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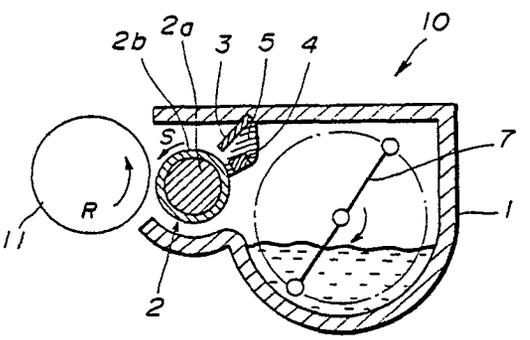
(54) Developing unit and image forming apparatus having the developing unit.

(57) A developing unit is used for for supplying a developer to a photosensitive body (11) for visualizing an electrostatic image on the photosensitive body into a toner image. The developing unit comprises a developer hopper (1) for accommodating the developer which includes a toner and carriers which are magnetic, a rotatable developing roller (2) for supplying the developer within the developer hopper and comprising an inner magnet roll (2a) and a non-magnetic outer sleeve (2b) which has a peripheral surface on which the developer is carried, a doctor blade (3, 3A, 3B) which is provided in a vicinity of the developing roller and forms a predetermined gap between the peripheral surface of the outer sleeve so that a thickness of the developer on the peripheral surface of the outer sleeve is restricted to a predetermined thickness, and a carrier accumulating part (4, 4A, 4B) provided in a vicinity of the doctor blade on an upstream side of a direction in which the developer within the developer hopper generally flows. The carrier accumulating part interacts with the inner magnet roll of the developing roller and forms a magnetic field between the inner magnet roll, so that a developer accumulation formed in a vicinity of the doctor blade has a carrier concentration higher than that at other parts within the developer hopper.

FIG.4



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DEVELOPING UNIT AND IMAGE FORMING APPARATUS HAVING THE DEVELOPING UNIT

BACKGROUND OF THE INVENTION

The present invention generally relates to developing units and image forming apparatuses having the developing units, and more particularly to a developing unit of an image forming apparatus which develops an electrostatic image which is formed on a peripheral surface of a photosensitive body by use of a 2-component developer which includes toner and carrier and the image forming apparatus which has the developing unit.

In image forming apparatuses such as a printer and a copying machine which form an image by electrophotography, a developing unit usually develops an electrostatic image which is formed on a peripheral surface of a photosensitive body by use of a developer. Such a developing unit generally uses as the developer a 2-component developer which includes toner and magnetic carrier, and it is important from the point of view of maintaining a high picture quality of the prints to maintain a mixture ratio of the toner and the carrier (that is, a toner density) constant.

Recently, the printer employs the so-called face-down system which ejects printed sheets with the face down and stacks the printed sheets so that the pages of the printed sheets become sequential. On the other hand, transport paths of the recording sheets should be simplified in order to maintain high stability and high reliability of the printer.

FIG.1 shows an essential part of a typical conventional printer. The printer shown in FIG.1 is designed so that a recording sheet 82 is transported above a photosensitive drum 81 in an approximately horizontal position. A developing unit 83 is arranged under a transport path of the recording sheet 82. A developing roller 84 which supplies a developer from the developing unit 83 to the photosensitive drum 81 is arranged in an upper half portion of the developing unit 83. A cleaning unit 85 is arranged on a downstream side of the photosensitive drum 81 along a transport direction of the recording sheet 82.

Some printers have a developing unit with means for electronically controlling the toner density to approximately 5 weight percent, for example. However, in printers which use a developer which is accommodated within a cartridge, the carrier is thrown away every time the developer cartridge is changed. For this reason, if possible, it is desirable to minimize the mixture ratio of the carrier. Then, this makes it possible to eliminate the need for controlling the toner density.

FIG.2 shows an essential part of a conventional printer which has no means for controlling the toner density. A developer hopper 91 has an agitator 92 which agitates the developer within the developer hopper 91. A developing roller 93 supplies the toner within the developer to a photosensitive drum 100 so as to develop an electrostatic image which is formed on a peripheral surface of the photosensitive drum 100. The developing roller 93 is made up of a magnet roll which constitutes a core magnetic portion and a non-magnetic outer sleeve. The outer sleeve and the inner magnet roll can rotate independently. A doctor plate 94 which is made of a non-magnetic material is fixed on the developer hopper 91 so as to restrict a thickness of a developer layer which is formed on the developing roller 93. The developer is supplied to the photosensitive drum 100 by the developing roller 93.

