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(54) Developing apparatus.

(57) In a developing apparatus wherein two-component developer consisting of toner (T) and carrier (C) is used and the rotation number of a developing roller (22) selected under normal mode can be changed under another mode under which the amount of toner used is different from that under normal mode, a magnetic sensor (30) is used as means for detecting toner concentration in a developer (D) containing section. Input voltage applied to the magnetic sensor (30) is adjusted and determined in such a way that the output voltage of the magnetic sensor (30) which is previously set relative to a reference toner concentration in the developer (D) becomes equal to a reference voltage, on which it is determined whether the adding of toner is started or stopped, even though the rotation number of the developing roller (22) selected under one mode is changed under another mode. The output voltage of the magnetic sensor (30) rises as the toner concentration in the developer (D) becomes low. The reference voltage is set 4V relative to the reference toner concentration of 4%, for example, and when the output voltage becomes larger than the reference voltage, the adding of toner is started. The output voltage becomes lower as the toner concentration becomes higher and when the output voltage becomes smaller than the reference voltage or equal to it, the adding of toner (T) is stopped. When the rotation number of the developing roller (22) is changed in this manner to change one mode to another, such input voltage that corresponds to the rotation number of the developing roller (22) is applied to the magnetic sensor (30) to control the toner density in the developer (D) by comparing the output voltage of the magnetic sensor (30) with the reference voltage selected under this another mode.

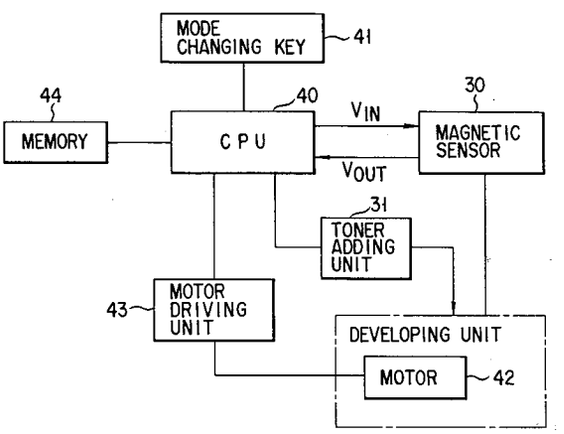

FIG. 2

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The present invention relates to a developing apparatus employed by an image forming apparatus such as the electrophotographic copy machine and printer and, more particularly, it relates to an developing apparatus wherein the copying can be carried out under plural modes such as the normal and the gradation-reproducing mode suitable for copying photos.

Recently, a developing apparatus of an image forming apparatus has been developed and used to more excellently copy photos.

In the case of this image forming apparatus, the rotation number of a developer carrying member in the developing apparatus is made variable in the normal and in the gradation-reproducing (or photo-reproducing) mode under which the amount of toner used is different from that in the normal mode.

One type of adding toner to the developing apparatus employed by this image forming apparatus comprises adding a predetermined amount of toner to every copying (or printing) sheet of paper (amount-fixed toner adding type). Another type comprises measuring the image density of a toner image on a photosensitive drum which serves as the image carrier and adding toner to the developing apparatus responsive to the image concentration measured (image concentration detecting type).

In the case of the image forming apparatus wherein the amount of developer supplied is made variable in the normal and in the gradation-reproducing mode suitable for copying photos or the rotation number of the developer carrying member is made variable, it is not arranged that the toner concentration in the developer is directly detected to add toner to the developing apparatus.

This makes it impossible to add an appropriate amount of toner to the developing apparatus. The toner density in the developer is thus made unstable, toner is sprayed from the developing unit to soil the inside of the image forming apparatus, and the quality of images copied is made inferior.

The present invention is therefore intended to eliminate the above-mentioned drawbacks.

Accordingly, the object of the present invention is to provide a developing apparatus wherein the rotation number of a developer carrying member is made variable in the normal and in the other mode under which the amount of toner used is different from that under the normal mode, the developing apparatus being capable of adding an appropriate amount of tone to make more stable the toner concentration in it, preventing toner from being sprayed and more stably forming images of a higher quality.

According to the present invention, there is provided a developing apparatus, comprising: means for applying a developing material to an electrostatic latent image at one of a first amount of developing material and a second amount of developing material which is different from the first amount of developing material, so as to develop the electrostatic latent image; means for selecting the first amount of developing material for the applying means in a first mode for developing a normal image, and selecting the second amount of developing material for the applying means in a second mode for developing an image hearing higher quality than the normal image; means for detecting a concentration of the developing material contained in the developing means, and outputting a data indicating the concentration of the developing material; and means for adjusting the data outputted by the detecting means in accordance with the amount of developing material selected by the selecting means.

According to a developing apparatus of the present invention wherein the rotation number of the developer carrying member is made variable in the normal and in the other mode in which the toner is used in an amount different from that used in the normal mode, the detecting level at the time of detecting the toner concentration in the developing material is changed to a level at which the toner concentration can be kept excellent, when the rotation number of the developing material carrying member is changed, so as to make the output of the toner concentration detecting means certain when the developer has a reference toner concentration, so that the adding of toner can be started or stopped to make more stable the toner concentration in the developing material.

This invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a sectional view schematically showing the main portion of the image forming apparatus according to an embodiment of the present invention;

Fig. 2 is a block diagram showing a toner

Fig. 2 is a block diagram showing a toner concentration control system;

Fig. 3 is a graph showing how the toner concentration of developer is related to voltages outputted from a magnetic sensor;

Fig. 4 is a graph showing how the rotation number of a developing roller is related to voltages inputted when the voltage outputted becomes equal to reference one while using a developer which has the reference toner concentration;

Fig. 5 is a graph showing how the concentration of an original is related to that of its image when the image forming operation is conducted in

normal and gradation-reproducing modes; and

Fig. 6 is a flow chart showing how the toner concentration is adjusted when the rotation number of a developing unit is changed.

An embodiment of the present invention will be described with reference to the accompanying drawings.

Referring to Fig. 1, there will be described at first the main portion of the electrophotographic copy machine which is an image forming apparatus according to the present invention.

A charging unit 2 which serves as the charging means, the exposing section of an exposing unit 3 which serves as the latent image forming means, a developing unit 4 which serves as the image developing means, a transfer unit 5 which serves as the image transfer means, a peeling-off unit 6 which serves as the paper sheet peeling-off means, a cleaner unit 7 which serves as the cleaning means, and a lamp 8 which serves as the de-charging means are arranged in this order around a photosensitive drum 1, which serves as the image carrier means, along the rotating direction of the drum 1.

A passage 11 is formed at an image transfer section 10 between the photosensitive drum 1 and the transfer unit 5 to convey or feed paper sheets P, on which an image is to be transferred, through it.

When image forming signal is received, the photo-sensitive drum 1 is rotated while being uniformly charged by the charging unit 2. An original set on an original table (not shown) is scanned and exposed onto the photosensitive drum 1 through the exposing unit 3. An electrostatic latent image which corresponds to the image on the original is thus formed on the photo-sensitive drum 1. This electrostatic latent image thus formed on the photosensitive drum 1 is developed to a toner image TI by the developing unit 4 as will be described later.

Synchronizing with the forming of the toner image TI, a paper sheet P is fed into the image transfer section 10 where the toner image TI is transferred onto the paper sheet P by the transfer unit 5.

Toner not transferred onto the paper sheet P but still remaining on the photosensitive drum 1 is removed by the cleaner unit 7 and charge remaining on the drum 1 is then de-charged by the de-charging lamp 8. The copy machine is thus made ready for a next image forming operation.

The developing unit 4 will be now described.

It has a casing 21 where two-component developer D consisting of toner (or coloring powder) and carrier (or magnetic powder) is contained in a developer containing section 20.

The casing 21 houses therein a developing roller 22 which is opposed to the photosensitive drum 1 and which serves as the developer carrying member. The developing roller 22 holds thereon the two-component developer D like a brush due to magnetic force and as it rotates, the two-component developer D thus held like the brush on it or magnetic developer brush DB is continuously brushed against the photosensitive drum 1.

Further housed in the casing 21 are a doctor blade 23 which serves as a means for controlling the thickness of the magnetic developer brush DB on the surface of the developing roller 22, and first and second mixers 24 and 25 which serves as means for feeding the developer D while stirring it in the developer containing section 20.

The developing roller 22 comprises a magnetic roll 22A which serves as a magnetic force generating member having plural magnetic N1, N2, S1, S2 and S3, and a non-magnetic developing sleeve 22b fitted onto the magnetic roll 22A and rotated along it. The two-component developer D is formed as the magnetic developer brush DB on the surface of the developing sleeve 22B by the action of magnetic force generated by the magnets S1, S2, S3, N1 and N2 and the developing sleeve 22B rotates carrying the magnetic developer brush DB thereon.

The two-component developer D contained in the developer containing section 20 is fed from the mixer 24 to the developing roller 22 and it is further fed in the anti-clockwise direction in Fig. 1 while being formed as the magnetic developer brush DB on the developing roller 22. The amount of the magnetic developer brush DB thus fed on the roller 22 is made certain by the doctor blade 23. The magnetic developer brush DB on the roller 22 is brushed against the photosensitive drum 1 at the position of the magnet N1 which is opposed to the drum 1, so that toner T can be stuck and developed as an electrostatic latent image on the photosensitive drum 1.

The magnetic developer brush DB which has been passed through the developing section is further passed over the magnet S3 and then released from the developing roller 22 and returned to the developer containing section 20.

The mixers 24 and 25 are rotated in reverse directions with a partition plate interposed between them and the developer D in the developer containing section 20 is circulated and stirred like flat loops by these mixers 24 and 25.

The toner T is added from a toner adding unit 31 (not shown in detail), which is attached to the developing unit 4 to the front side of the mixer 25 in the developer containing section 20. While being stirred together with the developer D in the developer containing section 20, it is fed to the rear side of the mixer 25 and then to the mixer 24. While

further stirred and fed by the mixer 24, a part of it is supplied to the developing roller 22.

The developer D which has been supplied to the developing roller 22 is passed through the developing section, as described above, as the developing sleeve 22b rotates round the developing roller 22, and it is then collected by the mixer 24. As the mixer 24 rotates, it is mixed with the developer D which has not been supplied to the developing roller 22, and it is further stirred and then fed to the mixer 25 at the front side of the mixer 24. It is thus circulated in the developing unit 4.

The toner concentration of the developer d in the developing unit 4 is detected by an auto toner sensor (ATS) 30 of the magnetic type which is located under the mixer 25.

The auto toner sensor 30 (which will be hereinafter referred to as magnetic sensor) includes a power source of voltage V^+, from which input voltage V_{IN} is applied to the magnetic sensor 30 to obtain output voltage V_{OUT} responsive to a certain toner concentration. In short, the output voltage V_{OUT} changes responsive to any change in the toner concentration of the developer D.

