special color toner. When the clutch CL is disengaged, the toner conveyance screw 136 stops rotating. When the toner conveyance screw 136 stops rotating, replenishment of the special color developer unit 50S with the special color toner is suspended.

[0128] The special color developer unit 50S is detachably attachable to the apparatus body 99 in the horizontal direction as indicated by the double-headed arrow as illustrated in FIG. 5. The horizontal direction corresponds to an axial direction of the rotary axis of the special color developer unit 50S, that is, the rotary axis of the rotary shaft 83Y, the rotary shaft 84Y, and the developing roller 51Y. The drive coupling 87 rotatably disposed on the side of the apparatus body 99 is driven by a motor M4 via gears 134, 135.

[0129] The special color developer unit 50S is more frequently replaced than the other developer units. As a result, the special color developer unit 50S is more frequently damaged or broken due to the replacement than the other developer units are. However, according to the embodiments of the present invention, possible damages and failure of the drive coupling 87 and the driven coupling 88 due to the replacement of the special color developer unit 50S can be reduced.

<Controller>

[0130] FIG. 7 is a block diagram of the controller 110 of the image forming apparatus 100. The controller 110 is constructed of a CPU, a RAM, and a ROM. The image forming units 60Y, 60M, 60C, 60Bk, and 60S, motors M1 to M6, the clutch CL, the scanner 8, the transfer belt unit 10, a temperature and humidity sensor 103, the optical sensor 102, and the like, are electrically connected to the controller 110. Then, the controller 110 controls those various parts and components based on a control program stored in the ROM and executed in the RAM.

[0131] Among the motors M1 to M6, the motors M1 to M4 are illustrated in FIG. 5. The motor M4 drives the image forming unit 60S, and the drive roller 72 of the intermediate transfer belt 11. The motor M5 drives four image forming units 60Y, 60C, 60M, and 60Bk. The motor M6 drives a sheet feed roller 3 and the fixing roller 62. Thus, by decreasing the number of motors, the image forming apparatus 100 can be made compact and a low production cost is realized.

[0132] The controller 110 controls image forming conditions to form an acceptable image. Specifically, the controller 110 causes each charged member in each of the image forming units 60 to be applied with the charging bias individually. With this structure, each charged member is uniformly charged to a predetermined proper electrical potential for each photoconductor drum 20.

[0133] Further, the controller 110 enables the power of five semiconductor lasers of the scanner 8 corresponding to each of the image forming units 60 to be controlled individually.

[0134] Furthermore, the controller 110 causes the developing bias with a predetermined bias amount for each developing roller of the colors of Y, C, M, Bk, and S to be applied to each developing roller of the image forming units 60. With such a control, a developing potential to electrostatically move the toner from the surface of the sleeve to the side of the photoconductor drum 20 is applied between the electrostatic latent image on the photoconductor drum 20 and the developing roller 51, thereby developing the electrostatic latent image.

[0135] In addition, the controller 110 performs a process control to optimize a density of toner of each color properly at a time of power-on or when a predetermined number of prints are formed.

<Replacement of special color toner>

[0136] FIG. 8 is a flowchart of an example of a replacement of the special color toner. The present replacement operation shows an example to replace the clear toner currently used with a white toner. First, in addition to the

four colors of Y, M, C, and Bk, the clear toner has been used (in Step S11).

[0137] From the above state, in order to use the white toner, the toner bottle of the clear toner needs to be replaced with a toner bottle of the white toner, and the developer unit of the clear toner needs to be replaced with the developer unit of the white toner. Further, the residual clear toner remaining in the toner conveyance tube 94, the diaphragm pump P, and the sub-hopper 120 needs to be discharged.

[0138] Therefore, with the toner bottle 9S of the clear toner removed, the diaphragm pump P is driven, so that the residual clear toner is collected in the developer unit 50S of the clear toner (S12).

[0139] When all the residual clear toner is collected in the developer unit 50S of the clear toner, the developer unit 50S is removed and the developer unit of the white toner is attached. In addition, in place of the toner bottle 9S of the clear toner, the toner bottle of white color is attached (S13).

[0140] When the developer unit of white color is attached, the drive coupling 87 of the side of the apparatus body 99 and the driven coupling 88 of the developer unit of white color are engaged in the axial direction (S14). As will be described later, the rotation stop position of the motor M4, the drive means of the side of the apparatus body 99, is controlled, so that the drive coupling 87 of the apparatus body 99 can stop rotating at a predetermined home position. With this control, the driven coupling 88 of the developer unit of white color is smoothly engaged with the drive coupling 87.

[0141] The rotation position of the driven coupling 88 of a new developer unit of white color is factory-adjusted to align with the home position of the drive coupling 87 of the apparatus body.

<Toner ejection mode>

[0142] When the developer unit 50S of clear toner is attached again after use of the developer unit 50S of white color, after removing the toner bottle of white toner, a toner ejection mode is performed (S15). Then, the toner bottle 9S of the clear toner is reattached, and the developer unit of white toner is replaced with the developer unit of clear toner (S16, S17).

[0143] The toner ejection mode is for the purpose of discharging the toner inside the toner supply mechanism 80 and can be initiated by operation of a control panel 160 as illustrated in FIG. 6. The control panel 160 is disposed at an operable position on top of the apparatus body 99 of the image forming apparatus 100.

[0144] The control panel 160 includes a keyboard 161 including a plurality of keys or buttons for inputting desired operations and instructions and a display panel 162 including a liquid crystal display panel to show status and data settings of the image forming apparatus. A toner ejection mode button 163 is disposed adjacent to the keyboard 161. When a user presses the toner ejection mode button 163, the toner ejection mode starts.

[0145] As illustrated in FIG. 9, the diaphragm pump P is driven at a high rotation speed in the toner ejection mode (S21), and the residual toner of special color remaining in the toner conveyance tube 94 is introduced to the sub-hopper 120 via the diaphragm pump P (S22). In addition, the toner conveyance screw 136 of the sub-hopper 120, and the first toner conveyance screw 53 and the second toner conveyance screw 54 of the developer unit 50 are driven, so that the residual toner inside the sub-hopper 120 is taken in the developer unit 50 (S23).

[0146] In the toner ejection mode, as illustrated in FIG. 10, a waste toner motor, a waste toner bottle motor, the motor M4, the motor M3, and the clutch CL are turned on (S31). The waste toner motor and the waste toner bottle motor are not shown in the figure; however, they are attached to the apparatus body. The above motors are driven for a predetermined time period, and discharging of the residual toner inside the toner supply mechanism 80 is complete (S32). Thereafter, the waste toner motor, the waste toner bottle motor, the motor M3, and the clutch CL are turned off (S33).

[0147] The developing motor M4 stops via the developing motor home position stop control, at a predetermined rotational position or the home position (S34). With the above control, the drive coupling 87 of the apparatus body side stops at a rotation position of the home position (S35).

