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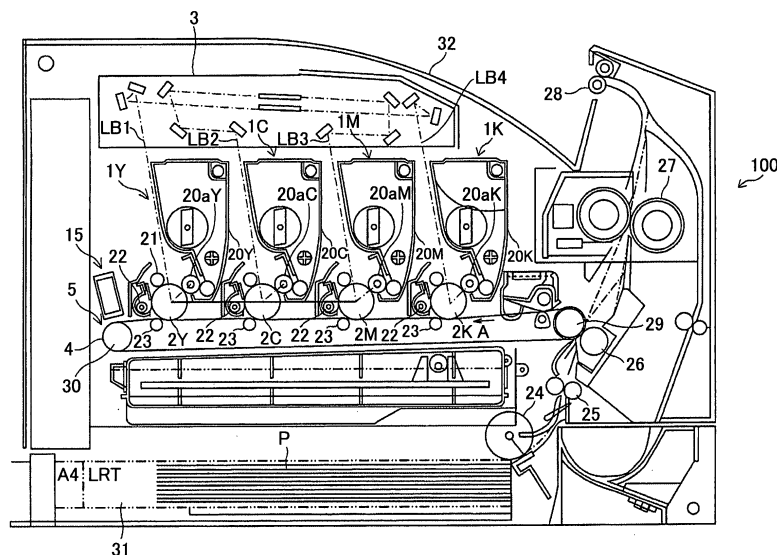
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(57) Time T_i since an immediately preceding rotational reference position 16a1 is calculated by a timer in accordance with a detection signal at a rotational reference position 16a1, and then it is stored. When a black photosensitive drum 2K is stopped in a monochrome

mode using the stored time T_i , the phase of the black photosensitive drum 2K is matched with the phases of the photosensitive drums 2Y, 2C, and 2M whose rotations are stopped in a color mode, thereby making it possible to prevent positional shifts between color toner images and a black toner image.

FIG.1

Description

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

2. Description of the Related Art

[0002] As image forming apparatuses configured to be electronic copying machines, printers, facsimile machines, or multifunction machines having at least two functions thereof, widely used are so-called tandem type color image forming apparatuses in which plural photosensitive drums are arranged side by side. Such a color image forming apparatus is configured to be capable of selecting not only a color mode in which different colors of toner images are formed on the front cylindrical surfaces of the plural photosensitive drums for color and then transferred to a transfer member in a superposed manner, but also a monochrome mode in which a black toner image is formed only on a photosensitive drum for black and then transferred to a transfer member.

[0003] In this case, gears for color and a gear for black are concentrically coupled with the color photosensitive drums and the black photosensitive drum, respectively. When these gears are rotated and driven, the respective photosensitive drums are rotated. At this time, due to the eccentricities of the color gears and the black gear, rotational irregularities occur in the color photosensitive drums and the black photosensitive drum, which may cause color shifts in the superposed toner images transferred to the transfer member. Therefore, in order to prevent the occurrence of the color shifts in the superposed toner images transferred to the transfer member, the color gears and the black gear are configured to be rotated with their predetermined phase relationships maintained. However, in the monochrome mode in which the black photosensitive drum is rotated and driven together with the black gear so as to form the black toner image on the black photosensitive drum, the color gears and the color photosensitive drums remain stopped. As a result, the above predetermined phase relationships are disrupted, which may cause the color shifts at the time of forming images in a subsequent color mode.

[0004] In order to solve this problem, Patent Document 1 proposes an image forming apparatus that has a driving motor for rotating and driving the black gear and a driving motor for rotating and driving the color gears. The image forming apparatus causes the black gear to stop at a position where the above predetermined phase relationships are obtained when the monochrome mode is terminated.

Patent Document 1: JP-B2-3496566

[0005] However, according to the image forming apparatus disclosed in Patent Document 1, the turning path of an endless transfer belt is changed in accordance with the color mode and the monochrome mode. In the monochrome mode, the transfer belt is separated from the color photosensitive drums so as to come into sliding

contact only with the black photosensitive drum. In the color mode, on the other hand, it comes into sliding contact not only with the black photosensitive drum but also with the color photosensitive drums. Therefore, it is necessary to change the turning path of the transfer belt in accordance with the change of the modes, which may cause fluctuations in the transfer speed of the transfer belt with ease and the color shifts.

[0006] The present invention has been made in view of the above circumstances and may provide an image forming apparatus capable of reliably reducing the occurrence of phase shifts in a short period of time and with a simple configuration even if a printing mode is switched between a color mode and a monochrome mode.

[0007] According to an aspect of the present invention, there is provided an image forming apparatus that has plural photosensitive drums for color on which chromatic toner images are to be formed, a photosensitive drum for black on which a black toner image is to be formed, gears for color that are arranged concentrically to the photosensitive drums for color and coupled with the photosensitive drums for color so as to be rotated together with the photosensitive drums for color, and a gear for black that is arranged concentrically to the photosensitive drum for black and coupled with the photosensitive drum for black so as to be rotated together with the photosensitive drum for black, and that is configured to be capable of selecting a color mode in which different colors of the chromatic toner images are formed on the photosensitive drums for color rotated and driven together with the gears for color, the black toner image is formed on the photosensitive drum for black rotated and driven together with the gear for black, and the chromatic toner images and the black toner image are transferred to a transfer member in a superposed manner so as to obtain a color image, and a monochrome mode in which the black toner image is formed on the photosensitive drum for black rotated and driven together with the gear for black after the gears for color and the photosensitive drums for color are stopped and only the black toner image is transferred to the transfer member to obtain a black image, characterized in that the gears for color of the photosensitive drums for color are meshed with corresponding driving gears coupled with and driven by a driving source and rotated and are arranged to correspond to the driving gears so as to stop rotations of the photosensitive drums for color when the gears for color are in a non-meshed state after being separated from the driving gears, the image forming apparatus having contact/separation means that moves the gears for color so as to be in a meshed state or in the non-meshed state with respect to the corresponding driving gears, rotational position detection means that is provided in the photosensitive drum for black and detects a rotational position of the photosensitive drum for black, the rotational position detection means detecting and storing the rotation stop position of the photosensitive drum for black in the color mode, and a control unit that controls, in the monochrome mode,

the photosensitive drum for black to be stopped at the same position as the stored rotation stop position of the photosensitive drum for black in the color mode.

[0008] The driving source may be a driving motor by which the gears for color and the gear for black are driven and rotated.

[0009] The plural photosensitive drums for color may be linearly arranged in parallel, the contact/separation means may have a guiding surface on which are alternately arranged a convex surface that pushes up the gears for color of the photosensitive drums for color so as to be in the non-meshed state with respect to the driving gears and a concave surface on which the gears for color are pushed down so as to be in the meshed state with respect to the driving gears, and the image forming apparatus may further have driving means that moves the contact/separation means in an arrangement direction of the photosensitive drums for color, the driving means controlling the contact/separation means to be moved in the arrangement direction of the photosensitive drums so that the gears for color are pushed up by the convex surface in the monochrome mode and separated from the driving gears so as to be in the non-meshed state and controlling the contact/separation means to be moved in the arrangement direction of the photosensitive drums so that the gears for color are pushed down to the concave surface in the color mode so as to be in the meshed state.

[0010] The driving gears corresponding to the gears for color and the driving source may be driven and coupled by plural other coupling gears.

[0011] The photosensitive drums for color and the photosensitive drum for black may be linearly arranged in parallel, and the chromatic toner images and the black toner image formed on the photosensitive drums for color and the photosensitive drum for black, respectively, may be transferred to an endless belt that is arranged parallel to the arrangement direction of the photosensitive drums and endlessly moved in the arrangement direction.

[0012] The contact/separation means may be arranged so that the corresponding photosensitive drums for color are separated from the endless belt simultaneously with the separation of the gears for color of the photosensitive drums for color from the corresponding driving gears, making the separation direction of the gears for color from the driving gears match the separation direction of the photosensitive drums for color from the endless belt.

[0013] When the rotational cycle of the gears for color is represented as T and an angle between an exposure position and a transfer position of a toner image of the photosensitive drum is represented as α the number of teeth of the driving gears corresponding to the gears for color may be set so that the rotational cycle T_2 of the driving gears is expressed by $T_2 = T \times (\alpha/360)/N$ where N is an integer.

[0014] The gears for color may be molded by the same mold.

[0015] The photosensitive drums for color may have rotational position detection means that detects rotational positions of the photosensitive drums for color.

[0016] The photosensitive drums for color may be integrally coupled with corresponding development units, and the development units may be moved together with the photosensitive drums for color that are moved as the gears for color are separated from the driving gears.

[0017] The photosensitive drums for color may be removably attached to an image forming apparatus main body.

[0018] The removing direction of the photosensitive drums for color from the image forming apparatus main body and the separation direction of the gears for color from the driving gears for color may be matched with each other.

[0019] The photosensitive drums for color may have detection means that detects the removals of the photosensitive drums for color.

[0020] In the image forming apparatus according to an embodiment of the present invention, the gears for color of the photosensitive drums for color are meshed with corresponding driving gears coupled with and driven by a driving source and rotated and are arranged to correspond to the driving gears so as to stop rotations of the photosensitive drums for color when the gears for color are in a non-meshed state after being separated from the driving gears. The image forming apparatus has contact/separation means that moves the gears for color so as to be in a meshed state or in the non-meshed state with respect to the corresponding driving gears, rotational position detection means that is provided in the photosensitive drum for black and detects a rotational position of the photosensitive drum for black, the rotational position detection means detecting and storing the rotation stop position of the photosensitive drum for black in the color mode, and a control unit that controls, in the monochrome mode, the photosensitive drum for black to be stopped at the same position as the stored rotation stop position of the photosensitive drum for black in the color mode. Accordingly, it is possible to provide the image forming apparatus capable of reliably reducing the occurrence of phase shifts in a short period of time and with a simple configuration even if a printing mode is switched between a color mode and a monochrome mode.

[0021] Other objects, features and advantages of the present invention will become more apparent from the following detailed description when read in conjunction with the accompanying drawings.