When the toner concentration in the developer D which passes over a head face 30A of the magnetic sensor 30 changes, magnetic permeability through the developer D changes and the output voltage V_{OUT} of the magnetic sensor 30 changes responsive to this change of the magnetic permeability. Depending upon whether or not the output voltage V_{OUT} is larger than reference voltage V_{STD}, it is decided whether or not the toner is added to the developer containing section 20.

The developing roller 22, and first and second mixers 24 and 25 of the developing unit 4 are driven by a motor 42 and their driven speeds can be changed under normal and gradation-reproducing modes, respectively, as will be described later.

Fig. 2 is a block diagram showing a toner concentration control system. A CPU 40 serves as a control means. Connected to this CPU 40 are the magnetic sensor 30, the toner adding unit 31, a key 41 for changing the mode from normal to gradation-reproducing one and vice versa, a circuit 43 for driving the motor 42 of the developing unit 4, and a memory 44 serving as a means for storing reference and input voltages V_{STD} and V_{IN} of the magnetic sensor 30 and the number of motor rotation.

Fig. 3 is a graph showing how the output voltage V_{OUT} of the magnetic sensor 30 is related to the toner concentration in the developer D when the rotation number of the mixer 25 of the developing unit 4 is certain and the input voltage V_{IN} of the magnetic sensor 30 is also certain.

When the toner concentration becomes low, the output voltage V_{OUT} rises in the case of this embodiment. The reference voltage V_{STD} is set equal to 4V when the reference toner concentration is 4%. When VOUT > V_{STD} (=4V), therefore, the toner is added to the developer containing section 20 and as the toner concentration in the developing unit 4 becomes higher, the output voltage V_{OUT} becomes lower and when $V_{OUT} \leqq V_{STD}$, the adding of toner to the developing unit 4 is stopped.

Fig. 4 is a graph showing how values of the input voltage V_{IN} are related to the rotation number of the mixer 25 in the developing unit 4 when the developer of reference toner concentration is used and V_{OUT} becomes equal to V_{STD}.

The rate of rotation numbers of the developing roller 22 and the mixer 25 is set 1 : 2 in the case of this embodiment. Under the normal mode, therefore, the rotation number of the roller 22 is set 150rpm and that of the mixer 25 is set 300rpm. And they are set 100rpm and 200rpm in the gradation-reproducing mode. Image characteristics (or relations of original and copy densities) in normal and gradation-reproducing modes, therefore, are as shown in Fig. 5. An apparent from Fig. 5, the curve of a line obtained in the gradation-reproducing mode is more gentle, which shows more rich in tone and which tells that the tone reproducing mode is more suitable for reproducing photos.

As described above, the rotation numbers of the developing unit 4 are set A (which represents that the developing roller 22 is 150rpm and that the mixer 25 is 300rpm) in the normal mode and they are set B (which represents that the developing roller 22 is 100rpm and the mixer 25 is 200rpm) in the gradation-reproducing mode. When the input voltage V_{IN} applied to the magnetic sensor 30 is set relative to A and B in such a way that $V_{IN}(A)$ = 6.25V and that $V_{IN}(B)$ = 3.5V, therefore, the output voltages $V_{OUT}(A)$ and (B) of the magnetic sensor 30 relative to the developer D of reference concentration at A and B become like that $V_{OUT}(A) = V_{OUT}(B) = V_{STD}$ = 4V. The toner concentration can be therefore controlled with a higher reliability whichever of these rotation numbers A and H is used.

$V_{IN}(A)$ and (B) may be set at the time when the toner is exchanged with new one. Or they may be previously related to each other in such a way that one of them is set but the other is automatically determined at the time when the toner is exchanged with new one. Or both of them are previously set in such a way that they can be left unchanged at the time when the toner is exchanged with new one.

Fig. 6 is a flow chart showing the flow of a process of selecting the rotation number of the developing unit 4, selecting V_{IN}, starting the copying operation, determining whether or not the toner

is added, and finishing the copying operation.

When the mode is selected by the mode changing key 41 on an operation panel, the rotation number of the developing unit 4 can be selected.

When the mode is selected in this manner, the rotation numbers of the developing roller 22 and first and second mixers 24 and 25 and the input voltage V_{IN} of the magnetic sensor 30 are determined by the CPU 40 (ST1 through ST3).

When the copying is started as shown at ST4, the output voltage V_{OUT} of the magnetic sensor 30 is measured as shown at ST5.

When $V_{OUT} > V_{STD}$ as shown at ST6, the toner is added as shown at ST7.

As described above, the magnetic sensor 30 is arranged so that its output voltage V_{OUT} rises as the toner concentration becomes low. In addition, the reference voltage V_{STD} is set equal to 4V when the reference toner concentration is 4%. When $V_{OUT} > V_{STS}$ (= 4V), therefore, the toner is added to the developing unit 4. The output voltage V_{OUT} becomes lower as the toner concentration in the developing unit 4 becomes higher, and when $V_{OUT} \leqq V_{STD}$, the adding of toner is stopped.

As shown at ST8, the control of toner added is continued, while measuring the magnetic sensor 30, until the copying is finished.