[0148] The rotational speed or a decelerating speed of the drive coupling 87 before the rotation stop is preferably small so as to stop the drive coupling 87 at a home position without any positional error. However, if the rotational speed or the decelerating speed is too slow, it takes too long before the drive coupling 87 stops. Accordingly, the drive coupling 87 is preferably stopped at the home position at the proper rotational speed or decelerating speed.

[0149] The rotational speed or the decelerated speed at the home position is at least less than the rotational speed or the decelerating speed when the drive coupling 87 stops in the mode other than the toner ejection mode. To reduce the rotational speed or the decelerating speed, the rotation speed of the developing motor M4 is reduced before or after the completion of toner ejection mode. The deceleration control is performed by the controller 110.

[0150] With the above control, the drive coupling 87 rotates at a relatively low rotation speed in the developing motor home position stop control. As a result, the decelerating speed of the drive coupling 87 when stop rotating is reduced, so that the rotation stop position or the home position does not vary so much. Thus, even when the developer unit as a driven member is replaced, possibility of abutting of the engagement parts of the couplings drastically reduces.

<Home position stop control of the developing motor>

[0151] FIG. 11 is a flowchart of rotation stop position control of the drive coupling 87 via the developing motor M4 in the toner ejection mode.

[0152] In the toner ejection mode, when the 5St developing motor M4 is driven, the home position stop control of the 5St developing motor M4 is started (in Step S41).

[0153] In the toner ejection mode, there is a greater possibility that the developer unit 50 is replaced with another developer unit 50. By contrast, in a mode other than the toner ejection mode, although the developer unit 50 is once removed, there is a stronger possibility that the same developer unit 50 is reattached.

[0154] Then, in the toner ejection mode, only when the developer unit 50 is detached, the drive coupling 87 stops rotating at the home position. When the developer coupling 87 stops at the home position, it takes time. The standby time in a mode other than the toner ejection mode can be reduced by the following method.

[0155] In a mode other than the toner ejection mode (or the non-toner ejection mode), the developer unit 50 once removed is again reattached in many cases. The once-removed developer unit 50 retains the same phase as that of the rotation position of the driving axis of the side of the apparatus body, so that, even though reattached without the home position stop control, the couplings do not interfere with respect to the axial direction.

[0156] Accordingly, in the non-toner ejection mode, the developing motor is swiftly stopped at an arbitrary rotation stop position, and the developer unit is reattached. With this control, the developer unit is smoothly reattached in short order and engaged via each coupling without any damage or failure of the couplings.

[0157] As described above, after starting the home position stop control of the 5St developing motor M4 in Step S41, it is determined whether two seconds have elapsed in S42. The time to start measuring these two seconds is when a predetermined part in the circumferential direction of the drive coupling 87 passes a predetermined position of the side of the apparatus body 99.

[0158] This time can be detected by the feeler 101 and the optical sensor 102. The drive coupling 87 rotates and reaches a predetermined home position in two seconds. If it is determined that two seconds have elapsed, in Step S43, it is determined whether the optical sensor 102 that detects the home position of the 5St drive coupling 87 detects "absence" of the feeler 101 and then, "presence" of the feeler 101.

[0159] The detection of the arrival at the home position may be performed by measuring a rotation speed of the developing motor M4 instead of measuring the time period of 2 seconds. Further, when the drive coupling 87 is driven by a stepping motor, the drive coupling 87 is configured to stop at a predetermined number of steps (for example, ten steps) after the optical sensor 102 detects "presence" of the feeler 101 after having detected "absence" of the feeler 101. With the above control, the drive coupling 87 can stop at the home position more precisely.

[0160] When it is detected that the feeler 101 is present, it is determined that the home position is detected successfully (S46). Then, the 5St developing motor M4 is controlled to be turned off (S47).

[0161] In Step S43, if it is detected that the feeler is absent, it is detected whether or not three seconds have elapsed (S44). If three seconds elapsed (Yes in S44), it is determined that the home position detection is failed (S45). Thereafter, the 5St developing motor M4 is controlled to be turned off (S47).

[0162] In the toner ejection mode of the toner supply mechanism 80, toner is discharged to the developer unit and reused, so that the toner discharged in the replacement operation is not wasted and the toner can be recycled.

[0163] The present invention is not limited to the embodiments described heretofore, and can be applied to other embodiments by modification in various forms. For example, the driven member is defined as the special color developer unit in the present embodiment; however, the driven member may be other developer unit for any color other than the special color. For example, the present exemplary embodiment can be applied to each of the Y, C, M, and Bk developer units detachably attachable to the apparatus body, or alternatively, to the toner container detachably attachable to the apparatus body.

[0164] In addition, the developer unit as a driven member is configured to detachably attachable to the apparatus body of the image forming apparatus in the axial direction of the developer unit; however, the driven member or the developer unit can be configured to detachably attachable to the apparatus body in the orthogonal direction relative to the axial direction. In either case, the controller controls the drive coupling to the side of the apparatus body to stop rotating at a predetermined rotation stop position or the home position, attachment/detachment of the couplings between the drive side and the driven side can be optimally performed even in the replacement of the driven member.

Claims

1. An electrophotographic image forming apparatus (100), comprising:

an apparatus body (99);
a drive coupling (87) disposed in the apparatus body (99) of the image forming apparatus (100);
a drive unit (M4) to rotate the drive coupling (87);
a controller (110) to control the drive unit (M4);
at least one driven member (50);
a developer unit (50) detachably attachable to the apparatus body (99) of the image forming apparatus (100);
a driven coupling (88) connected to the driven member (50); and

a toner supply unit (80) to supply toner or developer to the developer unit (50), wherein:

when the developer unit (50) is attached to the apparatus body (99) of the image forming apparatus (100), the driven coupling (88) engages the drive coupling (87) and the driven member (50) is driven by the drive unit (M4);
the image forming apparatus (100) includes a toner ejection mode to discharge the toner contained inside the toner supply unit (80);
the controller (110) controls the drive unit (M4) to cause the drive coupling (87) to stop at a predetermined rotation stop position in the toner ejection mode; and
in a mode other than the toner ejection mode, the controller (110) controls the drive unit (M4) to cause the drive coupling (87) to stop at a predetermined rotation stop position immediately when the drive coupling (87) is rotating.

2. The image forming apparatus (100) as claimed in claim 1, wherein, in the toner ejection mode, the controller (110) reduces a speed of the drive coupling (87) to stop at the predetermined rotation stop position below a speed of the drive unit (M4) to stop in a mode other than the toner ejection mode.

3. The image forming apparatus (100) as claimed in claim 1, wherein a direction of detachment of the developer unit (50) from the apparatus body (99) of the image forming apparatus (100) is along an axial direction of a rotary shaft (83Y, 84Y) of the driven member (50).

4. The image forming apparatus (100) as claimed in claim 1, wherein a direction of detachment of the developer unit (50) from the apparatus body (99) of the image forming apparatus (100) is orthogonal to an axial direction of a rotary shaft (83Y, 84Y) of the driven member (50).

5. The image forming apparatus (100) as claimed in claim 1, further comprising a toner conveyance screw (53Y, 54Y) in the developer unit (50),
wherein the driven coupling (88) is connected to the toner conveyance screw.