FIG. 1 is a cross-sectional view showing a schematic configuration of an image forming apparatus according to an embodiment of the present invention;
FIG. 2 a schematic view showing a driving relationship between photosensitive drums used in the image forming apparatus according to the embodiment of the present invention;
FIG. 3 is a schematic view showing the exposure

position and the transfer position of the photosensitive drum used in the image forming apparatus according to the embodiment of the present invention; FIGS. 4A through 4D are schematic views showing a contact/separation mechanism of photosensitive drum gears and two-stage driving gears used in the image forming apparatus according to the embodiment of the present invention, wherein FIG. 4A is a view showing a separation state 1, FIG. 4B is a view showing a separation state 2, FIG. 4C is a view showing a separation state 3, and FIG. 4D is a view showing a separation state 4;

FIGS. 5A through 5C are views showing attachment states of a member to be detected that is used in the image forming apparatus according to the embodiment of the present invention, wherein FIG. 5A is a side view showing the attachment state of the member to be detected to the photosensitive drum, FIG. 5B is a plan view of the member to be detected, and FIG. 5C is a side view showing the attachment state of the member to be detected when the photosensitive drum is separated from an intermediate transfer belt;

FIG. 6 is a perspective view showing phase detection patterns formed on the intermediate transfer belt used in the image forming apparatus according to the embodiment of the present invention;

FIGS. 7A and 7B are views showing the member to be detected that is used in the image forming apparatus according to the embodiment of the present invention, wherein FIG. 7A is a plan view of the member to be detected and FIG. 7B is a side view thereof; FIG. 8 is a block diagram showing a schematic configuration of a control unit for phase matching control used in the image forming apparatus according to the embodiment of the present invention;

FIG. 9 is a flowchart showing a method of the phase matching control in a color mode and a monochrome mode used in the image forming apparatus according to the embodiment of the present invention;

FIG. 10 is a flowchart showing the method of the phase matching control for the photosensitive drums used in the image forming apparatus according to the embodiment of the present invention; and

FIG. 11 is a flowchart showing the method of the phase matching control at the time of replacing the photosensitive drums used in the image forming apparatus according to the embodiment of the present invention.

[0022] Referring to the accompanying drawings, a description is specifically made of an embodiment of the present invention.

[0023] FIG. 1 is a cross-sectional view showing a schematic configuration of an electrophotographic printer as an image forming apparatus according to the embodiment of the present invention. The printer according to this embodiment has process cartridges 1Y, 1C, 1M, and

1K and development units 20Y, 20C, 20M, and 20K corresponding to the colors of yellow (Y), cyan (C), magenta (M), and black (K) (hereinafter referred to as Y, C, M, and K), respectively. The process cartridges 1Y, 1C, 1M, and 1K have photosensitive drums 2Y, 2C, 2M, and 2K, respectively. Charging units 21 and cleaning units 22 are integrally attached to the peripheries of the photosensitive drums 2Y, 2C, 2M, and 2K. When the photosensitive drums 2Y, 2C, 2M, and 2K are removed from an apparatus main body 100, the charging units 21 and the cleaning units 22 attached to the photosensitive drums 2Y, 2C, 2M, and 2K are also removed together with the photosensitive drums 2Y, 2C, 2M, and 2K. The photosensitive drums 2Y, 2C, 2M, and 2K of the process cartridges 1Y, 1C, 1M, and 1K are linearly arranged in parallel on an endless intermediate transfer belt 4 stretched between a driving roller 29 and a driven roller 30 along the moving direction (as indicated by arrow A) of the endless intermediate transfer belt 4. The respective colors of toner images formed on the photosensitive drums 2Y, 2C, 2M, and 2K are transferred to the intermediate transfer belt 4 by primary transfer rollers 23.

[0024] The development units 20Y, 20C, 20M, and 20K accommodate the toner of yellow, cyan, magenta, and black, respectively, and supply the respective colors of toner to the front cylindrical surfaces of the photosensitive drums 2Y, 2C, 2M, and 2K through development rollers 20aY, 20aC, 20aM, and 20aK arranged separated from the peripheries of the photosensitive drums 2Y, 2C, 2M, and 2K with a predetermined interval. As described below, the development rollers 20aY, 20aC, 20aM, and 20aK are moved up and down with the predetermined interval as the photosensitive drums 2Y, 2C, 2M, and 2K are moved up and down.

[0025] An optical scanning unit 3 optically scans the front surfaces of the photosensitive drums 2Y, 2C, 2M, and 2K of the process cartridges 1Y, 1C, 1M, and 1K with laser beams LB1, LB2, LB3, and LB4 emitted based on the control signal of an optical writing circuit. With this optical scanning, electrostatic latent images for Y, C, M, and K are formed on the photosensitive drums 2Y, 2C, 2M, and 2K uniformly charged with the charging units 21. Note that, in the optical scanning unit 3, the laser beams emitted from a laser oscillator are applied to photosensitive bodies through plural optical lenses and mirrors while being deflected with a polygon mirror rotated and driven by a motor.

[0026] Below the process cartridges 1Y, 1C, 1M, and 1K in FIG. 1 is arranged a transfer unit 5 that moves the intermediate transfer belt 4 as a transfer body while stretching the same. In addition to the intermediate transfer belt 4, the transfer unit 5 as transfer means has, for example, a cleaning unit (not shown) that cleans the toner remaining after toner images transferred to the intermediate transfer belt 4 are transferred to a transfer member P by a secondary transfer roller 26. During a process in which the intermediate transfer belt 4 passes through primary transfer rollers 23 for Y, C, M, and K one by one,

the toner images of Y, C, M, and K on the photosensitive drums 2Y, 2C, 2M, and 2K are transferred to the intermediate transfer belt 4 in a superposed manner. Accordingly, a superposed toner image with four colors of toner (hereinafter referred to as a four-color toner image) is formed on the intermediate transfer belt 4. Note that pattern detection means 15 is arranged that detects a speed fluctuation detection pattern of the toner image on the intermediate transfer belt 4 after the toner image of Y is transferred from the photosensitive drum 2Y by the primary transfer roller 23.

[0027] The four-color toner image formed on the intermediate transfer belt 4 is transferred to the transfer member P such as a transfer sheet, which is separately ejected from a sheet accommodation cassette 31 by a feed roller 24 and fed in accordance with adjusted timing by a resist roller 25, by the secondary transfer roller 26. The toner image transferred onto the transfer member P is heated and pressed by a fixing unit 27 so as to be fixed and then ejected onto a sheet receiving tray 32 by a sheet ejection roller 28.

[0028] According to the printer of this embodiment, it is possible to select either a color mode in which the four-color toner image of Y, C, M, and K is formed on the transfer member P or a monochrome mode in which the toner image of black is formed on the transfer member P. When an operator selects either mode through the panel (not shown) of the apparatus main body 100, an image corresponding to the modes is formed on the transfer member P.

[0029] FIG. 2 shows an example of a driving mechanism consisting of gears from a motor gear 6 attached to a driving motor as a driving source to photosensitive drum gears 10Y, 10C, 10M, and 10K attached to the photosensitive drums 2Y, 2C, 2M, and 2K, respectively. The motor gear 6 is meshed with coupling gears 7a and 7c and coupled therewith. The coupling gear 7a is meshed with a coupling gear 7b and coupled therewith, and the coupling gear 7c is meshed with a coupling gear 7d and coupled therewith. Moreover, the coupling gear 7b is meshed with large diameter gears 8a3 and 8a4 of two-stage driving gears 8K and 8M, and the coupling gear 7d is meshed with large diameter gears 8a2 and 8a1 of two-stage driving gears 8C and 8Y. Thus, the torque of the motor gear 6 is transmitted to the two-stage driving gears 8Y, 8C, 8M, and 8K, so that small diameter gears 8b1, 8b2, 8b3, and 8b4 concentrically coupled with the large diameter gears 8a1, 8a2, 8a3, and 8a4 of the two-stage driving gears 8Y, 8C, 8M, and 8K are rotated and driven. Then, the photosensitive drum gears 10Y, 10C, 10M, and 10K are meshed with the small diameter gears 8b1, 8b2, 8b3, 8b4 of the two-stage driving gears 8Y, 8C, 8M, 8K, respectively, so as to be rotated and driven. The photosensitive drum gears 10Y, 10C, 10M, and 10K are concentrically attached to the photosensitive drums 2Y, 2C, 2M, and 2K, respectively. As described below, the photosensitive drum gears 10Y, 10C, and 10M of the photosensitive drums 2Y, 2C, and 2M are arranged so as to

be movable up and down in the direction as indicated by arrow B when they are meshed with or separated from the small diameter gears 8b1, 8b2, and 8b3 of the two-stage driving gears 8Y, 8C, and 8M by a contact/separation member 12 (contact/separation means) (see FIG. 4B).

[0030] Here, in order to prevent the occurrence of color shifts due to speed fluctuations resulting from the eccentricities of the two-stage driving gears 8Y, 8C, 8M, and 8K, the coupling gears 7a, 7b, 7c, and 7d, and the motor gear 6 arranged upstream of the photosensitive drum gears 10Y, 10C, 10M, and 10K, the following relationship has to be maintained.

[0031] As described above, light is irradiated from the optical scanning unit 3 of the image forming apparatus to expose the photosensitive drums 2Y, 2C, 2M, and 2K, so that electrostatic latent images corresponding to respective colors are formed on the photosensitive drums 2Y, 2C, 2M, and 2K. Then, toner adheres to the electrostatic latent images so as to form the respective color toner images on the photosensitive drums 2Y, 2C, 2M, and 2K. The toner images are transferred from the photosensitive drums 2Y, 2C, 2M, and 2K to the intermediate transfer belt 4. As shown in FIG. 3, when the rotational angular speeds of the photosensitive drums 2Y, 2C, 2M, and 2K at the exposure position A and the transfer position B of a photosensitive drum 2 are the same, the image on the intermediate transfer belt 4 is not influenced even if speed fluctuations occur between the exposure and the transfer. This is a phenomenon caused when an image expanding and contracting at the time of the exposure contracts and expands at the time of the transfer and is well-known in the art. In order to match the rotational angles of the photosensitive drums 2 with each other at the time of the exposure and the transfer, the speed fluctuation having a cycle $1/m$ times (where m is an integer) the cycle between the exposure and the transfer is provided. Accordingly, a speed difference between the exposure and the transfer does not occur. Therefore, in order to prevent the occurrence of the speed difference between the exposure and the transfer, a gear ratio is only required to be set so that the cycle per rotation of the gears arranged upstream of the photosensitive drum gears 10Y, 10C, 10M, and 10K is $1/m$ times (where m is an integer) the cycle between the exposure and the transfer of the photosensitive drum. For example, it is set as follows.

[0032] When the number of gear teeth of the photosensitive drum gears 10Y, 10C, 10M, and 10K is represented as "Za," the rotational cycle is represented as "T," and the angle between the exposure position A and the transfer position B of the photosensitive drum 2 is represented as " α ," the time T1 for the photosensitive drum 2 to move from the exposure position A to the transfer position B is expressed by $T1 = T \times (\alpha/360)$.

[0033] On the other hand, the number of gear teeth "Za2" of the small diameter gears 8b1, 8b2, 8b3, and 8b4 of the two-stage driving gears 8Y, 8C, 8M, and 8K is

expressed by $Za2 = Za \times (\alpha/360)$, and the rotational cycle "T2" thereof is expressed by $T2 = T1/N$. When the number of gear teeth of the large diameter gears 8a1, 8a2, 8a3, and 8a4 is represented as "Zb1," the number of gear teeth "Za3" of the coupling gears 7a, 7b, 7c, and 7d is expressed by $Za3 = Zb1/N$, and the rotational cycle "T3" thereof is expressed by $T3 = T1/N$. Furthermore, the number of gear teeth "Za4" of the motor gear 6 is expressed by $Za4 = Zb1/N$, and the rotational cycle "T4" thereof is expressed by $T4 = T1/N$ (where N is an integer).