In the developing unit of the printer shown in FIG.2, the developer is accumulated on the back of the restricting plate 94 and forms a developer accumulation 95. Hence, the mixture ratio of the carrier at the periphery of the developing roller 93 is not controlled.

The developing unit shown in FIG.2 operates on the assumption that the carrier of the developer is accumulated on the back of the restricting plate 94 when the developer accumulation 95 is formed. However, there is no guarantee that a sufficiently large quantity of the carrier is accumulated in the developer accumulation 95. For this reason, as the quantity (or level) of the developer within the developer hopper 91 decreases, there are problems in that the toner density decreases in the vicinity of the developing roller 93 and the picture quality of the prints becomes poor.

SUMMARY OF THE INVENTION

Accordingly, it is a general object of the present invention to provide a novel and useful developing unit in which the problems described above are eliminated.

Another and more specific object of the present invention is to provide a developing unit for supplying a developer to an image bearing member for visualizing an electrostatic image on the image bearing member into a toner image, comprising a developer hopper for accommodating the developer which includes toner and magnetic carrier, a rotatable developing roller for supplying the developer within the developer hopper and comprising an inner magnet roll and a non-magnetic outer sleeve which has a peripheral surface on which the developer is carried, a doctor blade which is provided within the developer hopper in a

vicinity of the developing roller and having a tip end which forms a predetermined gap between the peripheral surface of the outer sleeve so that a thickness of the developer on the peripheral surface of the outer sleeve is restricted to a predetermined thickness, and carrier accumulating means provided in a vicinity of the doctor blade on an upstream side along a direction in which the developer within the developer hopper generally flows towards the developing roller. The carrier accumulating means forms a magnetic field so that a developer accumulation formed in a vicinity of the doctor blade has a carrier concentration higher than that of the developer at other parts within the developer hopper. According to the developing unit of the present invention, it is possible to positively form the developer accumulation which has a high concentration of the carrier in the vicinity of the developing roller. For this reason, it is possible to ensure an appropriate toner density on the developing roller and stably supply the developer to the photosensitive body without the need to provide a special toner density control device. As a result, prints of improved picture quality can be made in an image forming apparatus which uses the developing unit.

Still another object of the present invention is to provide an image forming apparatus comprising an image bearing member, a developer hopper for accommodating a developer which includes toner and magnetic carrier, a rotatable developing roller for supplying the developer within the developer hopper to the image bearing member so as to visualize an electrostatic image on the image bearing member into a toner image, where the developing roller comprises an inner magnet roll and a non-magnetic outer sleeve which has a peripheral surface on which the developer is carried, a doctor blade which is provided within the developer hopper in a vicinity of the developing roller, where the doctor blade has a tip end which forms a predetermined gap between the peripheral surface of the outer sleeve so that a thickness of the developer on the peripheral surface of the outer sleeve is restricted to a predetermined thickness, carrier accumulating means provided in a vicinity of the doctor blade on an upstream side along a direction in which the developer within the developer hopper generally flows towards the developing roller, where the carrier accumulating means forms a magnetic field so that a developer accumulation formed in a vicinity of the doctor blade has a carrier concentration higher than that of the developer at other parts within the developer hopper, transport means for transporting a recording sheet to the image bearing member, and transfer means for transferring the toner image on the image bearing member onto the recording sheet. According to the image forming apparatus of the present invention, it is possible to positively form the developer accumulation which has a high concentration of the carrier in the vicinity of the developing roller. For this reason, it is possible to ensure an appropriate toner density on the developing roller and stably supply the developer to the photosensitive body without the need to provide a special toner density control device. As a result, prints of improved picture quality can be made.

Other objects and further features of the present invention will be apparent from the following detailed description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG.1 is a side view in cross section showing an essential part of a typical conventional printer;

FIG.2 is a side view in cross section showing an essential part of a conventional printer which has no means for controlling a toner density;

FIG.3 is a side view in cross section generally showing a laser printer to which a first embodiment of a developing unit according to the present invention is applied;

FIG.4 is a side view in cross section showing the first embodiment of the developing unit according to the present invention together with a photosensitive drum;

FIG.5 is a side view in cross section showing an essential part of a lasers printer to which a second embodiment of the developing unit according to the present invention is applied;

FIG.6 is a toner density versus number of prints characteristic for explaining the effects of the present invention; and

FIG.7 is a side view in cross section showing an essential part of a third embodiment of the developing unit according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG.3 generally shows a laser printer to which a first embodiment of a developing unit according to the present invention is applied. The laser printer shown in FIG.3 comprises a developing unit 10, a photosensitive drum 11, a precharger 12, an electrostatic image forming means 13 which is made up of a light emitting diode (LED) array, for example, a transfer unit 14 a discharger 15, a cleaning unit 16, and a fixing unit 17 which is provided to the left of the transfer unit 14.