6. The image forming apparatus (100) as claimed in claim 5, wherein the developer unit (50) is a special developer unit (50S) for white toner or transparent toner.

7. The image forming apparatus (100) as claimed in claim 6, comprising at least five image forming units (60) each comprising an image carrier (20) and a developer unit (50).

FIG. 1

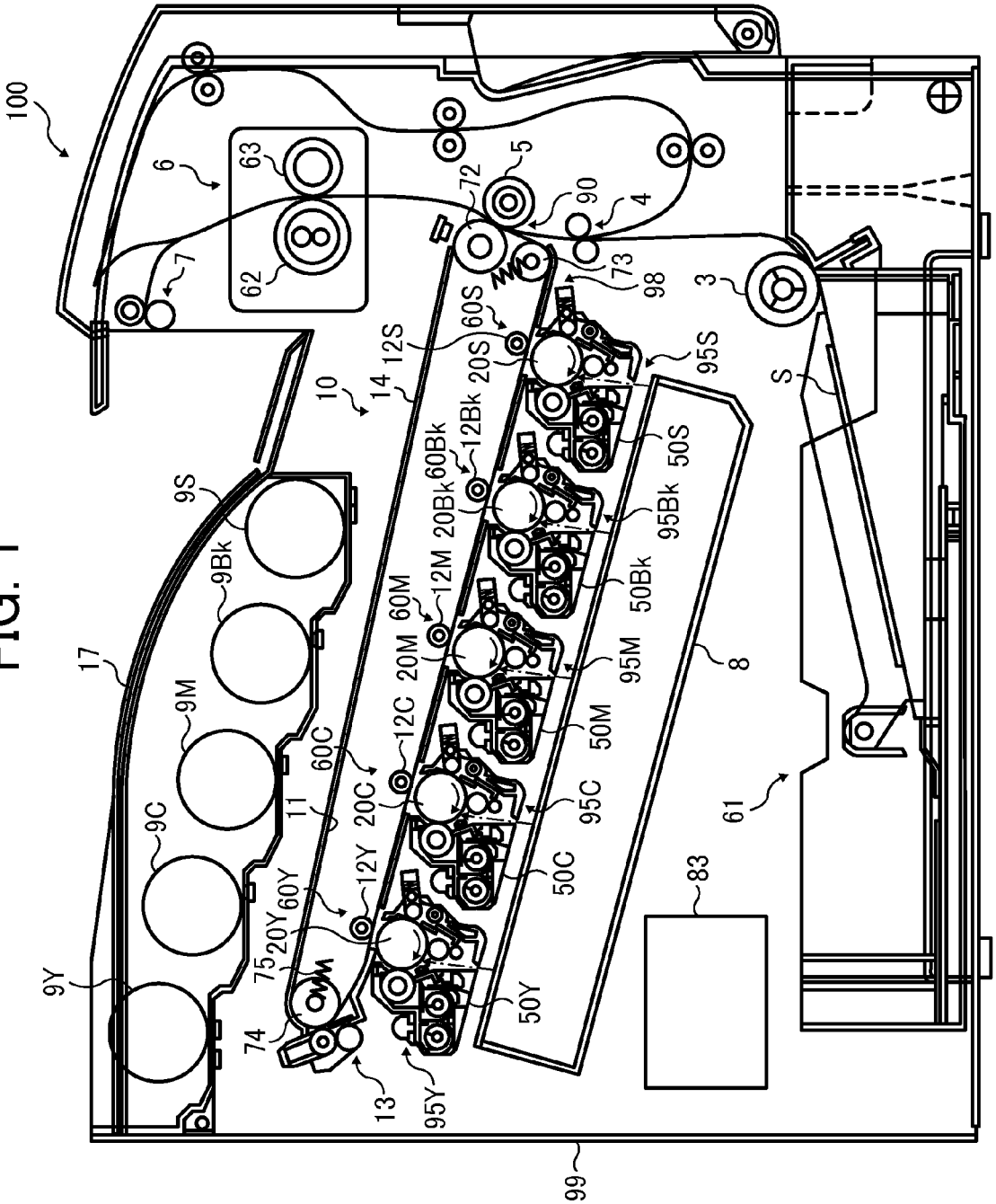

100
6
63
62
7
5
72
90
4
73
98
3
S
60S
12S
20S
95S
14
10
12Bk
60Bk
20Bk
50S
95Bk
50Bk
9S
9Bk
12M
60M
20M
95M
50M
8
17
9M
12C
60C
20C
95C
50C
11
61
9C
12Y
60Y
20Y
75
50Y
83
9Y
74
13
95Y
99