According to the present invention as described above, V_{IN}(A) and (B) which are selected in such a way that $V_{OUT} = V_{STD}$ at the rotation numbers A and B of the developing unit are stored in the memory 44 when the magnetic sensor 30 is to be adjusted at the step of exchanging the toner with new one. And when the rotation numbers of the developing roller 22 and first and second mixers 24 and 25 are changed at the step of changing the mode from normal to gradation-reproducing one and vice versa, the value of V_{IN} is changed responsive to their rotation numbers. Therefore, the toner concentration in the developer D can be held certain to keep image stability higher.

Although the magnetic sensor 30 has been located under the second mixer 25 in the above case, it is not limited to this position.

It should be understood that various changes and modifications can be made without departing from the spirit and scope of the present invention.

Claims

1. A developing apparatus, comprising:

means (4) for applying a developing material to an electrostatic latent image at one of a first amount of developing material and a second amount of developing material which is different from the first amount of developing material, so as to develop the electrostatic latent image;

means (41) for selecting the first amount of developing material for said applying means in a first mode for developing a normal image, and selecting the second amount of developing material for said applying means in a second mode for developing an image hearing higher quality than the normal image;

means (30) for detecting a concentration of the developing material contained in said developing means, and outputting a data indicating the concentration of the developing material; and

means (40) for adjusting the data outputted by said detecting means in accordance with the amount of developing material selected by the selecting means.

2. The developing apparatus according to claim 1, characterized in that said developing material is consisted of toner and carrier.

3. The developing apparatus according to claim 2, characterized in that the data outputted by the detecting means (30) shows a voltage which varies with a change in magnetic permeability of the developing material contained in said applying means (4).

4. A developing apparatus comprising:

an image carrier (1);

means (3) for forming an electrostatic latent image on said image carrier (1);

means (4) for developing the electrostatic latent image formed on said image carrier (1), by applying a developing material to said image carrier (1);

means (40) for setting a rate at which to apply the developing means to said image carrier;

means (40), having a detecting surface located within said developing means (4), for detecting a magnetic permeability of the developing material contained in said developing means (4);

means (40) for applying a first voltage to said permeability-detecting means, said first voltage having been determined by the supply-rate set by said supply-rate setting means;

means (40) for changing the first voltage applied by said voltage-applying means to a second voltage in accordance with the magnetic permeability detected by said permeability-detecting means and for outputting the second voltage; and

means (30) for detecting the amount of the developing material contained in said developing means, from the second voltage outputted by said voltage-changing means (40).

5. The developing apparatus according to claim 4, characterized in that said developing material is consisted of toner and carrier.

6. The developing apparatus according to claim 5, characterized in that said detecting means (30) detects the toner concentration of the developing material.

7. The developing apparatus according to claim 6, which further comprises mode-selecting means (41) for selecting a normal mode for forming normal images or a gradation-reproducing mode for forming images with gradation, and in which said supply-rate setting means sets the rate of applying the developing material to said image carrier (1), in accordance with the mode selected by said mode-selecting means.

8. A developing apparatus comprising:

an image carrier (1);

means (3) for forming an electrostatic latent image on said image carrier (1);

means (20), having a developing material containing unit for containing developing material and a rotary member (22), for applying developing material from the containing unit to said image carrier when rotated at a given speed, thereby to develop the electrostatic latent image formed on said image carrier;

means (42) for rotating said rotary member at a given speed;

means (30), having a detecting surface located within said developing means (4), for detecting a magnetic permeability of the developing material contained in said developing means (4);

means (40) for applying a first voltage of a given value to said permeability-detecting means (30);

means (30) for controlling said voltage-applying means to change the voltage applied to said permeability-detecting means, in accordance with the speed at which said rotary member is rotated by said rotating means;

means (40) for changing the first voltage applied by said voltage-applying means (40) to a second voltage in accordance with the magnetic permeability detected by said permeability-detecting means (30) and for outputting the second voltage; and

means for detecting the amount of the developing material contained in said developing means, from the second voltage outputted by said voltage-changing means.

9. The developing apparatus according to claim 8, characterized in that said developing material is consisted of toner and carrier.

10. The developing apparatus according to claim 9, characterized in that said detecting means (30) detects toner concentration of the developing material from the first voltage applied by said voltage-applying means (40), and determines the amount of the toner contained in said developing means (20) from the toner concentration.

11. The developing apparatus according to claim 8, characterized by further comprising mode-selecting means (41) for selecting a normal mode for forming normal images or a gradation-reproducing mode for forming images with gradation, and control means (40) for controlling said rotating means such that said rotating means rotates said rotary member at a first speed when said mode-selecting means (41) selects the normal mode and at a second speed lower than the first speed when said mode-selecting means (41) selects the gradation-reproducing mode.