A recording sheet 19 which is placed on a hopper 18 is fed towards a feed roller 21 by a pick roller 20 which rotates while pressing the recording

sheet 19 against the hopper 18. The photosensitive drum 11 rotates in a direction R. The recording sheet 19 is fed from the hopper 18 by the feed roller 21 through a transport path 22, and a guide roller 23 transports this recording sheet 19 to the transfer unit 14 in synchronism with the rotation of the photosensitive drum 11.

The formation of a toner image on the photosensitive drum 11 and the transfer of the toner image onto the recording sheet 19 are carried out in the following manner.

The peripheral surface of the photosensitive drum 11 is uniformly charged by the precharger 12, and an electrostatic image is formed on the peripheral surface of the photosensitive drum 11 depending on an image data which describes an image which is to be printed on the recording sheet 19. The electrostatic image on the photosensitive drum 11 is visualized into a toner image by the developing unit 10. The toner image is transferred onto the recording sheet 19 by the transfer unit 14, and the recording sheet 19 which has the toner image is transported to the left in FIG.3 where the fixing unit 17 fixes the toner image on the recording sheet 19. Finally, the recording sheet 19 is ejected face down (that is, with the image facing down) onto a stacker 25 by an eject roller 24.

After the toner image is transferred onto the recording sheet 19, the peripheral surface of the photosensitive drum 11 is discharged by the discharger 15 and the residual toner on the photosensitive drum 11 is removed from the peripheral surface by the cleaning unit 16.

FIG.4 shows the developing unit 10 on an enlarged scale together with the photosensitive drum 11. The developing unit 10 comprises a developer hopper 1 which accommodates a developer which includes toner and carrier. The toner and carrier are both magnetic materials, and the mixture ratio of the carrier is in a range of approximately 10 to 20 weight percent with respect to the toner.

For example, the toner is a fine powder mixture of resin, carbon black and magnetite. On the other hand, the carrier is a fine powder of ferrite or magnetite. However, it is not essential that the toner is magnetic.

An agitator 7 is provided within the developer hopper 1 for agitating the developer within the developer hopper 1. The agitator 7 rotates clockwise and lifts the developer towards the top left of the developer hopper 1 in FIG.4. A developing roller 2 is rotatably provided in an upper half portion of the developer hopper 1. The developing roller 2 is made up of an inner magnet roll 2a, and an outer non-magnetic sleeve 2b which has a hollow cylindrical shape and is loosely fitted over the inner magnet roll 2a. The inner magnet roll 2a and the outer sleeve 2b are both rotatable, and the inner magnet roll 2a and the outer sleeve 2b may rotate in the same direction S. Alternatively, the outer sleeve 2b may rotate in the direction S and the inner magnet roll 2a may rotate in a direction opposite to the direction S. In this embodiment, it is assumed for the sake of convenience that the inner magnet roll 2a rotates in the direction S at a first rotational speed and the outer sleeve 2b also rotates in the direction S at a second rotational speed which is smaller than the first rotational speed. For example, the magnet roll 2a comprises a plurality of symmetric magnetic poles extending in an axial direction.

As the inner magnet roll 2a and the outer sleeve 2b rotate, the developer which is lifted by the agitator 7 is supplied to the photosensitive drum 11 by the developing roller 2. Hence, the electrostatic image formed on the peripheral surface of the photosensitive drum 11 is visualized into a toner image.

For example, the developing roller 2 which is made up of the inner magnet roll 2a and the outer sleeve 2b which are rotatable is known from the United States Patent No.4,640,880, and the rotation of the inner magnet roll 2a and the outer sleeve 2b in the mutually opposite directions is discussed in Asanae et al., "New Two-Component Electrostatic Developing Method", Hitachi Metals Technical Report, Vol.5, 1989. Accordingly, a detailed description of the developing roller 2 and the rotating direction of the inner magnet roll 2a and the outer sleeve 2b will be omitted in the present specification.

Of course, the inner magnet roll 2a may be fixed to the outer sleeve 2b. Such a structure is also well known in the art.