FIG. 2

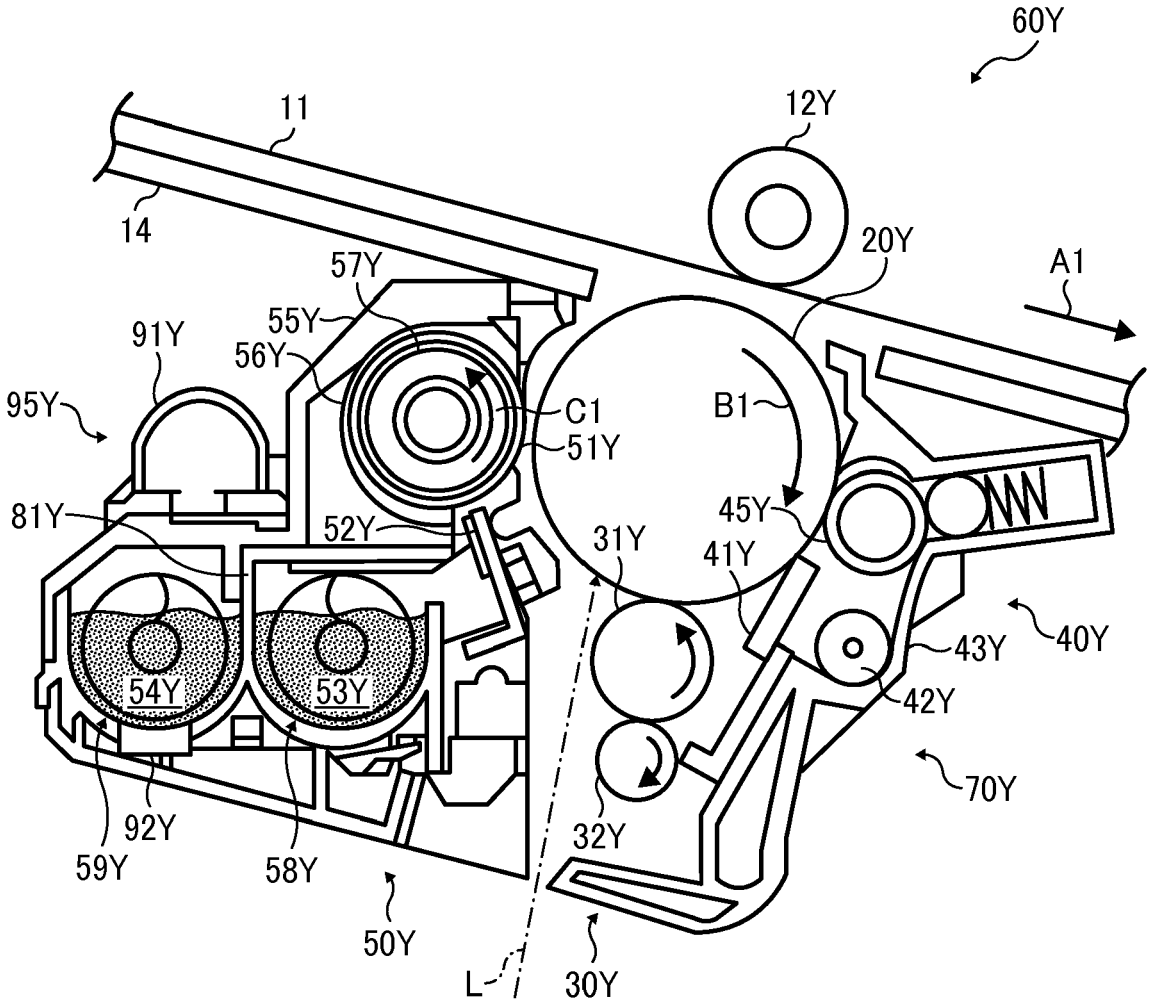

60Y
11
12Y
14
20Y
A1
57Y
55Y
91Y
56Y
95Y
C1
B1
51Y
81Y
52Y
45Y
31Y
41Y
54Y
53Y
43Y
40Y
42Y
70Y
92Y
32Y
59Y
58Y
50Y
L
30Y

FIG. 3A

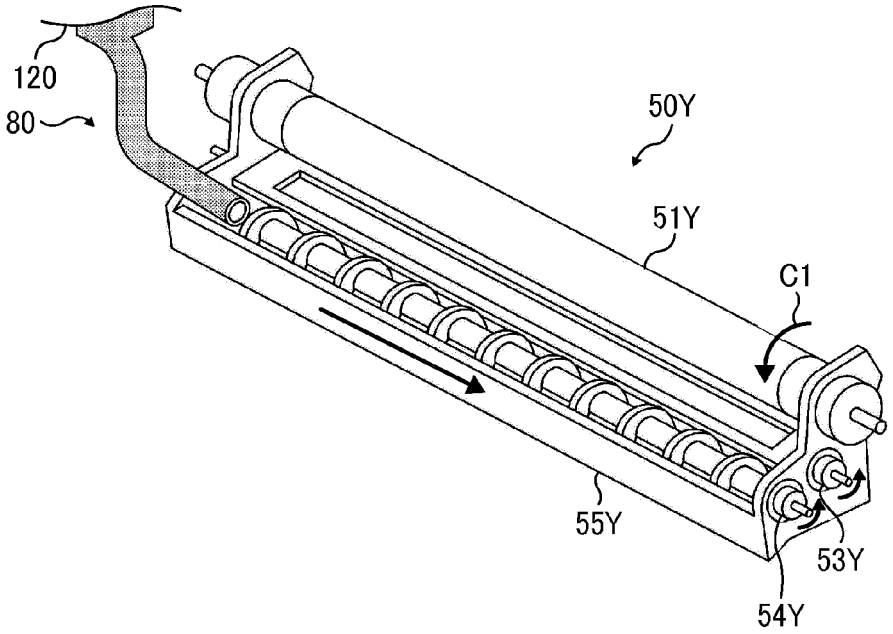

120
80
50Y
51Y
C1
55Y
53Y
54Y

FIG. 3B

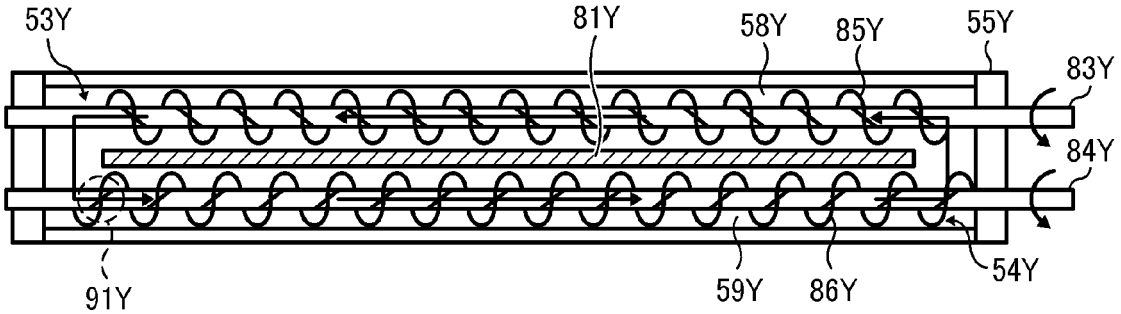

53Y
81Y
58Y
85Y
55Y
83Y
84Y
91Y