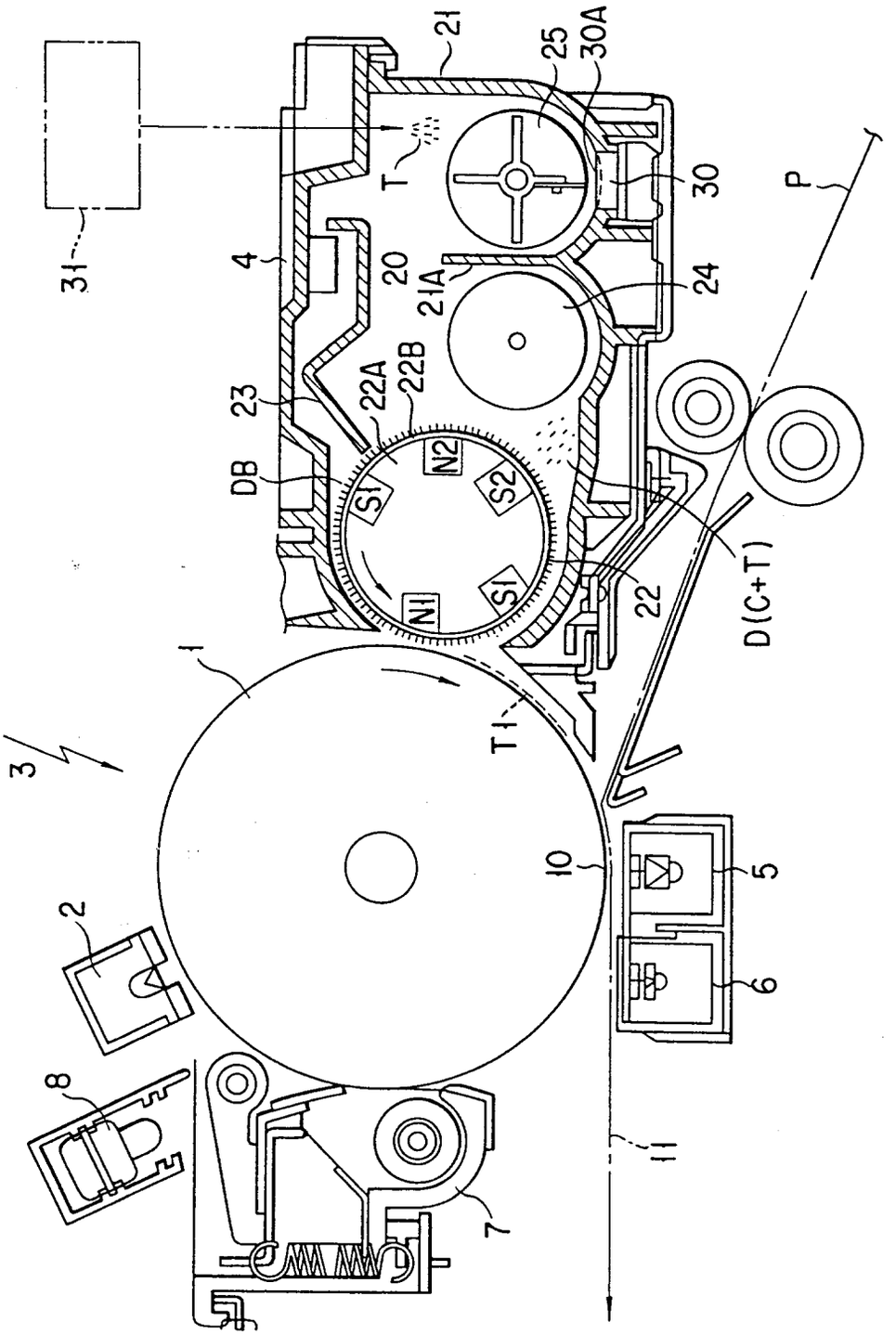
21
25
30A
T
30
P
31
4
20
21A
24
23
22A
22B
DB
S1
N2
S2
S1
N1
22
D(C+T)
1
T1
3
10
5
2
6
8
11
7

FIG. 1

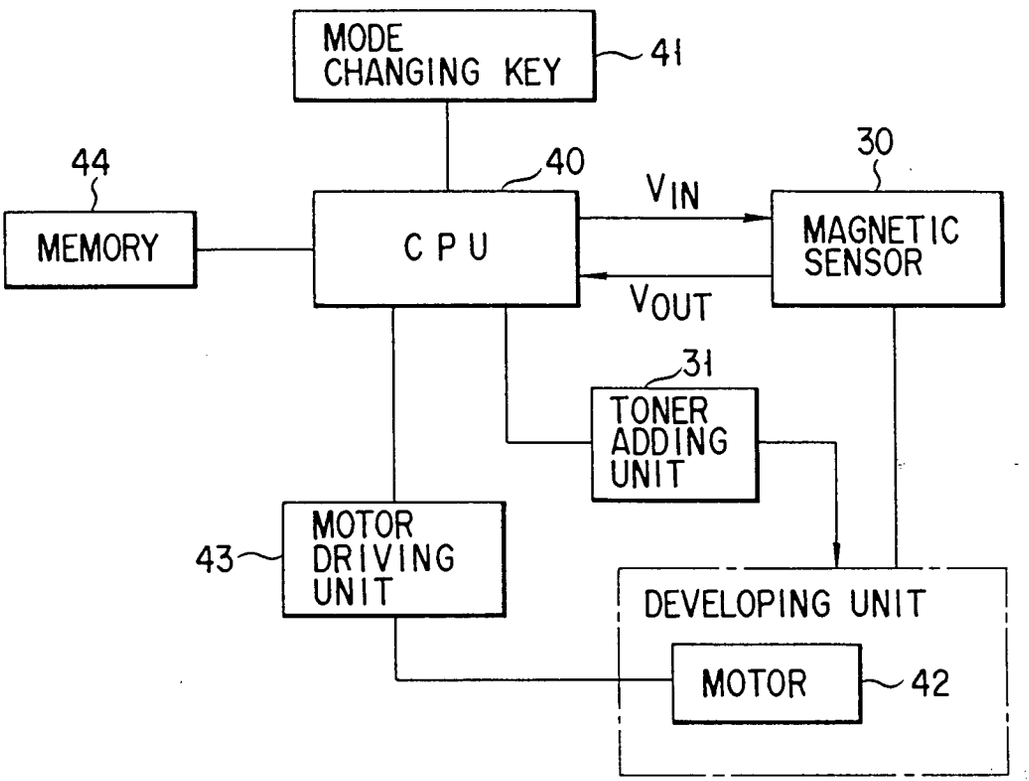
MODE CHANGING KEY
41
44
40
30
MEMORY
CPU
VIN
MAGNETIC SENSOR
VOUT
31
TONER ADDING UNIT
43
MOTOR DRIVING UNIT
DEVELOPING UNIT
MOTOR
42