[0034] As described above, when the number of gear teeth of the photosensitive drum gears 10Y, 10C, 10M, and 10K is represented as "Za," the rotational cycle thereof is represented as "T," and the angle between the exposure position A and the transfer position B of the photosensitive drum 2 is represented as " α ," the number of gear teeth of the two-stage driving gears 8Y, 8C, 8M, and 8K and that of the motor gear 6 are set so that the rotational cycle T2 of the two-stage driving gears 8Y, 8C, 8M, and 8K can be expressed by $T2 = T \times (\alpha/360)/N$. Accordingly, it is possible to prevent the occurrence of color shifts of images due to the speed fluctuations of the coupling gears 7a, 7b, 7c, and 7d and that of the motor gear 6 arranged upstream of the photosensitive drum gears 10Y, 10C, 10M, and 10K. In this case, when the waveforms of the fluctuations are largely different even if the phases of the speed fluctuations of the photosensitive drums 2Y, 2C, 2M, and 2K are matched with each other, the effect is reduced by half. Therefore, it is preferred to mold the photosensitive drum gears 10Y, 10C, 10M, and 10K with the same mold so that their eccentricities become the same.

[0035] According to the image forming apparatus of this embodiment, the contact/separation member 12 is used so that the photosensitive drum gears 10Y, 10C, and 10M are meshed with or separated from the corresponding two-stage driving gears 8Y, 8C, and 8M. Referring here to FIGS. 4A through 4D, a description is made of operations in which the photosensitive drum gears 10Y, 10C, and 10M are meshed with or separated from the corresponding two-stage driving gears 8Y, 8C, and 8M by the contact/separation member 12.

[0036] As shown in FIG. 4A, the contact/separation member 12 includes a rectangular guiding member 12a having a guiding surface 12b that comes into contact with rotational shafts 13Y, 13C, 13M, and 13K of the photosensitive drums 2Y, 2C, 2M, and 2K and includes a driving gear 11 that moves the guiding member 12a along the arrangement direction (as indicated by arrow C) of the photosensitive drums 2Y, 2C, 2M, and 2K. The guiding surface 12b of the guiding member 12a alternates between having concave surfaces 12b1 that allow movement of the rotational shafts 13Y, 13C, 13M, and 13K of the photosensitive drums 2Y, 2C, 2M, and 2K elastically pressed downward by a pressing member (not shown) such as a spring in the downward direction (as indicated by arrow E1) and having convex surfaces 12b2 that allow movement of the rotational shafts 13Y, 13C, and 13M in

the upward direction (as indicated by arrow E2 in FIG. 4B) against the pressing force generated by the pressing member. When the rotational shafts 13Y, 13C, 13M, and 13K come into contact with the concave surfaces 12b1, the photosensitive drum gears 10Y, 10C, 10M, and 10K are meshed with the small diameter gears 8b1, 8b2, 8b3, and 8b4 of the two-stage driving gears 8Y, 8C, 8M, and 8K. With the rotation of the small diameter gears 8b1, 8b2, 8b3, and 8b4, the photosensitive drum gears 10Y, 10C, 10M, and 10K are rotated to thereby rotate the photosensitive drums 2Y, 2C, 2M, and 2K. On the other hand, when the rotational shafts 13Y, 13C, and 13M come into contact with the convex surfaces 12b2 of the guiding surface 12b, the photosensitive drum gears 10Y, 10C, and 10M are pushed up by the distance L so as to be separated from the small diameter gears 8b1, 8b2, and 8b3. Thus, even if the small diameter gears 8b1, 8b2, 8b3, and 8b4 are rotated, the photosensitive drum gears 10Y, 10C, and 10M are not rotated, but remain stopped. Accordingly, the rotations of the photosensitive drums 2Y, 2C, and 2M are also stopped.

[0037] The lower surface of the guiding member 12a is provided with a rack 12c meshed with the driving gear 11. With the rotation of the driving gear 11, the guiding member 12a is moved in the right and left horizontal directions (as indicated by arrow C). Accordingly, as shown in FIG. 4A, when the driving gear 11 is rotated to make the rotational shafts 13Y, 13C, 13M, and 13K of the photosensitive drums 2Y, 2C, 2M, and 2K come into contact with the concave surfaces 12b1 of the guiding surface 12b, the photosensitive drum gears 10Y, 10C, 10M, and 10K are meshed with the small diameter gears 8b1, 8b2, 8b3, and 8b4 to rotate the photosensitive drums 2Y, 2C, 2M, and 2K. As a result, this makes it possible to transfer toner images to the intermediate transfer belt 4 in full color, i.e., it is possible to perform color mode printing (separation state 1). Note that in FIG. 4A reference numeral 42 denotes a guiding groove formed in the guiding member 12a and serves as a guiding mechanism that reliably guides the guiding member 12a in the right and left horizontal directions together with a guiding projection 43 formed in the apparatus main body.

[0038] Furthermore, as shown in FIG. 4D, when the driving gear 11 is rotated to move the guiding member 12a in the left direction, the rotational shafts 13Y, 13C, and 13M of the photosensitive drums 2Y, 2C, and 2M come into contact with the convex surfaces 12b2 of the guiding member 12a, and the photosensitive drum gears 10Y, 10C, and 10M are separated from the small diameter gears 8b1, 8b2, and 8b3, respectively. Then, the rotations of the photosensitive drums 2Y, 2C, and 2M are stopped, and only the black photosensitive drum gear 10K is meshed with the small diameter gear 8b4. As a result, it is possible for the black photosensitive drum 2K to transfer a black toner image to the intermediate transfer belt 4, i.e., it is possible to perform monochrome mode printing (separation state 4). Thus, the driving gear 11 is rotated to move the guiding member 12a in the horizontal

direction, thereby making it possible to perform the color mode printing and the monochrome mode printing.

[0039] Moreover, according to the image forming apparatus of this embodiment, it is possible to align the rotational positions of the photosensitive drums 2Y, 2C, 2M, and 2K using the contact/separation member 12 so that the transfer positions of the toner images of the photosensitive drums 2Y, 2C, 2M, and 2K are matched with each other when the photosensitive drums 2Y, 2C, 2M, and 2K are assembled or replaced.

[0040] As described below, the alignment of the rotational positions of the photosensitive drums 2Y, 2C, 2M, and 2K, is performed in accordance with the separation states 1 through 4 after the phases of the photosensitive drums 2Y, 2C, 2M, and 2K are adjusted using phase detection patterns (see FIG. 10). Referring here to FIGS. 4A through 4D, the separation states 1 through 4 are described.

[0041] FIG. 4B shows a state in which the rotation of the photosensitive drum 2Y is stopped so that the phase of the photosensitive drum 2Y is matched with the phases of the photosensitive drums 2C, 2M, and 2K whose phases are matched with each other (separation state 2). In other words, the driving gear 11 is rotated to move the guiding member 12a from the position shown in FIG. 4C in the right direction. Thus, only the rotational shaft 13Y of the photosensitive drum 2Y is pushed up by the convex surface 12b2, and the small diameter gear 8b1 is separated from the photosensitive drum gear 10Y to stop the rotation of the photosensitive drum 2Y. Then, when the reference positions of the photosensitive drums 2C, 2M, and 2K whose phases are matched with each other are matched with the reference position of the photosensitive drum 2Y while stopped, the guiding member 12a is moved in the right direction to guide the rotational shaft 13Y of the photosensitive drum 2Y to the concave surface 12b1. Thus, the above separation state 1 is activated. Under this separation state 1, it is possible to rotate the photosensitive drum 2Y together with the other photosensitive drums 2C, 2M, and 2K with their phases matched with each other.

[0042] FIG. 4C shows a state in which the rotations of the photosensitive drums 2C and 2Y are stopped so that the phase of the photosensitive drum 2C is matched with the phases of the photosensitive drums 2M and 2K whose phases are matched with each other (separation state 3). In other words, the driving gear 11 is rotated to further move the guiding member 12a in the left direction to make the rotational shafts 13Y and 13C come into contact with the convex surfaces 12b with the rotation of the photosensitive drum 2Y stopped. Accordingly, the small diameter gears 8b1 and 8b2 are separated from the photosensitive drum gears 10Y and 10C to stop the rotations of the photosensitive drums 2Y and 2C. Then, when the photosensitive drums 2M and 2K whose phases are matched with each other are matched with the phase of the photosensitive drum 2C, the guiding member 12a is moved in the right direction to guide the rotational shaft

13C of the photosensitive drum 2C to the concave surface 12b1. Thus, the above separation state 2 is activated. Under this separation state 2, it is possible to rotate the photosensitive drum 2C together with the other photosensitive drums 2M and 2K with their phases matched with each other.

[0043] FIG. 4D shows a state in which the rotations of the photosensitive drums 2Y, 2C, and 2M are stopped so that the phase of the photosensitive drum 2K is matched with the phase of the photosensitive drum 2M (separation state 4). Under this state, it is possible to match the phase of the photosensitive drum 2K with the phase of any of the photosensitive drums 2Y, 2C, and 2M when stopped. In this case, however, the phase of the photosensitive drum 2M is matched with the phase of the photosensitive drum 2K. In other words, the driving gear 11 is rotated to further move the guiding member 12a in the left direction to also push up the rotational shaft 13M of the photosensitive drum 2M so as to separate the small diameter gears 8b1, 8b2, and 8b3 from the photosensitive drums 10Y, 10C, and 10M. Accordingly, the photosensitive drums 2Y, 2C, and 2M are stopped at their predetermined reference rotational positions. Then, when the black photosensitive drum 2K reaches its predetermined reference rotational position and matches the reference rotational position of the photosensitive drum 2M, the driving gear 11 is rotated to activate the separation state 3 shown in FIG. 4C. As a result, the reference rotational positions and the phases of the photosensitive drums 2K and 2M are matched with each other. Note that the separation state 4 is applied not only to the matching of the phases of the photosensitive drums 2M and 2K, but also to black printing in the monochrome mode.

[0044] In the above embodiment, the black photosensitive drum 2K is configured to be rotated at all times. However, by adequately setting the positions of the convex surfaces 12b2 and concave surfaces 12b1 of the guiding surface 12b of the guiding member 12a, it is also possible to form color toner images using other colors such as magenta, cyan, or yellow in the monochrome mode or form color toner images mixed with two or more of these colors while the black photosensitive drum gear 10K and the small diameter gear 8b4 are separated.

[0045] Next, a description is made of detection mechanisms for detecting the rotational positions of the photosensitive drums 2Y, 2C, 2M, and 2K. According to this embodiment, each of the photosensitive drums 2Y, 2C, 2M, and 2K is provided with a rotational position detection mechanism for detecting its reference rotational position.

[0046] FIGS. 5A through 5C are views showing the detection mechanisms for detecting the rotational positions of the photosensitive drums 2Y, 2C, 2M, and 2K used in the image forming apparatus of this embodiment. In this embodiment, each of the photosensitive drums 2Y, 2C, 2M, and 2K uses the same mechanism. Therefore, FIGS. 5A through 5C exemplify the case of the photosensitive drum 2Y.