59Y
86Y
54Y

FIG. 3C

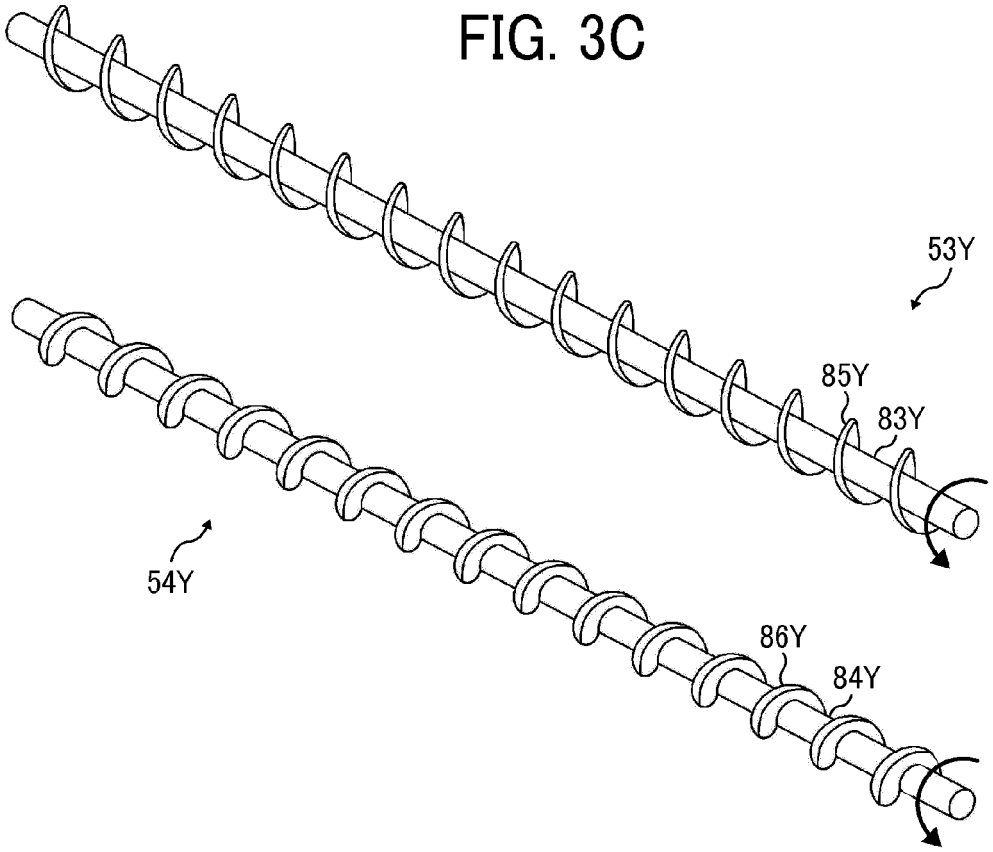


FIG. 4A

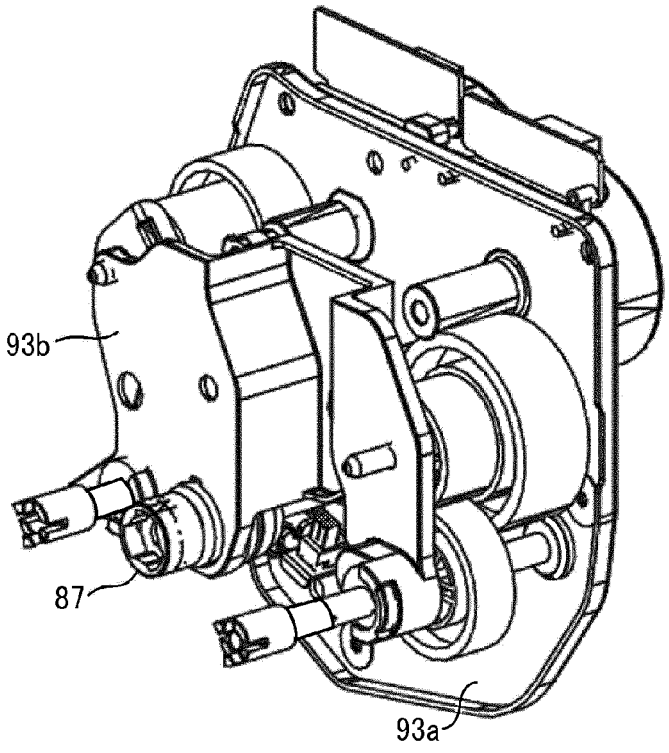


FIG. 4B

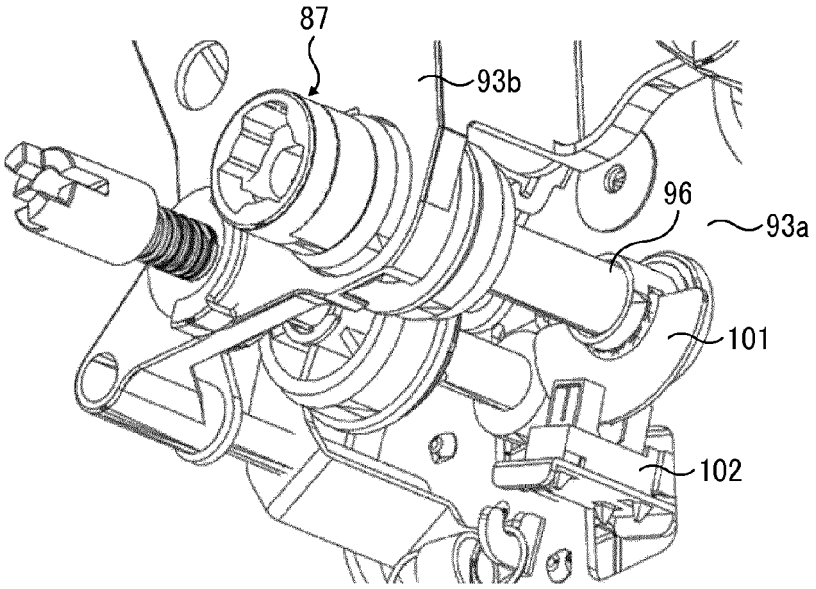


FIG. 4C

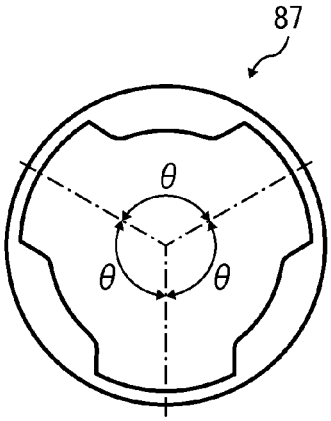


FIG. 4D

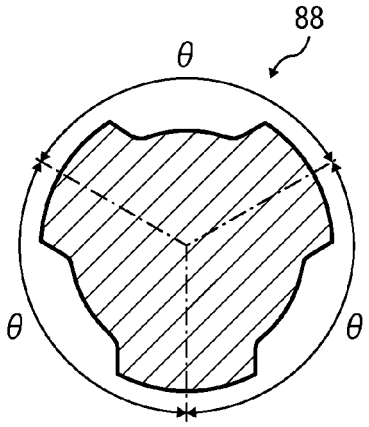


FIG. 5

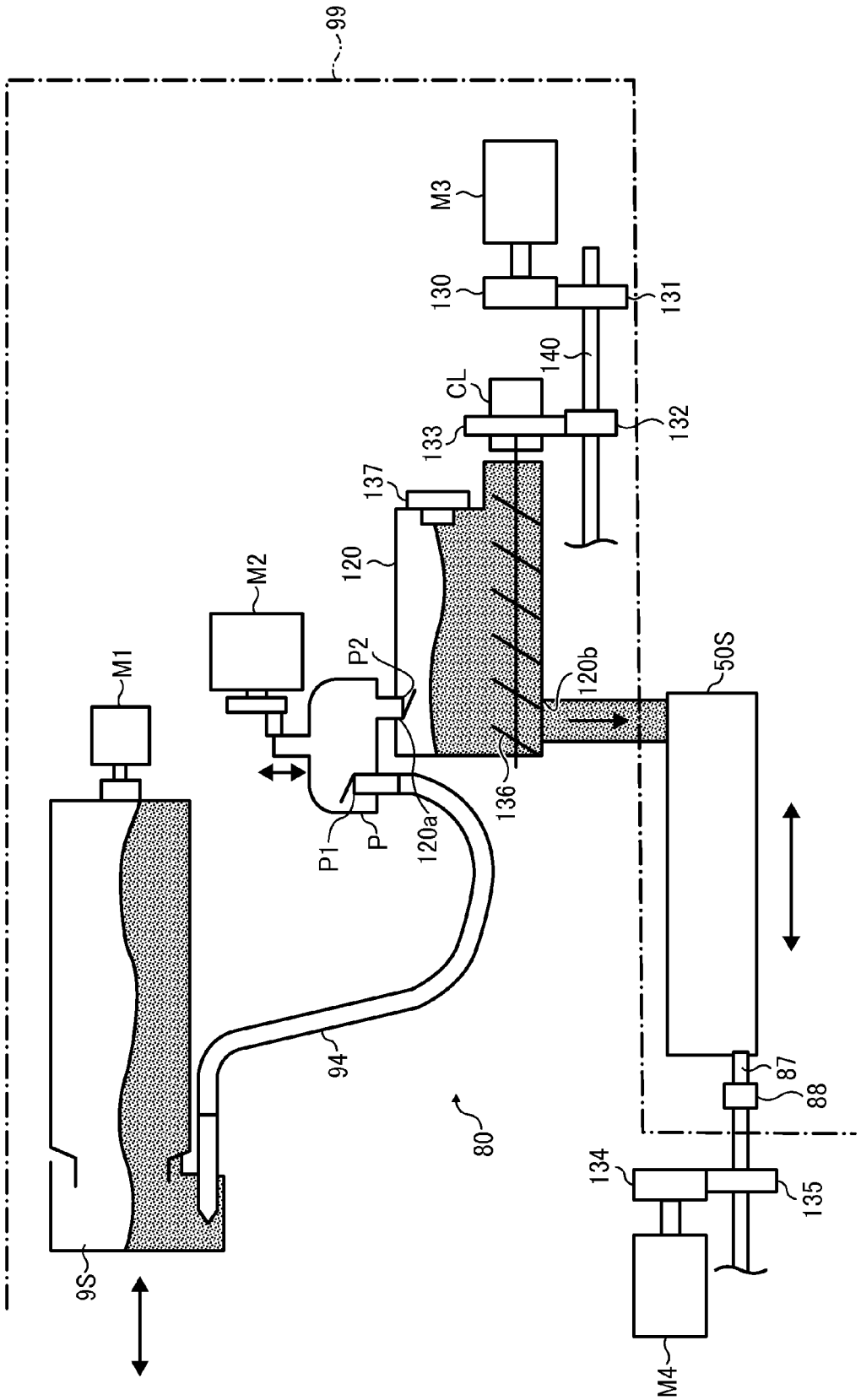

99
M3
130