A doctor blade 3 is fixed on the developer hopper 1 in a vicinity of the developing roller 2. The doctor blade 3 is made of a non-magnetic plate which has a width approximately the same as the length of the developing roller 2. This doctor blade 3 has a fixed position relative to the developing roller 2 so that a predetermined gap (that is, a doctor gap) is formed between a free tip end of the doctor blade 3 and the peripheral surface of the developing roller 2. Hence, the developer which adheres on the peripheral surface of the developing roller 2 hits the doctor blade 3 when the thickness of the developer on the peripheral surface of the developing roller 2 exceeds the predetermined gap. As a result, the thickness of the developer on the peripheral surface of the developing roller 2 is maintained constant.

A carrier accumulating means 4 is provided in a vicinity of the doctor blade 3, that is, on the back side of the doctor blade 3 and on the upstream

side along the direction in which the developer flows. For example, the carrier accumulating means 4 comprises a magnetic material such as a magnet rod which has a length approximately the same as the length of the inner magnet roll 2a within the developing roller 2.

By the provision of the carrier accumulating means 4, a magnetic field is formed by the carrier accumulating means 4, and the carrier which has the magnetic characteristic is attracted by this magnetic field. Consequently, a developer accumulation 5 is formed in a vicinity of the carrier accumulating means 4 up to the doctor blade 3 as indicated by hatchings in FIG.4. Of course, the developer accumulation 5 includes the toner and the carrier. However, because the carriers are attracted by the magnetic field formed by the carrier accumulating means 4, the mixture ratio of the carrier in the developer accumulation 5 is high compared to the mixture ratio of the developer in the bottom portion of the developer hopper 1. For example, the mixture ratio of the carrier in the developer accumulation 5 is approximately 50 weight percent.

Therefore, the mixture ratio of the carrier is positively maintained to a relatively large value in the developer accumulation 5. For this reason, even when the mixture ratio of the carrier becomes low in the developer which is accommodated within the developer hopper 1, it is possible to stably supply a sufficient quantity of the carrier to the developing roller 2, and an appropriate toner density is always obtainable on the peripheral surface of the developing roller 2. It is also possible to maintain the mixture ratio of the carrier to a large value in an initial state where the quantity (level) of the developer within the developer hopper 1 is large. The picture quality of the prints is thus maintained to a satisfactory quality.

Next, a description will be given of a second embodiment of the developing unit according to the present invention. FIG.5 shows an essential part of a laser printer to which the second embodiment of the developing unit according to the present invention is applied. In FIG.5, those parts which are basically the same as those corresponding parts in FIGS.3 and 4 are designated by the same reference numerals, and a description thereof will be omitted.

In FIG.5, a doctor blade (restricting plate) 3A and the developing roller 2 are provided on a common bracket 30 so that the position of the doctor blade 3A is fixed relative to the developing roller 2. A carrier accumulating means 4A is provided directly on the doctor blade 3A. The carrier accumulating means 4A comprises a flexible or rubber magnet. For example, TF-RE magnet manufactured by MAGX and FP magnet manufactured by Tokyo Ferrite may be used as the flexible or rubber magnet.

In actual practice, it is desirable that the photosensitive drum 11 is slightly movable with respect to the developing roller 2 generally in the horizontal direction in FIG.5. When the photosensitive drum 11 moves slightly, the developing roller 2 must make a corresponding slight movement. For this reason, it is advantageous to provide the doctor blade 3A and the developing roller 2 on the same bracket 30 to maintain the fixed positional relationship between the doctor blade 3A and the developing roller 2 even when the developing roller 2 undergoes a slight movement.

According to this embodiment, a developer accumulation is formed similarly to the first embodiment, and the same effects of the first embodiment are obtainable.

Next, a description will be given of a toner density versus number of prints characteristic for explaining the effects of the present invention, by referring to FIG.6. In FIG.6, the ordinate indicates the toner density in weight percent, and the abscissa indicates the number of prints made. As the number of prints increases, the level of the developer within the developer hopper 1 decreases.

A characteristic II shown in FIG.6 is obtained with the second embodiment under the following conditions. The developing roller 2 has a diameter of 20 mm, and the outer sleeve 2b is made of aluminum. The outer sleeve 2b is rotated at 162 rpm in the direction S, and the inner magnet roll 2a is rotated at 1023 rpm in the same direction S. The inner magnet roll 2a has 8 symmetric magnetic poles with 750±50 G (Gauss) between the poles, and the magnetic field variance along the longitudinal direction of the developing roller 2 is 80 G or less. The doctor blade 3A is made of stainless steel which is non-magnetic. The carrier accumulating means 4A is made up of a flexible or rubber magnet having a size of 3mm x 8 mm x 200 mm and having a maximum energy product of 10^6 G Oe (Gaus-Oersted). The flexible or rubber magnet may be isotropic or anisotrpic. Further, each print which is made has a printed area (black area) which is approximately 5 % of the total area of the recording sheet 19.