[0047] As the detection mechanisms for detecting the rotational positions of the photosensitive drums 2Y, 2C, 2M, and 2K used in the image forming apparatus of this embodiment, there are a disk-shaped member 16 that is attached to the rotational shaft 13Y of the photosensitive drum 2Y and is rotated in synchronization with the photosensitive drum 2Y, and a detection sensor 17 such as an optical sensor that detects the rotational position of the member 16 are used, as shown in FIG. 5A. Furthermore, as shown in FIG. 5B, the member 16 has a concave notched part 16a at its periphery. As shown in FIG. 5A, the detection sensor 17 provided at the photosensitive drum 2Y that transfers a toner image to the intermediate transfer belt 4 detects the notched part 16 to detect the rotational position of the photosensitive drum 2Y.

[0048] The photosensitive drum 2Y has attached at its end the photosensitive drum gear 10Y meshed with the small diameter gear 8b1 of the two-stage driving gear 8Y, and is rotated while being in sliding contact with the intermediate transfer belt 4 by the rotation of the large diameter gear 8a1 rotated and driven by the motor gear 6. Accordingly, a yellow toner image formed on the front surface of the photosensitive drum 2Y is transferred to the intermediate transfer belt 4. By setting the rotational position at which the toner image on the photosensitive drum 2Y starts to be transferred to the intermediate transfer belt 4 as the reference position, the notched part 16a of the member 16Y is detected as it passes the immediate front of the detection sensor 17. In accordance with a detection signal at this time, the guiding member 12a of the contact/separation member 12 is moved and rotated, for example, by one revolution to activate the state shown in FIG. 4B. Accordingly, as shown in FIG. 5C, the photosensitive drum gear 10Y is separated from the small diameter gear 8b1 of the two-stage driving gear 8Y, while the intermediate transfer belt 4 is separated from the photosensitive drum 2Y. As a result, the photosensitive drum 2Y can be stopped at the reference rotational position.

[0049] In this manner, the rotational positions of the photosensitive drums 2Y, 2C, 2M, and 2K are matched with each other. Accordingly, it is possible to prevent the positional shifts of the transfer positions of the photosensitive drums 2Y, 2C, 2M, and 2K. In this case, when the separation direction E3 of the photosensitive drum 2Y from the intermediate transfer belt 4 is matched with the separation direction E2 of the photosensitive drum gear 10Y from the small diameter gear 8b1 of the two-stage driving gear 8Y by the convex surfaces 12b2 of the guiding member 12a of the contact/separation member 12, the photosensitive drum 2Y is automatically separated from the intermediate transfer belt 4 as the photosensitive drum gear 10Y is separated from the small diameter gear 8b1 of the two-stage driving gear 8Y by the convex surfaces 12b2 of the guiding member 12a. Accordingly, it is possible to prevent damage on the front surface caused when the photosensitive drum 2Y comes into sliding contact with the intermediate transfer belt 4.

[0050] According to this embodiment, in order to detect

the positional shifts of the photosensitive drums 2Y, 2C, 2M, and 2K, respective colors of phase detection patterns 14 are transferred from the photosensitive drums 2Y, 2C, 2M, and 2K to the intermediate transfer belt 4 as shown in FIG. 6. An interval D between the phase detection patterns 14 is detected by the pattern detection means 15, thereby making it possible to detect phase shifts. When the phase shifts are detected in this manner, the reference rotational positions of the photosensitive drums 2Y, 2C, 2M, and 2K are corrected as described above, thereby making it possible to correct the positional shifts.

[0051] According to this embodiment, it is possible to correct the reference positions of the photosensitive drums 2Y, 2C, 2M, and 2K in this manner. However, even if the reference positions of the photosensitive drums 2Y, 2C, 2M, and 2K in the color mode are set in accordance with this method, the reference position of the black photosensitive drum 2K, i.e., the stop position of the black photosensitive drum 2K in the color mode is caused to be shifted when the mode is switched between the color mode and the monochrome mode. As a result, color shifts occur between color toner images and a black toner image. When correction of the color shifts is attempted in accordance with the steps shown in FIGS. 4A through 4D, it is necessary to perform the adjustment described above. If such an adjustment is performed every time the mode is switched between the color mode and the monochrome mode, the downtime of the image forming apparatus is increased.

[0052] The present invention makes it possible to reduce the downtime as much as possible so as to correct the color shifts in a short period of time. For this purpose, the notched part 16a of the member 16 that is attached to the black photosensitive drum 2K is detected by the detection sensor 17, and the rotation stop position of the black photosensitive drum 2K in the color mode is stored in advance. The black photosensitive drum 2K in the monochrome mode is controlled to be stopped at the same position as the rotation stop position of the black photosensitive drum 2K in the color mode. Accordingly, the rotation stop position of the black photosensitive drum 2K in the monochrome mode becomes the same as that in the color mode. Therefore, even if the mode is switched from the monochrome mode to the color mode, the reference positions of the photosensitive drums 2Y, 2C, 2M, and 2K in the color mode are matched with each other, thereby making it possible to prevent the color shifts between the color toner images and the black toner image.

[0053] FIG. 7A shows the reference position 16a1 of a member 16K to be detected that is attached to the rotational shaft 13K of the black photosensitive drum 2K and the position of the notched part 16a2 when the rotation of the black photosensitive drum 2K is stopped in the color mode. FIG. 7B shows an arrangement relationship between the member 16K to be detected and the detection sensor 17. As shown in FIG. 7A, in order to detect the rotation stop position 16a2 of the black photosensitive drum 2K in the color mode, time T_i since the

immediately preceding rotational reference position 16a1 is calculated by a timer in accordance with a detection signal at the rotational reference position 16a1, and then it is stored. When the black photosensitive drum 2K is stopped in the monochrome mode using the stored time Ti, the phase of the black photosensitive drum 2K is matched with the phases of the photosensitive drums 2Y, 2C, and 2M whose rotations are stopped in the color mode, thereby making it possible to prevent the positional shifts between the color toner images and the black toner image.

[0054] FIG. 8 is a diagram showing a schematic configuration of a control unit that controls the rotation stop position of the black photosensitive drum 2K when the printing mode is switched. Reference numeral 33 denotes detection means including the member 16 that is attached to the black photosensitive drum 2K and the detection sensor 17. Reference numeral 34 denotes the timer that calculates the time Ti from the immediately preceding rotational reference position 16a1 of the black photosensitive drum 2K to the rotation stop position 16a2. Reference numeral 35 denotes storage means that stores the time Ti. Reference numeral 36 denotes the control unit that controls photosensitive drum stopping means 37 that stops the rotation of the photosensitive drum 2K, photosensitive drum driving means 38 that starts and drives the rotation of the photosensitive drum 2K, and contact/separation member driving means 39 that operates the contact/separation member 12 to activate the states shown in FIGS. 4A through 4D. Reference numeral 40 denotes mode switching means that switches the printing modes between the color mode and the monochrome mode. Reference numeral 41 denotes photosensitive drum operations inputting means through which the rotation and stopping operations of the photosensitive drum 2K are input. Referring here to FIG. 9, a description is made of the controlling of the rotation stop position of the black photosensitive drum 2K using the control unit 36.

[0055] FIG. 9 is a flowchart showing a method of controlling the rotation stop position of the black photosensitive drum 2K. First, when the starting of a printing operation is input through the photosensitive drum operations inputting means 41, the driving motor (not shown) is rotated to drive and rotate the motor gear 6. With the rotation of the motor gear 6, the two-stage driving gears 8K, 8M, 8C, and 8Y are rotated and driven through the coupling gears 7a, 7b, 7c, and 7d (step S1). Subsequently, the control unit 36 determines whether the printing mode has been set to be the color mode based on a signal from the mode switching means 40 (step S2). When the printing mode has been set to be the color mode (YES), the control unit 36 determines and confirms that the contact/separation member 12 has been in the separation state 1 based on a signal from the contact/separation member driving means 39 and then performs the printing operation (step S3). Based on a stop operation signal from the photosensitive drum operations in-

putting means 41, the control unit 36 operates the photosensitive drum stopping means 37 to stop the rotation of the motor gear 6. At the same time, the timer 34 is operated based on a signal that the detection means 33 detects immediately before the rotation of the black photosensitive drum 2K is stopped so as to calculate the time Ti until the rotation is stopped, and then the time Ti stored in the storage means 35 is rewritten (overwritten with the new time Ti) (step S4). After this, the printing operation is terminated (step S5).

[0056] Next, when the printing mode has not been set to be the color mode (NO) in step S2, the control unit 36 controls and drives the contact/separation member driving means 39 so that the contact/separation member 12 is in the separation state 4 based on a switching signal from the mode switching means 40 to switch to the monochrome mode (step S6). After it is confirmed that the contact/separation member driving means 39 has been driven to set the monochrome mode, the printing operation for black is performed (step S7). After the printing operation for black is terminated, the control unit 36 controls the photosensitive drum stopping means 37 so that the rotation of the black photosensitive drum 2K is stopped when the time Ti elapses since the reference position detection signal based on a reference position detection signal detected immediately before the rotation of the black photosensitive drum 2K is stopped and the time Ti stored in step S4 (step S8). When the rotation of the black photosensitive drum 2K is stopped, the contact/separation member driving means 39 is operated to set the contact/separation member 12 to be in the separation state 1 (step S9). The printing operation is then terminated.

[0057] As described above, even when the printing operation is performed in the monochrome mode, the rotation of the black photosensitive drum 2K is stopped at the position matching the rotation stop position of the black photosensitive drum 2K when the printing operation is performed in the color mode. Therefore, when the printing mode is next switched to the color mode, the color printing is performed with the reference positions of the photosensitive drums 2Y, 2C, 2M, and 2K matched with each other, thereby making it possible to prevent the occurrence of the positional shifts between the color toner images and the black toner image.

[0058] Furthermore, according to this embodiment, it is possible to match the phases of the photosensitive drums 2Y, 2C, 2M, and 2K with each other using the contact/separation member 12 shown in FIG. 4 and the phase detection patterns shown in FIG. 6. FIG. 10 describes a method of matching the phases of the photosensitive drums 2Y, 2C, 2M, and 2K with each other. First, phase matching control is started to set the contact/separation member 12 to be in the separation state 1 (step S11). Next, the photosensitive drum gears 10Y, 10C, 10M, and 10K set to be in the separation state 1 are meshed with the two-stage driving gears 8Y, 8C, 8M, and 8K to rotate the photosensitive drums 2Y, 2C, 2M,

and 2K. With the rotations of the photosensitive drums 2Y, 2C, 2M, and 2K, the respective colors of the phase detection patterns 14 are transferred to the intermediate transfer belt 4 (step S12). The phase detection patterns 14 thus formed on the intermediate transfer belt 4 are detected by the pattern detection means 15 (step S13), and then an optimum phase difference is calculated based on a detected signal (step S14).