131
140
CL
133
132
137
120
M2
P2
M1
120b
50S
136
P1
P
120a
94
80
87
88
134
135
9S
M4

FIG. 6

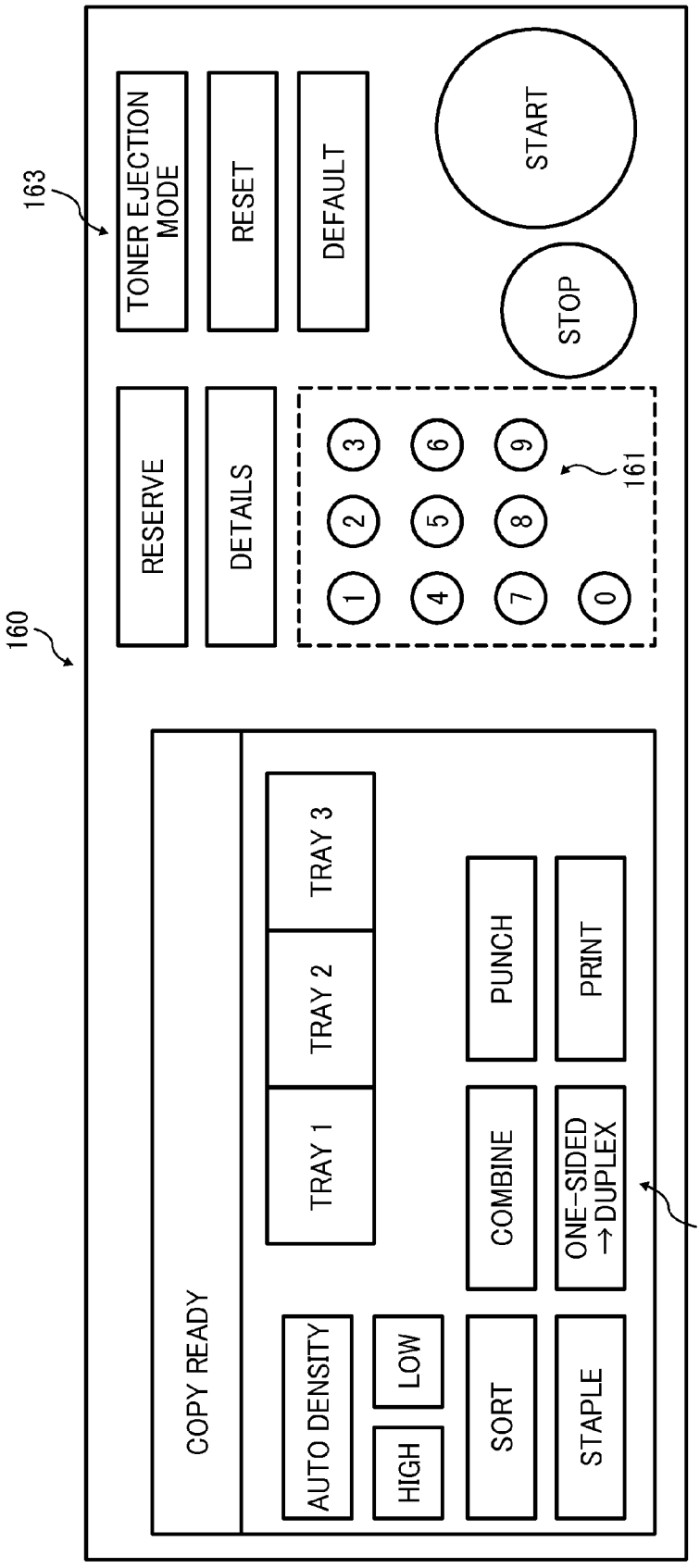

160
163
TONER EJECTION MODE
RESET
DEFAULT
START
STOP
RESERVE
DETAILS
1
2
3
4
5
6
7
8
9
0
161
COPY READY
AUTO DENSITY
HIGH
LOW
TRAY 1
TRAY 2
TRAY 3
SORT
COMBINE
PUNCH
STAPLE
ONE-SIDED →DUPLEX
PRINT
162