On the other hand, a characteristic I shown in FIG.6 is obtained with the same structure excluding the carrier accumulating means 4A. It can be readily seen by comparing the characteristics I and II that the provision of the carrier accumulating means 4A considerably stabilizes the toner density as the developer level within the developer hopper 1 decreases.

Next, a description will be given of a third embodiment of the developing unit according to the present invention, by referring to FIG.7. In

FIG.7, those parts which are the same as those corresponding parts in FIG.5 are designated by the same reference numerals, and a description thereof will be omitted.

In this embodiment, a doctor blade 3B itself is magnetic and constitutes a carrier accumulating means 4B. For example, the doctor blade 3B is made of a metal, a zinc plated steel, an electrolytic zinc-coated steel sheet (SECC), a magnet and the like. According to this embodiment, substantially the same effects are obtainable as in the first and second embodiments.

In the described embodiments, the doctor blade and the developing roller are provided in the upper half portion of the developer hopper. However, the present invention is not limited to such an arrangement. For example, the doctor blade and the developing roller may be provided in the lower half portion of the developer hopper. In other words, the printer may be used in any position.

Moreover, the present invention is not limited to the application to the printer. The present invention is applicable to other image forming apparatuses such as copying machines and facsimile machines.

In addition, the developing unit may take a form of a cartridge which is replaceable.

The image forming apparatus is not necessarily limited to the electrophotographic apparatus and may be an electrostatic apparatuses.

Of course, the cross sectional shape of the carrier accumulating means 4A is not limited to square or rectangular shapes, and may have other shapes such as circular and oval shapes.

Further, the present invention is not limited to these embodiments, but various variations and modifications may be made without departing from the scope of the present invention.

Claims

1. A developing unit for supplying a developer to an image bearing member (11) for visualizing an electrostatic image on the image bearing member into a toner image, said developing unit comprising a developer hopper (1) for accommodating the developer which includes toner and carrier, said carrier being magnetic, a rotatable developing roller (2) for supplying the developer within said developer hopper, said developing roller comprising an inner magnet roll (2a) and a non-magnetic outer sleeve (2b) which has a peripheral surface on which the developer is carried, and a doctor blade (3, 3A, 3B) which is provided within said developer hopper in a vicinity of said developing roller, said doctor blade having a tip end which forms a predetermined gap between the peripheral surface of said outer sleeve so that a thickness of the developer on the peripheral surface of said outer sleeve is restricted to a predetermined thickness, characterized in that there is provided: carrier accumulating means (4, 4A, 4B) provided in a vicinity of said doctor blade (3, 3A, 3B) on an upstream side of a direction in which the developer within said developer hopper (1) generally flows, said carrier accumulating means forming a magnetic field so that a developer accumulation (5) formed in a vicinity of said doctor blade has a carrier concentration higher than that at other parts within said developer hopper.

2. The developing unit as claimed in claim 1, characterized in that said carrier accumulating means (4, 4A, 4B) comprises a magnetic member (4, 4A, 4B).

3. The developing unit as claimed in claim 2, characterized in that said magnetic member (4, 4A, 4B) is made of a flexible magnet.

4. The developing unit as claimed in claim 2 or 3, characterized in that said magnetic member (4A) is provided directly on said doctor blade (3A).

5. The developing unit as claimed in any of claims 1 to 4, characterized in that said doctor blade (3, 3A, 3B) is made of a non-magnetic material.

6. The developing unit as claimed in any of claims 1 to 4, characterized in that said doctor blade (3B) is made of a magnetic material, said doctor blade itself constituting said carrier accumulating means (4B).

7. The developing unit as claimed in any of claims 1 to 6, characterized in that said doctor blade (3) is provided on said developer hopper (1) with a fixed position relative to said developing roller (2).

8. The developing unit as claimed in any of claims 1 to 6, characterized in that there is further provided a bracket (30) for rotatably supporting said developing roller (2), said doctor blade (3A, 3B) being provided on said bracket with a fixed position relative to said developing roller.

9. The developing unit as claimed in any of claims 1 to 8, characterized in that said inner magnet roll (2a) is fixed to said outer sleeve (2b).