[0059] Then, the contact/separation member 12 is set to be in the separation state 4 (step S15) to match the phase of the photosensitive drum 2K with the phase of the photosensitive drum 2M (step S16). Next, the contact/separation member 12 is set to be in the separation state 3 (step S17) to match the phase of the photosensitive drum 2K with the phase of the photosensitive drum 2C (step S18). Similarly, the contact/separation member 12 is set to be in the separation state 2 (step S19) to match the phase of the photosensitive drum 2K with the phase of the photosensitive drum 2Y (step S20). At last, the time T_i from the rotational reference position 16a1 to the rotation stop position is measured by the detection means 33 attached to the black photosensitive drum 2K, and then the time T_i stored in the storage means 35 is rewritten and stored again (step S21).

[0060] As described above, according to this embodiment, it is possible to easily, promptly, and reliably match the phases of the photosensitive drums 2Y, 2C, 2M, and 2K with each other.

[0061] Furthermore, according to this embodiment, the phase matching control is performed when the photosensitive drums 2Y, 2C, 2M, and 2K are replaced in the image forming apparatus. FIG. 11 shows a flowchart of the phase matching control. According to this embodiment, the photosensitive drums 2Y, 2C, 2M, and 2K are provided with an IC tag (not shown) in which an identification number is embedded. Moreover, the apparatus main body 100 is provided with communication means (not shown) that reads the information items of the IC tags of the photosensitive drums 2Y, 2C, 2M, and 2K. Based on the information items of the IC tags of the photosensitive drums 2Y, 2C, 2M, and 2K, it is determined whether the photosensitive drums 2Y, 2C, 2M, and 2K have been replaced.

[0062] First, as shown in FIG. 11, it is determined whether the door of the apparatus main body 100 has been opened (step S30). When the door of the apparatus main body 100 has been opened, it is determined whether a control open flag exists (step S31). When the open flag exists, a flow after step S30 is repeated. Conversely, when the open flag does not exist, the control open flag is set (step S32) and the flow after step S30 is repeated.

[0063] When the door of the apparatus main body 100 has not been opened in step S30, it is determined whether the control open flag exists (step S33). When the open flag does not exist, it is determined that the photosensitive drums 2Y, 2C, 2M, and 2K (the process cartridges 1Y, 1C, 1M, and 1K) have not been removed and replaced. Then, the flow after step S30 is repeated.

[0064] Conversely, when the open flag exists in step S33, communication with the IC tags of the photosensitive drums 2Y, 2C, 2M, and 2K is performed (step S34). Then, it is determined whether the identification numbers read from the IC tags match the identification numbers stored in the memory of the control section (not shown) of the image forming apparatus (step S35).

[0065] When these identification numbers do not match each other, it is determined that the photosensitive drums 2Y, 2C, 2M, and 2K (the process cartridges 1Y, 1C, 1M, and 1K) have been replaced. Accordingly, the phase matching control is performed (step S36). In other words, a solenoid (not shown) as moving means is operated based on the detection result of the pattern detection means 15 as phase difference detection means to adjust the phase differences of the driving speed fluctuations of the photosensitive drums 2Y, 2C, 2M, and 2K. Then, the control open flag is deleted (step S37). After this, the identification numbers in the memory of the apparatus main body are rewritten, and then the flow is terminated.

[0066] Conversely, when these identification numbers match each other in step S35, it is determined that the photosensitive drums 2Y, 2C, 2M, and 2K (the process cartridges 1Y, 1C, 1M, and 1K) have not been replaced. Accordingly, the flow is terminated after steps S37 and S38 without performing the phase matching control. Thus, the positional shifts of plural toner images formed on the intermediate transfer belt 4 in a superposed manner are corrected every time the photosensitive drums 2Y, 2C, 2M, and 2K (the process cartridges 1Y, 1C, 1M, and 1K) are replaced. Therefore, it is possible to provide a color image without causing color shifts at all times. Thus, with the provision of the IC tags in the photosensitive drums or the process cartridges having the photosensitive drums, it is possible to avoid correcting positional shifts when the photosensitive drums have not been replaced even if the door of the apparatus main body has been opened and closed.

[0067] Furthermore, according to this embodiment, the development units 20Y, 20C, 20M, and 20K are integrally attached to the photosensitive drums 2Y, 2C, 2M, and 2K, respectively. As described above, when the photosensitive drums 2Y, 2C, 2M, and 2K are separated from the intermediate transfer belt 4 at the time of the phase matching control, the development units 20Y, 20C, 20M, and 20K are moved up and down while a positional relationship between the photosensitive drums 2Y, 2C, 2M, and 2K and the development units 20Y, 20C, 20M, and 20K is maintained. Accordingly, the positional relationship between the photosensitive drums 2Y, 2C, 2M, and 2K and the development units 20Y, 20C, 20M, and 20K is maintained to be constant even if the photosensitive drums 2Y, 2C, 2M, and 2K are separated from the intermediate transfer belt 4 at the time of the phase matching control. As a

result, it is possible to form excellent images on the front surfaces of the photosensitive drums 2Y, 2C, 2M, and 2K at all times.

[0068] Furthermore, the separation direction of the photosensitive drums 2Y, 2C, 2M, and 2K from the intermediate transfer belt 4 at the time of the phase matching control is matched with the removing direction (upward direction) of the photosensitive drums 2Y, 2C, 2M, and 2K or the process cartridges 1Y, 1M, 1C, and 1K from the apparatus main body 100. Therefore, it is possible to remove and assemble the photosensitive drums 2Y, 2C, 2M, and 2K or the process cartridges 1Y, 1M, 1C without changing the contact position between the contact/separation member 12 and the rotational shafts 13Y, 13C, 13M, and 13K of the photosensitive drums 2Y, 2C, 2M, and 2K. In this case, the process cartridges 1Y, 1C, 1M, and 1K are removed in the upward direction after the optical scanning unit 3 arranged above the process cartridges 1Y, 1C, 1M, and 1K is removed.

[0069] Moreover, with the provision of the detection means that detects the removals of the photosensitive drums 2Y, 2C, 2M, and 2K or the process cartridges 1Y, 1C, 1M, and 1K from the apparatus main body 100, it is possible to avoid the phase matching control when the photosensitive drums 2Y, 2C, 2M, and 2K or the process cartridges 1Y, 1C, 1M, and 1K are removed from the apparatus main body 100.

[0070] The present invention is not limited to the specifically disclosed embodiments, but variations and modifications may be made without departing from the scope of the present invention.

Claims

1. An image forming apparatus that has plural photosensitive drums for color on which chromatic toner images are to be formed, a photosensitive drum for black on which a black toner image is to be formed, gears for color that are arranged concentrically to the photosensitive drums for color and coupled with the photosensitive drums for color so as to be rotated together with the photosensitive drums for color, and a gear for black that is arranged concentrically to the photosensitive drum for black and coupled with the photosensitive drum for black so as to be rotated together with the photosensitive drum for black, and that is configured to be capable of selecting a color mode in which different colors of the chromatic toner images are formed on the photosensitive drums for color rotated and driven together with the gears for color, the black toner image is formed on the photosensitive drum for black rotated and driven together with the gear for black, and the chromatic toner images and the black toner image are transferred to a transfer member in a superposed manner so as to obtain a color image, and

a monochrome mode in which the black toner image is formed on the photosensitive drum for black rotated and driven together with the gear for black after the gears for color and the photosensitive drums for color are stopped and only the black toner image is transferred to the transfer member to obtain a black image, **characterized in that**

the gears for color of the photosensitive drums for color are meshed with corresponding driving gears coupled with and driven by a driving source and rotated and are arranged to correspond to the driving gears so as to stop rotations of the photosensitive drums for color when the gears for color are in a non-meshed state after being separated from the driving gears, the image forming apparatus having contact/separation means that moves the gears for color so as to be in a meshed state or in the non-meshed state with respect to the corresponding driving gears,

rotational position detection means that is provided in the photosensitive drum for black and detects a rotational position of the photosensitive drum for black, the rotational position detection means detecting and storing the rotation stop position of the photosensitive drum for black in the color mode, and a control unit that controls, in the monochrome mode, the photosensitive drum for black to be stopped at the same position as the stored rotation stop position of the photosensitive drum for black in the color mode.

2. The image forming apparatus according to claim 1, **characterized in that**

the driving source is a driving motor by which the gears for color and the gear for black are driven and rotated.

3. The image forming apparatus according to claim 1 or 2, **characterized in that**

the plural photosensitive drums for color are linearly arranged in parallel, the contact/separation means has a guiding surface on which are alternately arranged a convex surface that pushes up the gears for color of the photosensitive drums for color so as to be in the non-meshed state with respect to the driving gears and a concave surface on which the gears for color are pushed down so as to be in the meshed state with respect to the driving gears, and

the image forming apparatus further has driving means that moves the contact/separation means in an arrangement direction of the photosensitive drums for color, the driving means controlling the contact/separation means to be moved in the arrangement direction of the photosensitive drums so that the gears for color are pushed up by the convex surface in the monochrome mode and separated from the driving gears so as to be in the non-meshed

state and controlling the contact/separation means to be moved in the arrangement direction of the photosensitive drums so that the gears for color are pushed down to the concave surface in the color mode so as to be in the meshed state.

4. The image forming apparatus according to any one of claims 1 through 3, **characterized in that** the driving gears corresponding to the gears for color and the driving source are driven and coupled by plural other coupling gears. 5
5. The image forming apparatus according to any one of claims 1 through 4, **characterized in that** the photosensitive drums for color and the photosensitive drum for black are linearly arranged in parallel, and the chromatic toner images and the black toner image formed on the photosensitive drums for color and the photosensitive drum for black, respectively, are transferred to an endless belt that is arranged parallel to the arrangement direction of the photosensitive drums and endlessly moved in the arrangement direction. 15 20
6. The image forming apparatus according to claim 5, **characterized in that** the contact/separation means is arranged so that the corresponding photosensitive drums for color are separated from the endless belt simultaneously with the separation of the gears for color of the photosensitive drums for color from the corresponding driving gears, making the separation direction of the gears for color from the driving gears match the separation direction of the photosensitive drums for color from the endless belt. 25 30 35
7. The image forming apparatus according to any one of claims 1 through 6, **characterized in that**, when the rotational cycle of the gears for color is represented as T and an angle between an exposure position and a transfer position of a toner image of the photosensitive drum is represented as α , the number of teeth of the driving gears corresponding to the gears for color is set so that the rotational cycle T2 of the driving gears is expressed by $T2 = T \times (\alpha/360)/N$ where N is an integer. 40 45
8. The image forming apparatus according to any one of claims 1 through 7, **characterized in that** the gears for color are molded by the same mold. 50
9. The image forming apparatus according to any one of claims 1 through 8, **characterized in that** the photosensitive drums for color have rotational position detection means that detects rotational positions of the photosensitive drums for color. 55
10. The image forming apparatus according to any one

of claims 1 through 9, **characterized in that** the photosensitive drums for color are integrally coupled with corresponding development units, and the development units are moved together with the photosensitive drums for color that are moved as the gears for color are separated from the driving gears.