FIG. 7

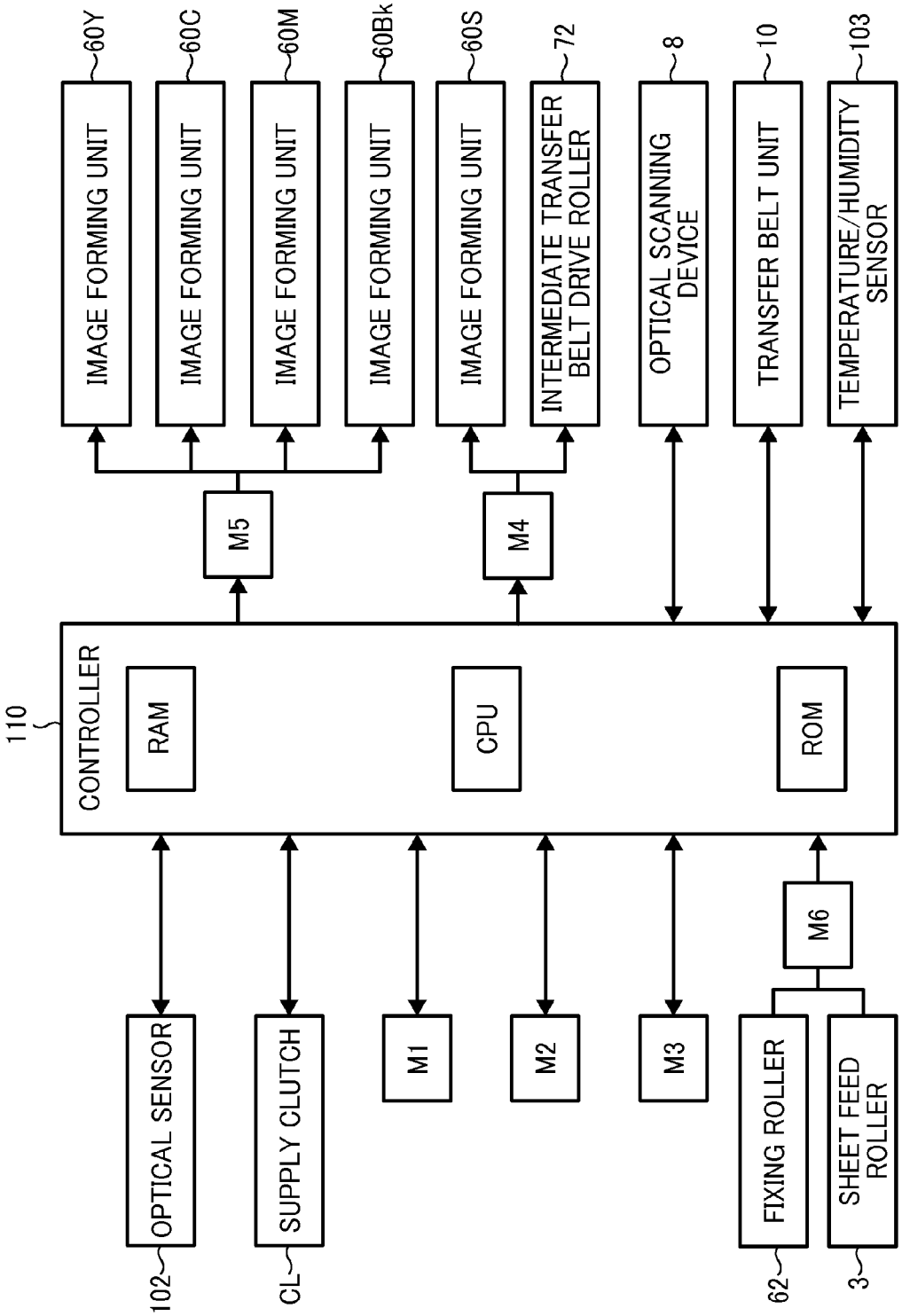

110
CONTROLLER
RAM
CPU
ROM
60Y
60C
60M
60Bk
60S
72
8
10
103
IMAGE FORMING UNIT
IMAGE FORMING UNIT
IMAGE FORMING UNIT
IMAGE FORMING UNIT
IMAGE FORMING UNIT
INTERMEDIATE TRANSFER BELT DRIVE ROLLER
OPTICAL SCANNING DEVICE
TRANSFER BELT UNIT
TEMPERATURE/HUMIDITY SENSOR
M5
M4
M6
M1
M2
M3
OPTICAL SENSOR
SUPPLY CLUTCH
FIXING ROLLER
SHEET FEED ROLLER
102
CL
62
3

FIG. 8

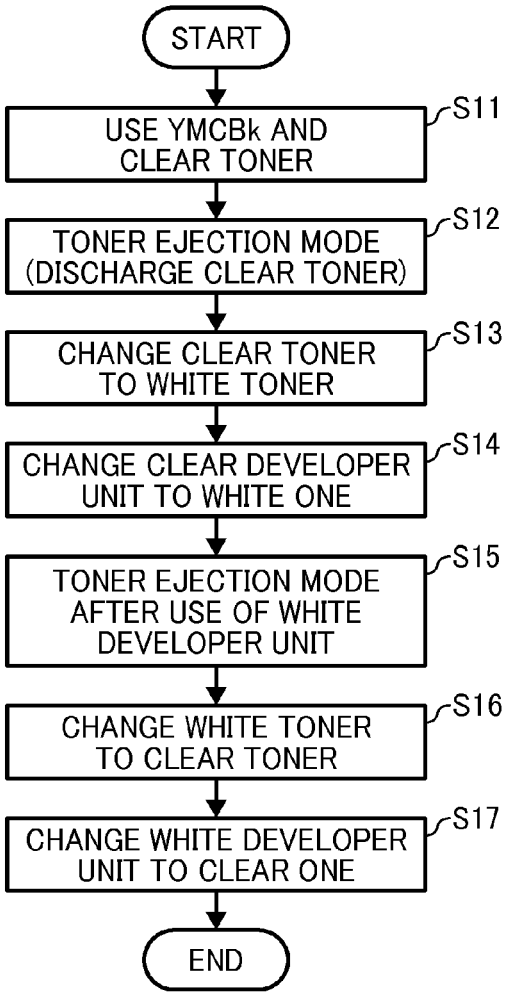

START
USE YMCBk AND CLEAR TONER
S11
TONER EJECTION MODE (DISCHARGE CLEAR TONER)
S12
CHANGE CLEAR TONER TO WHITE TONER
S13
CHANGE CLEAR DEVELOPER UNIT TO WHITE ONE
S14
TONER EJECTION MODE AFTER USE OF WHITE DEVELOPER UNIT
S15
CHANGE WHITE TONER TO CLEAR TONER
S16
CHANGE WHITE DEVELOPER UNIT TO CLEAR ONE
S17
END

FIG. 9

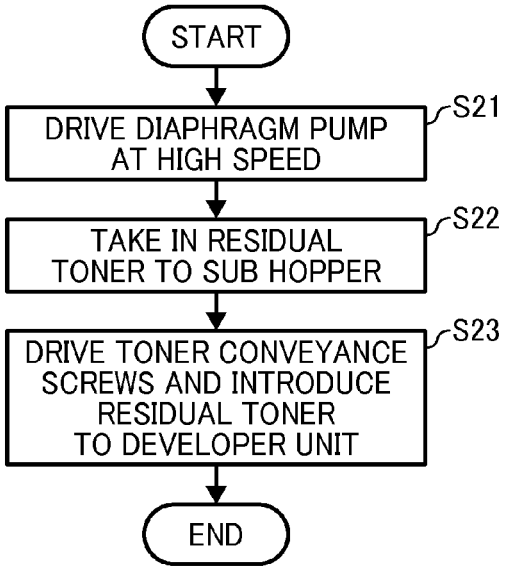

START
DRIVE DIAPHRAGM PUMP AT HIGH SPEED
S21
TAKE IN RESIDUAL TONER TO SUB HOPPER
S22
DRIVE TONER CONVEYANCE SCREWS AND INTRODUCE RESIDUAL TONER TO DEVELOPER UNIT
S23
END