FIG. 2

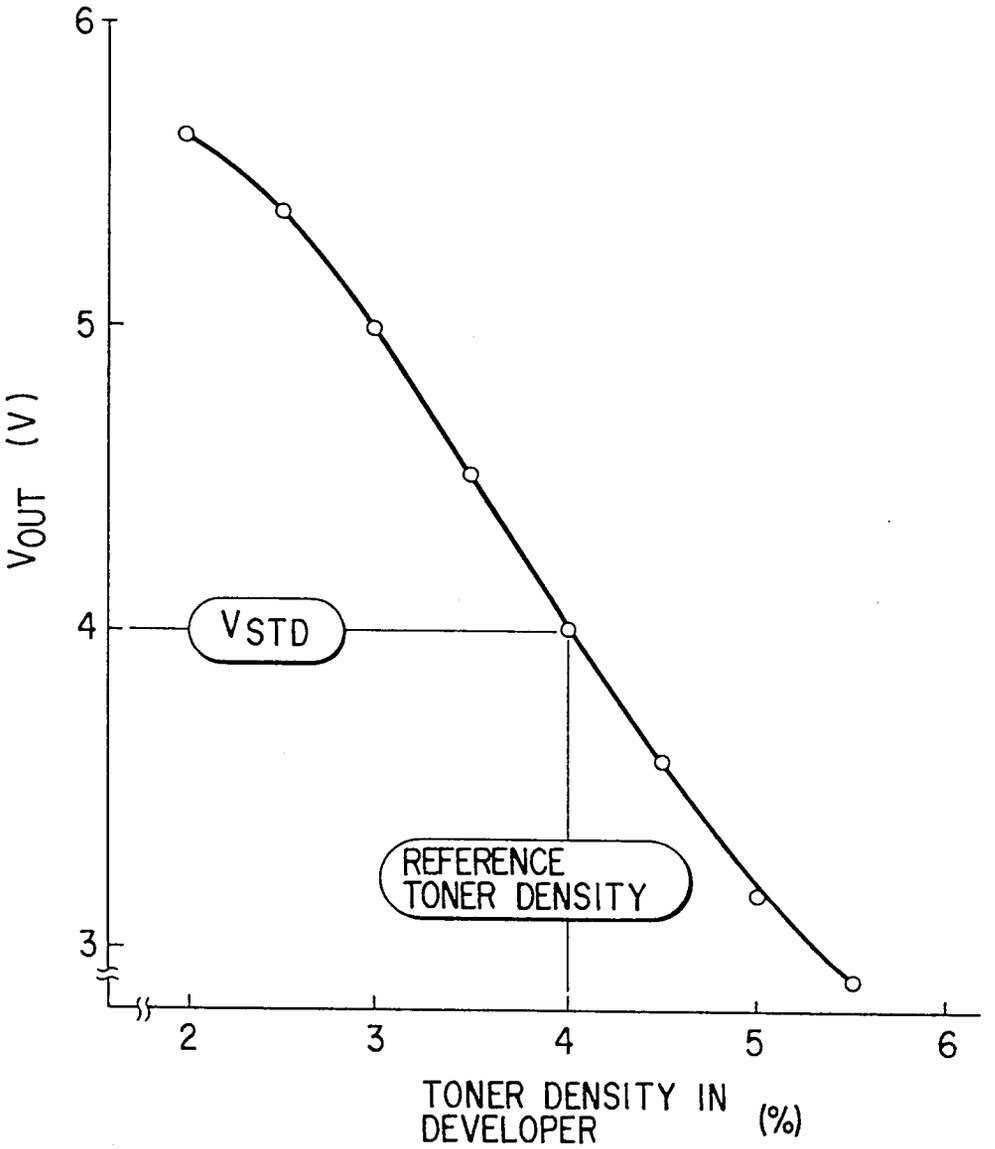
6
5
4
3
VOUT (V)
VSTD
REFERENCE
TONER DENSITY
2
3
4
5
6
TONER DENSITY IN
DEVELOPER
(%)