11. The image forming apparatus according to any one of claims 1 through 10, **characterized in that** the photosensitive drums for color are removably attached to an image forming apparatus main body.
12. The image forming apparatus according to claim 11, **characterized in that** the removing direction of the photosensitive drums for color from the image forming apparatus main body and the separation direction of the gears for color from the driving gears for color are matched with each other.
13. The image forming apparatus according to claim 11 or 12, **characterized in that** the photosensitive drums for color has detection means that detects the removals of the photosensitive drums for color.

FIG.1

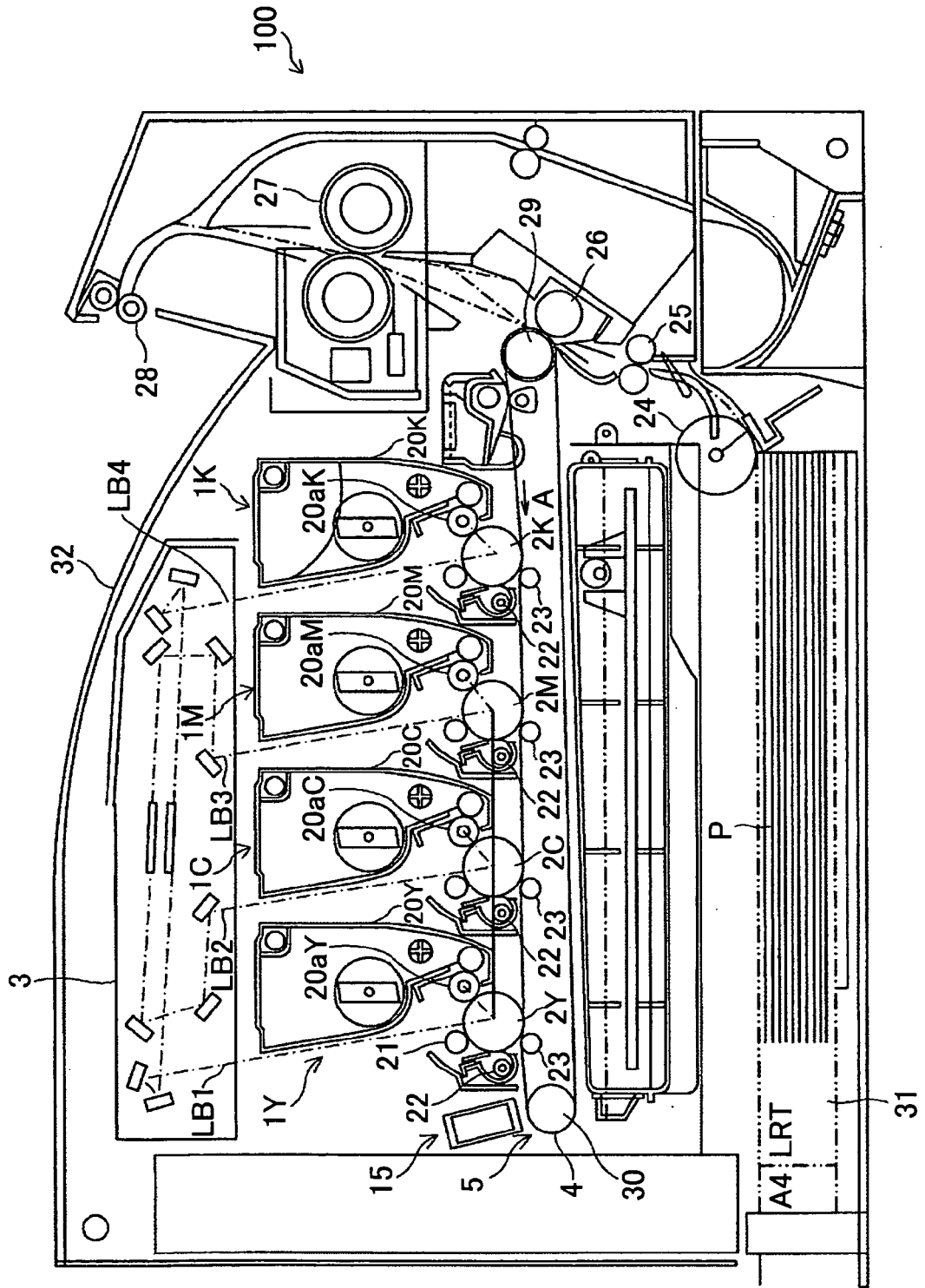


FIG.2

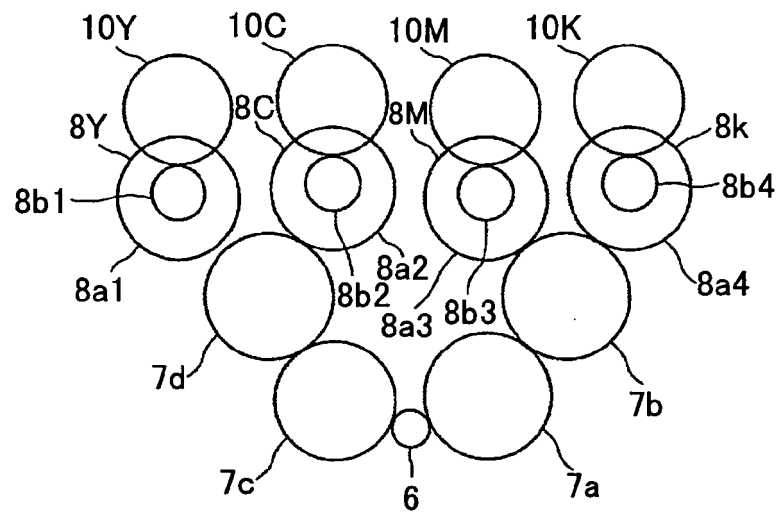
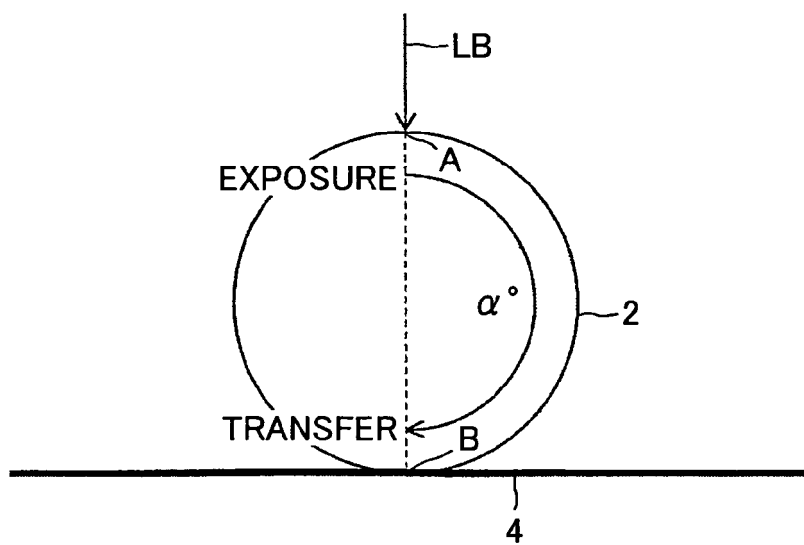