10. The developing unit as claimed in any of claims 1 to 8, characterized in that said inner magnet roll (2a) comprises a plurality of symmetric magnetic poles, and is rotatable independently of said outer sleeve (2b).

11. The developing unit as claimed in claim 10, characterized in that said inner magnet roll (2a) and said outer sleeve (2b) are rotatable in the same direction at mutually different rotational speeds.

12. The developing unit as claimed in claim 10, characterized in that said inner magnet roll (2a) and said outer sleeve (2b) are rotatable in mutually

opposite directions.

13. The developing unit as claimed in any of claims 1 to 12, characterized in that an average a mixture ratio of the carriers with respect to the toner within the developer is in a range of approximately 10 to 20 weight percent.

14. The developing unit as claimed in claim 13, characterized in that said developer accumulation (5) has a mixture ratio of approximately 50 weight percent.

15. The developing unit as claimed in any of claims 1 to 14, characterized in that the toner within the developer is magnetic.

16. The developing unit as claimed in any of claims 1 to 15, characterized in that there is further provided an agitator (7) which is provided within said developer hopper (1) for agitating the developer within said developer hopper.

17. The developing unit as claimed in any of claims 1 to 16, characterized in that said developing roller (2) and said doctor blade (3, 3A, 3B) are provided in an upper half portion of said developer hopper (1).

18. An image forming apparatus comprising an image bearing member (11), a developer hopper (1) for accommodating a developer which includes toner and carrier, said carrier being magnetic, a rotatable developing roller (2) for supplying the developer within said developer hopper to said image bearing member so as to visualize an electrostatic image on the image bearing member into a toner image, said developing roller comprising an inner magnet roll (2a) and a non-magnetic outer sleeve (2b) which has a peripheral surface on which the developer is carried, a doctor blade (3, 3A, 3B) which is provided within said developer hopper in a vicinity of said developing roller, said doctor blade having a tip end which forms a predetermined gap between the peripheral surface of said outer sleeve so that a thickness of the developer on the peripheral surface of said outer sleeve is restricted to a predetermined thickness, transport means (21, 23) for transporting a recording sheet (19) to said image bearing member, and transfer means (14) for transferring the toner image on said image bearing member onto the recording sheet, characterized in that there is further provided: carrier accumulating means (4, 4A, 4B) provided in a vicinity of said doctor blade (3, 3A, 3B) on an upstream side along a direction in which the developer within said developer hopper (1) generally flows towards said developing roller (2), said carrier accumulating means forming a magnetic field so that a developer accumulation formed in a vicinity of said doctor blade has a carrier concentration higher than that of the developer at other parts within said developer hopper.

19. The image forming apparatus as claimed in claim 18 wherein said image bearing member (11) has a rotatable drum, characterized in that said transport means (21, 23) transports the recording sheet (19) above said image bearing member to make contact with said image bearing member, and said developing roller (2) is provided in an upper half portion of said developer hopper (1).

20. The image forming apparatus as claimed in claim 18 or 19, characterized in that said carrier accumulating means (4, 4A, 4B) comprises a magnetic member (4, 4A, 4B).