FIG. 3

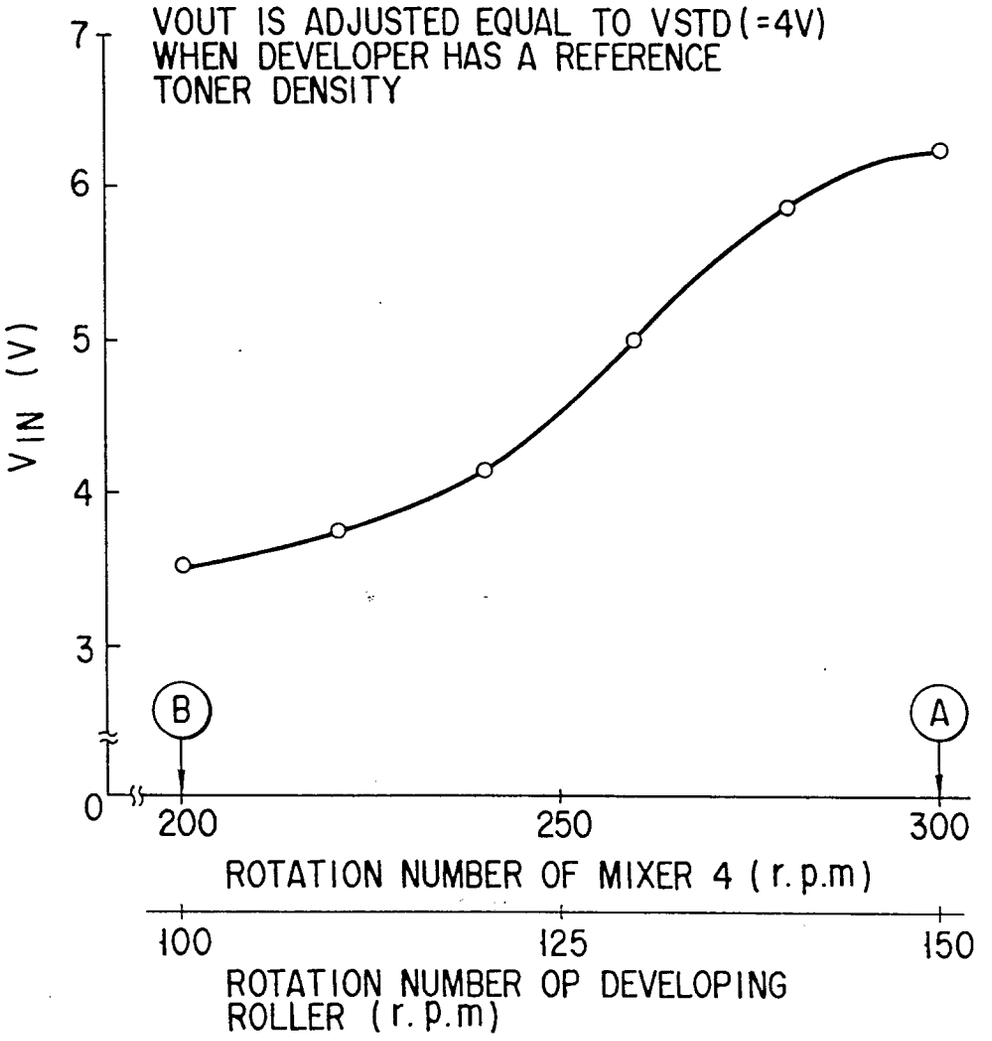
VOUT IS ADJUSTED EQUAL TO VSTD (=4V)
WHEN DEVELOPER HAS A REFERENCE
TONER DENSITY
7
6
5
4
3
0
VIN (V)
B
A
200
250
300
ROTATION NUMBER OF MIXER 4 (r.p.m)
100
125
150
ROTATION NUMBER OP DEVELOPING
ROLLER (r.p.m)

FIG. 4

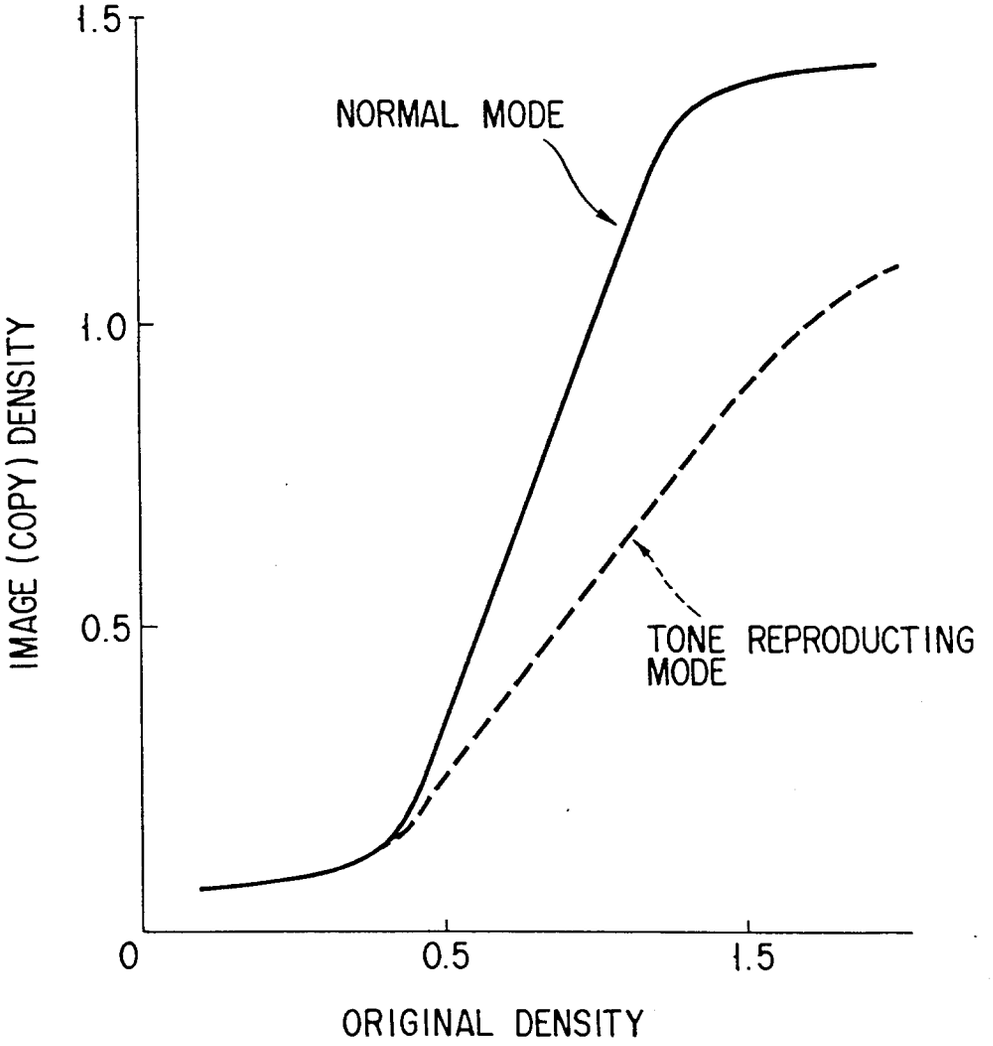
1.5
1.0
0.5
0
0.5
1.5
IMAGE (COPY) DENSITY
ORIGINAL DENSITY
NORMAL MODE
TONE REPRODUCTING MODE