FIG.3



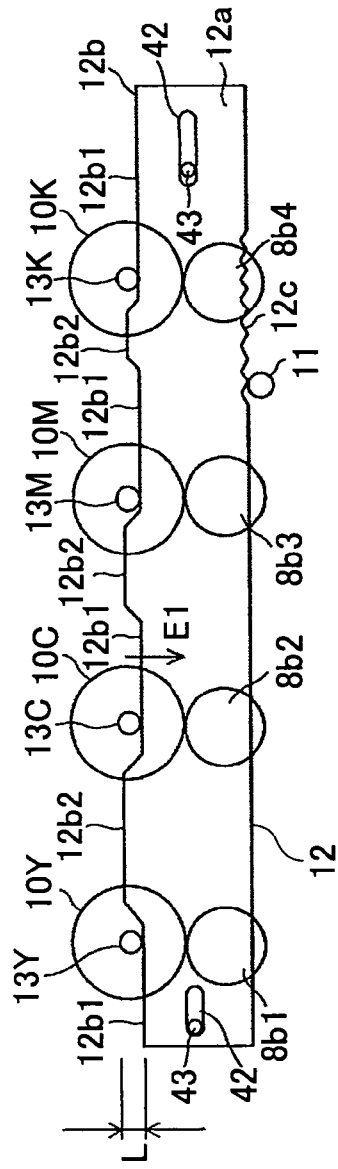


FIG. 4A SEPARATION STATE 1

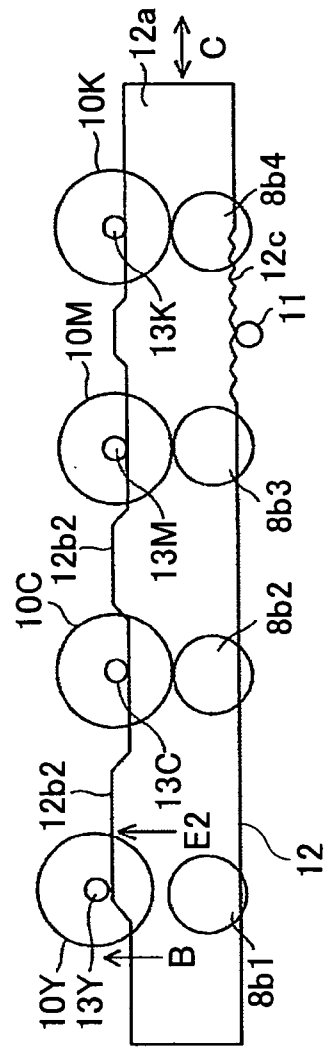


FIG. 4B SEPARATION STATE 2

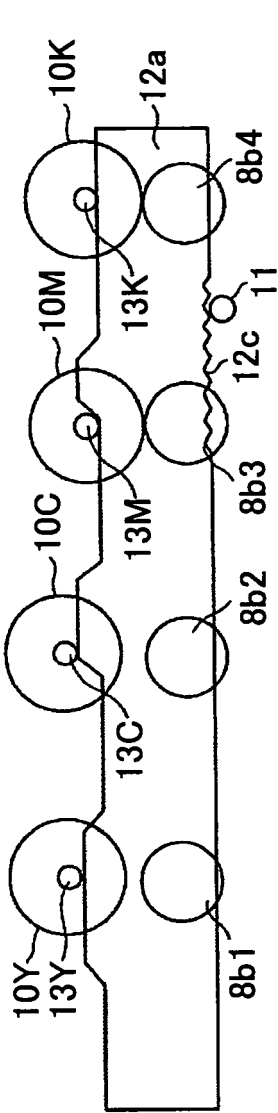


FIG.4C SEPARATION STATE 3

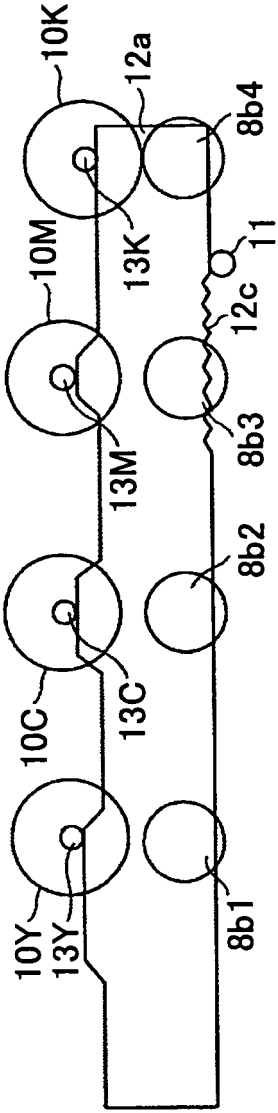


FIG.4D SEPARATION STATE 4

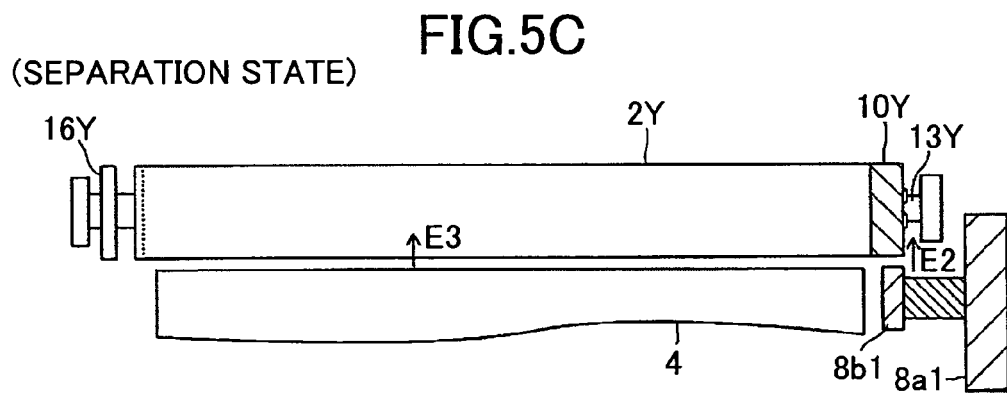
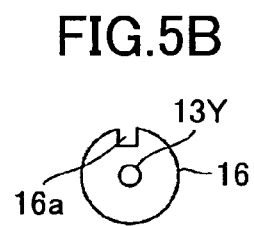
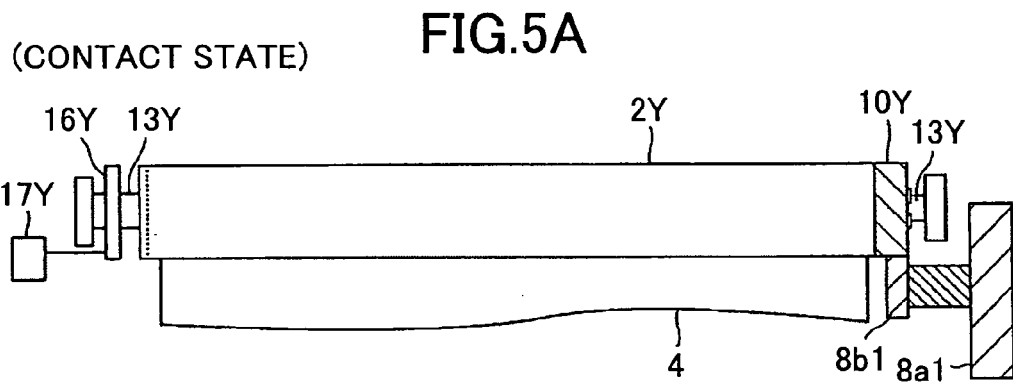