FIG. 10

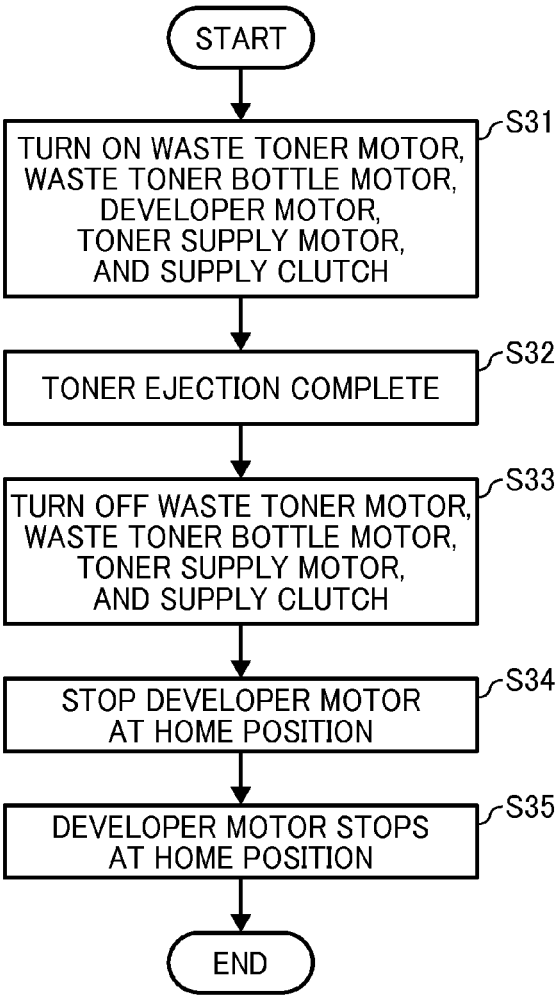
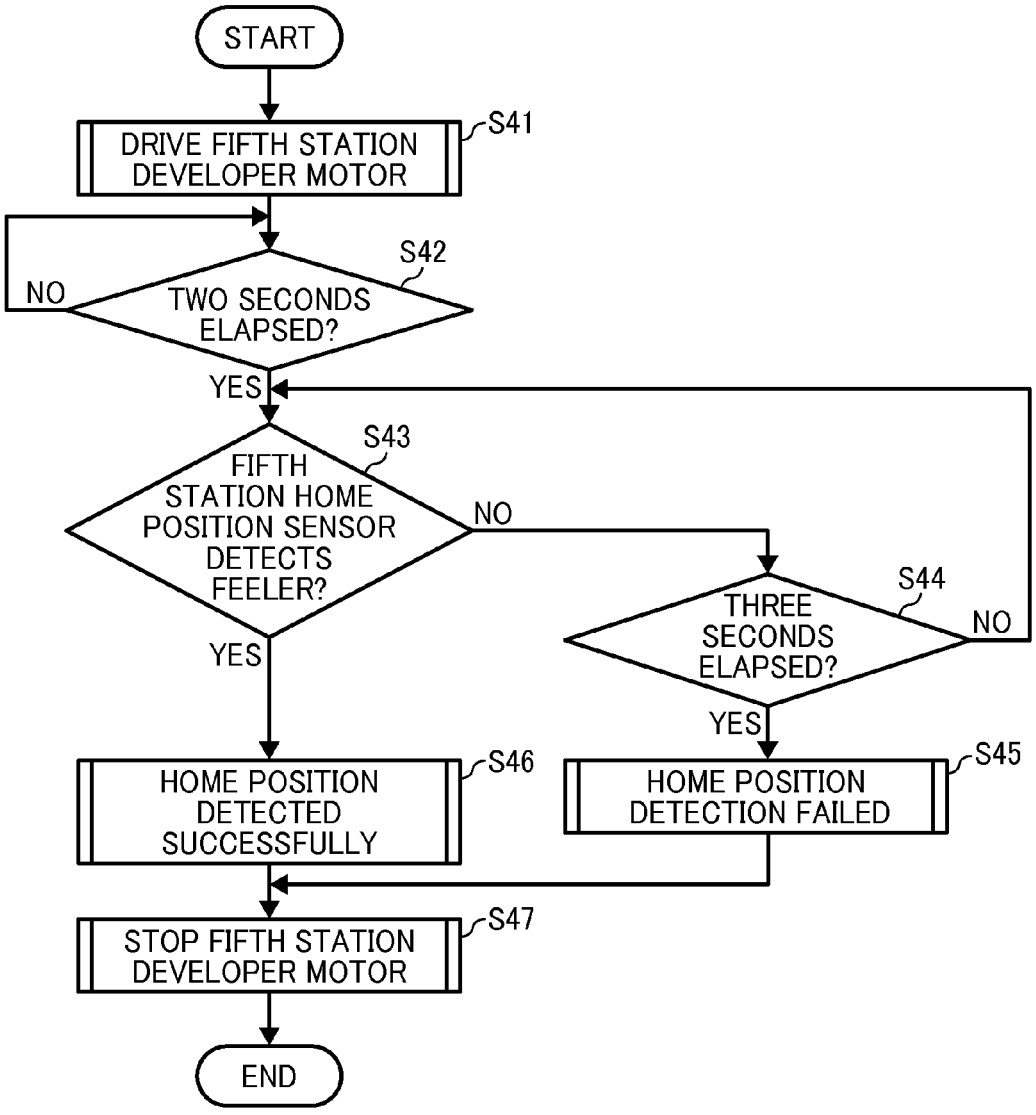

START
TURN ON WASTE TONER MOTOR, WASTE TONER BOTTLE MOTOR, DEVELOPER MOTOR, TONER SUPPLY MOTOR, AND SUPPLY CLUTCH
S31
TONER EJECTION COMPLETE
S32
TURN OFF WASTE TONER MOTOR, WASTE TONER BOTTLE MOTOR, TONER SUPPLY MOTOR, AND SUPPLY CLUTCH
S33
STOP DEVELOPER MOTOR AT HOME POSITION
S34
DEVELOPER MOTOR STOPS AT HOME POSITION
S35
END

FIG. 11


START
DRIVE FIFTH STATION DEVELOPER MOTOR
S41
S42
NO
TWO SECONDS ELAPSED?
YES
S43
FIFTH STATION HOME POSITION SENSOR DETECTS FEELER?
NO
YES
S44
THREE SECONDS ELAPSED?
NO
YES
HOME POSITION DETECTED SUCCESSFULLY
S46
HOME POSITION DETECTION FAILED
S45
STOP FIFTH STATION DEVELOPER MOTOR
S47
END

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EUROPEAN SEARCH REPORT

Application Number
EP 15 15 5801

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	15 July 2015	Scarpa, Giuseppe

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