FIG. 5

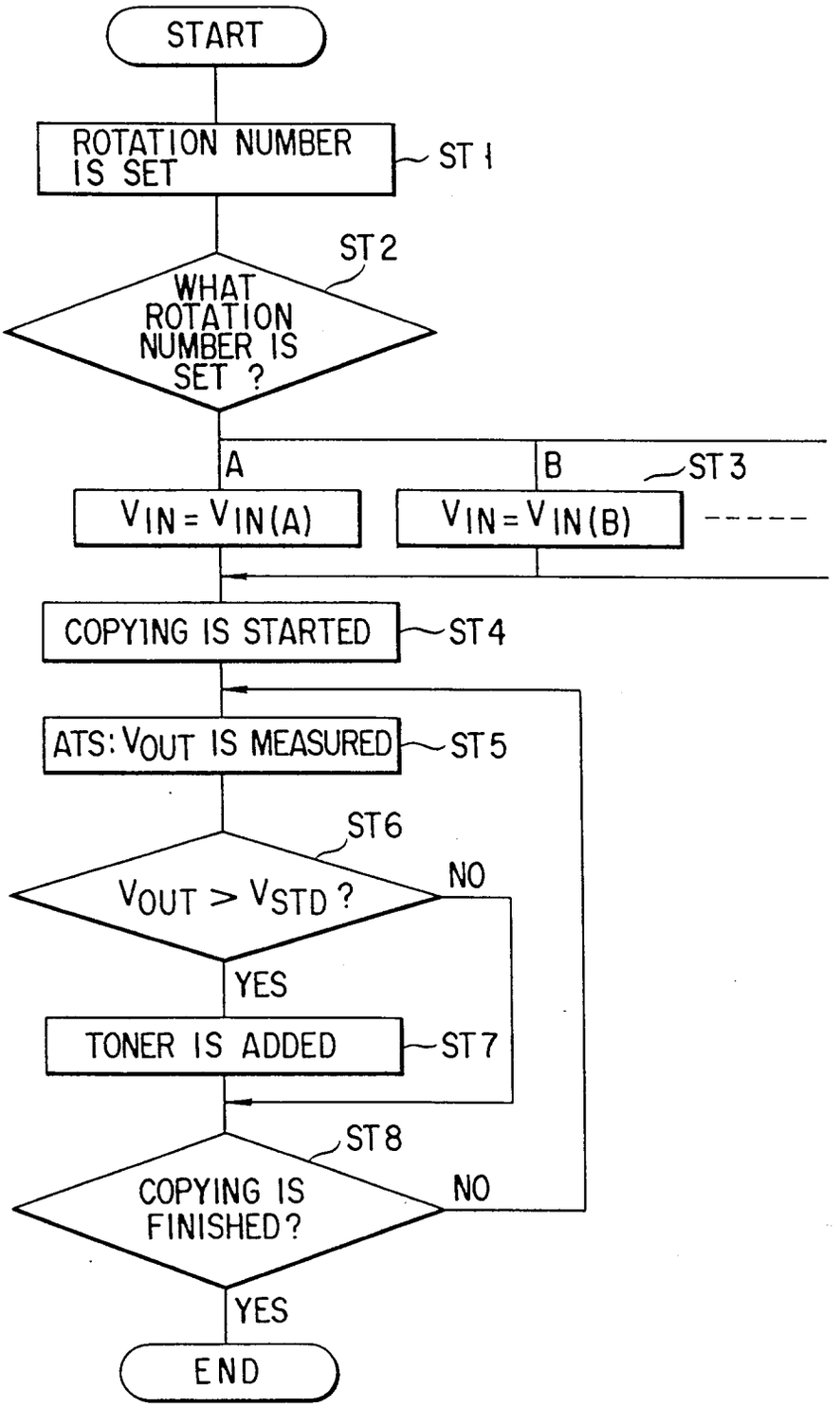
START
ROTATION NUMBER IS SET
ST1
ST2
WHAT ROTATION NUMBER IS SET ?
A
B
ST3
VIN = VIN(A)
VIN = VIN(B)
COPYING IS STARTED
ST4
ATS: VOUT IS MEASURED
ST5
ST6
VOUT > VSTD ?
NO
YES
TONER IS ADDED
ST7
ST8
COPYING IS FINISHED?
NO
YES
END

FIG. 6