FIG. 1 PRIOR ART

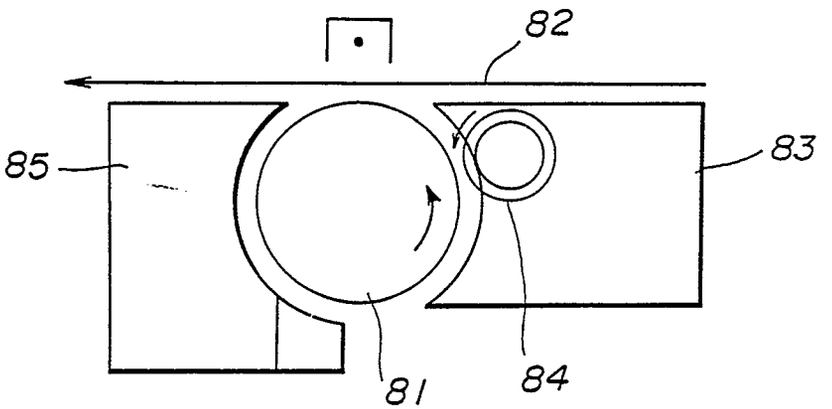

FIG. 2 PRIOR ART

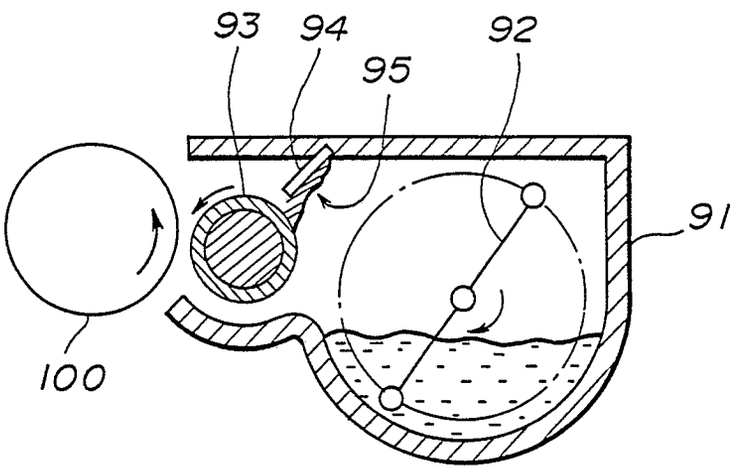

FIG.3

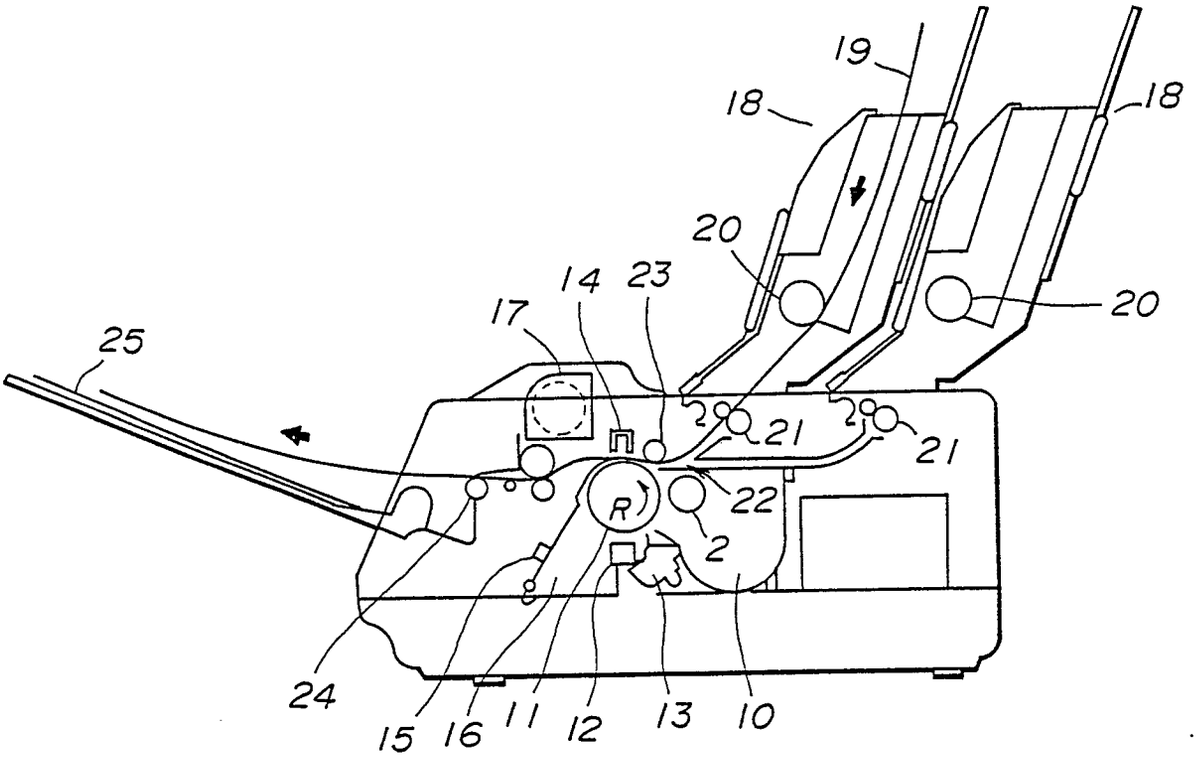