FIG.6

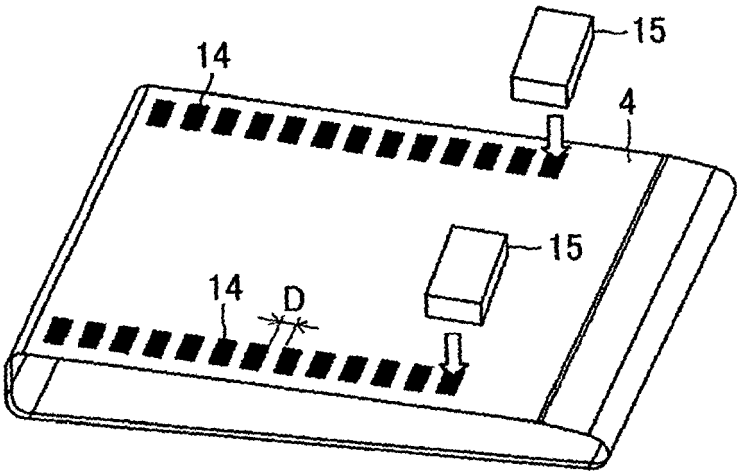


FIG.7A

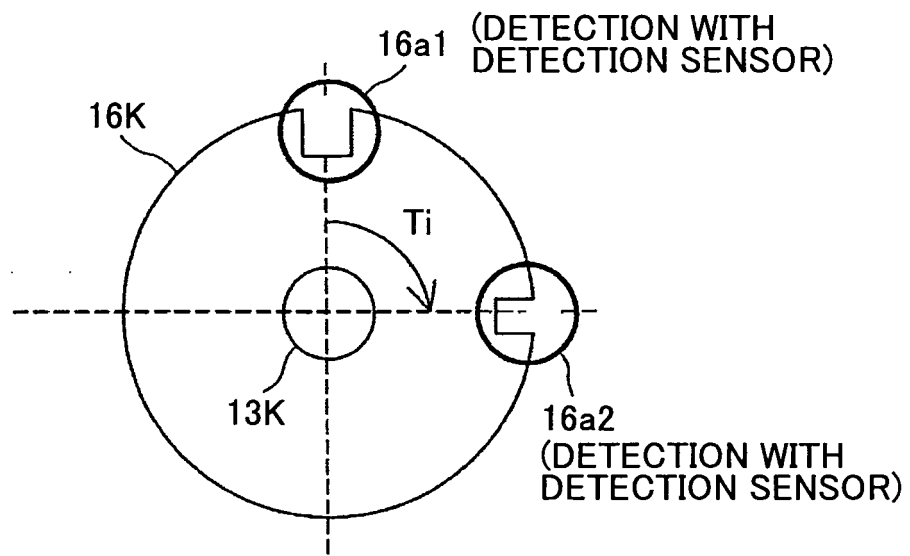


FIG.7B

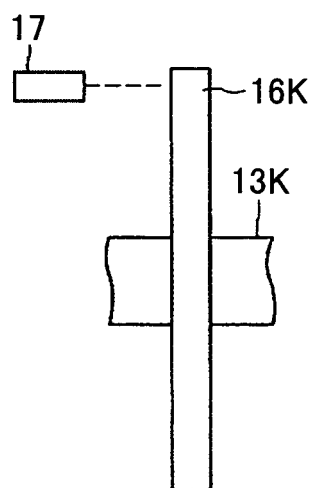


FIG.8

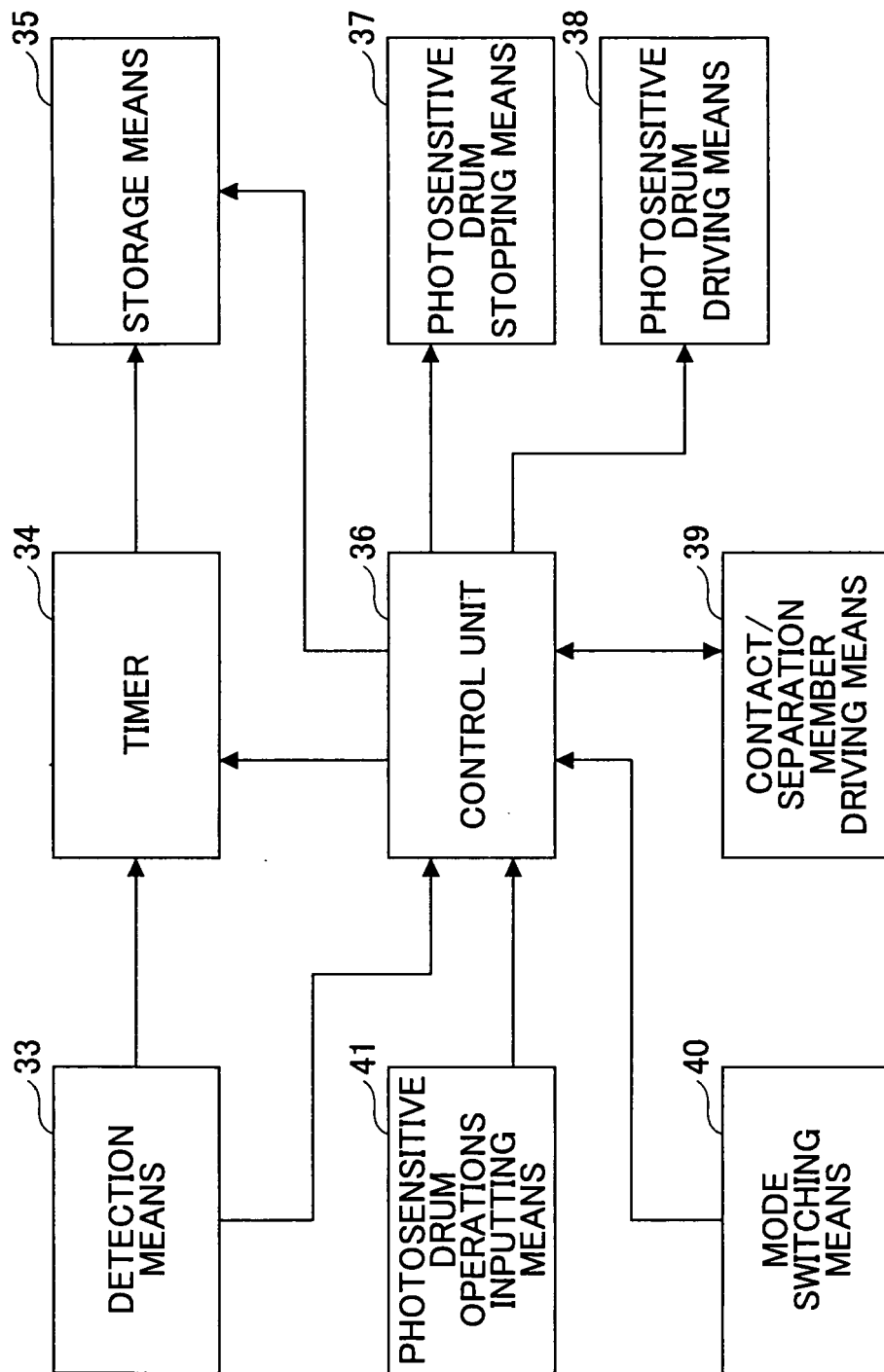


FIG.9

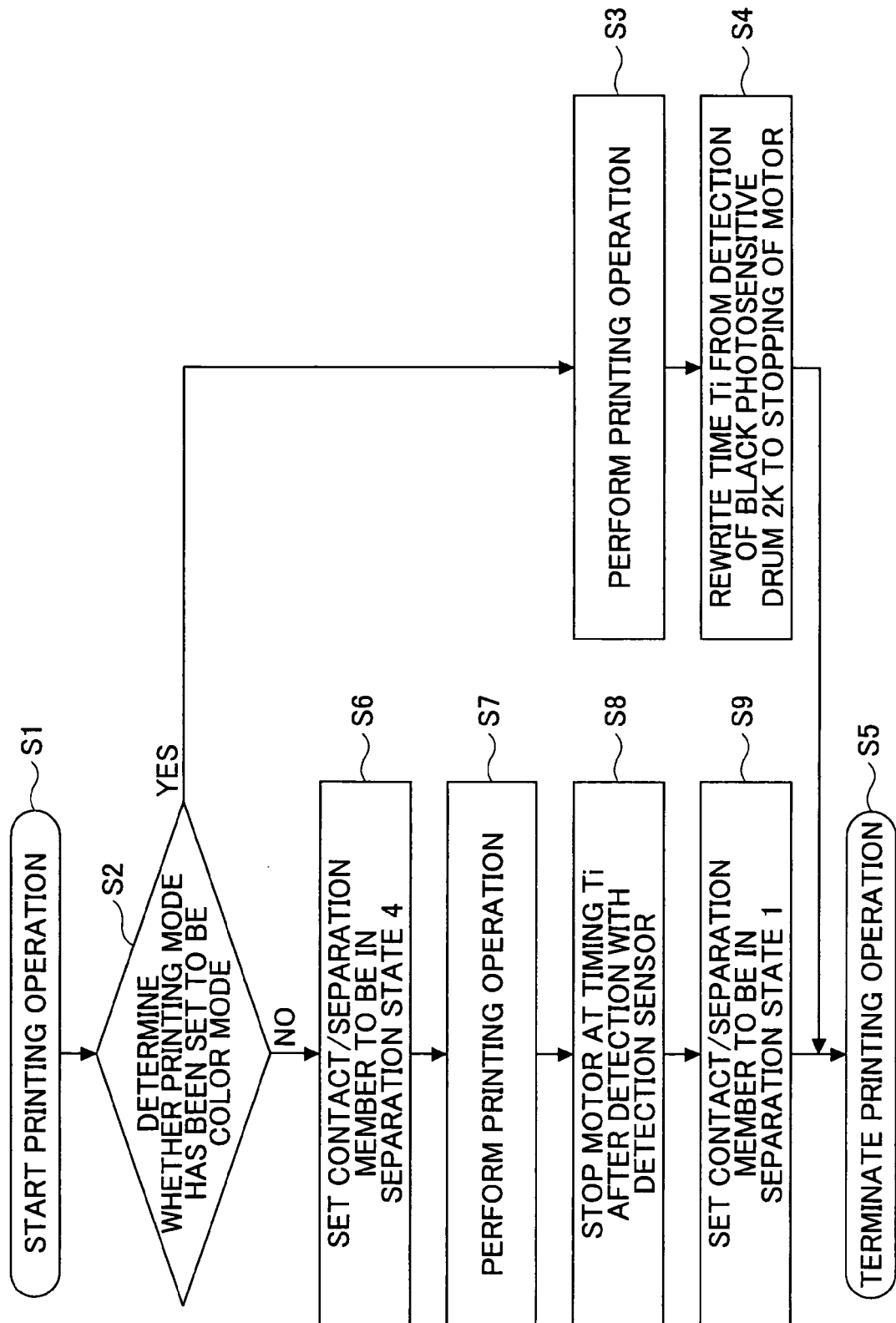


FIG.10

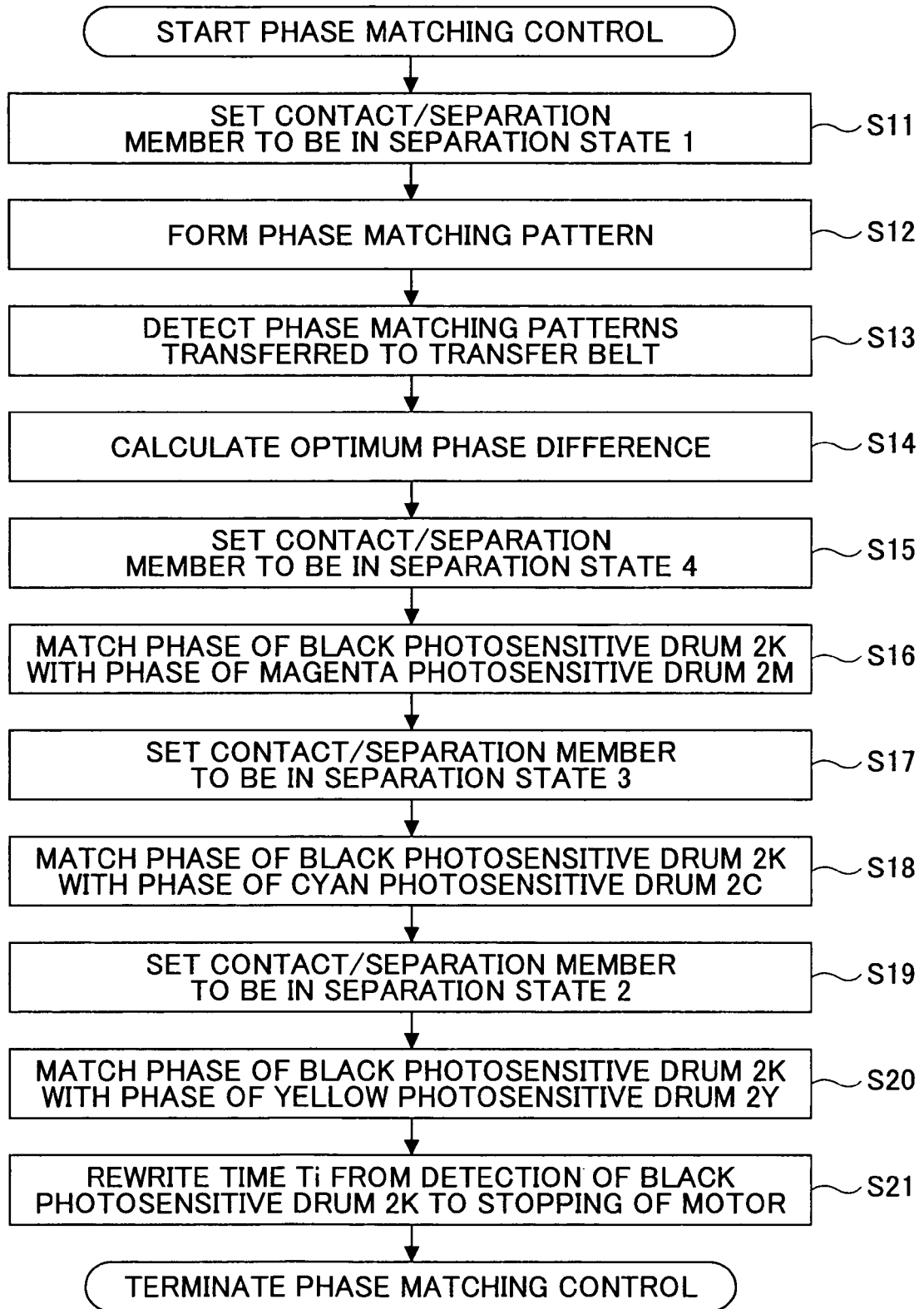
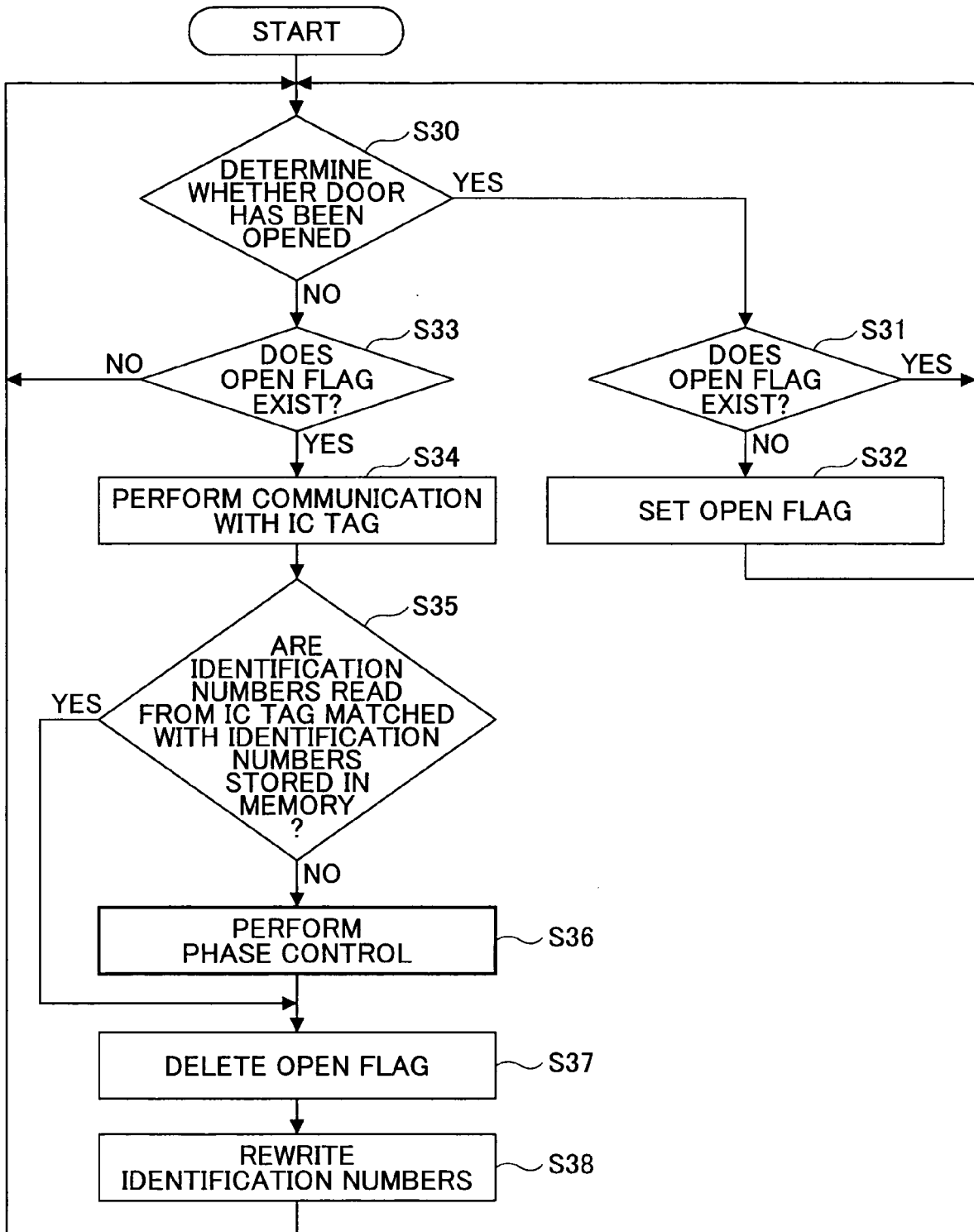


FIG.11



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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