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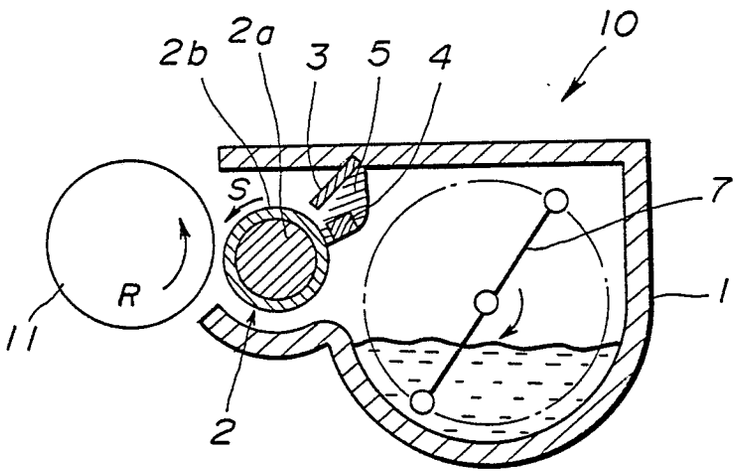
FIG.4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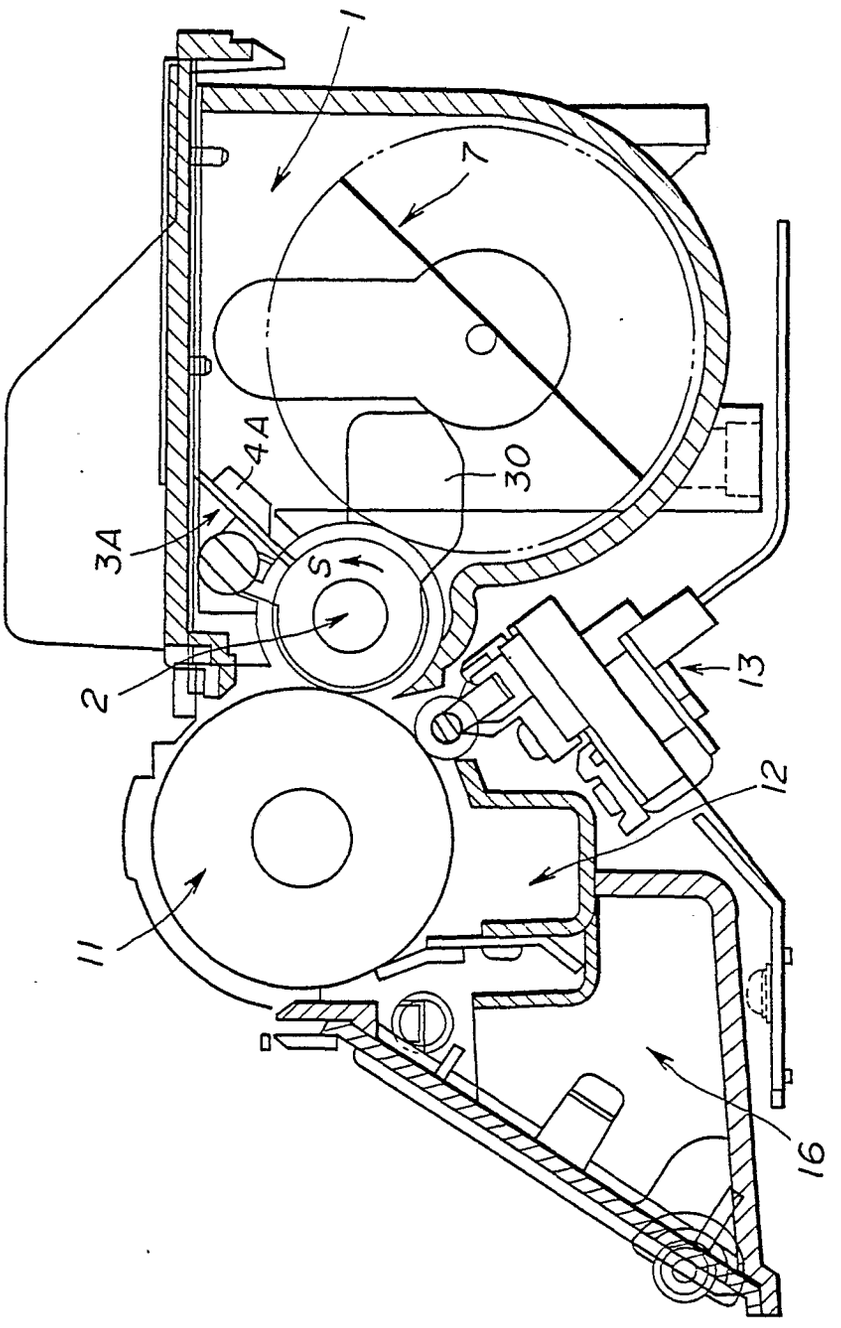

FIG.5

FIG.6

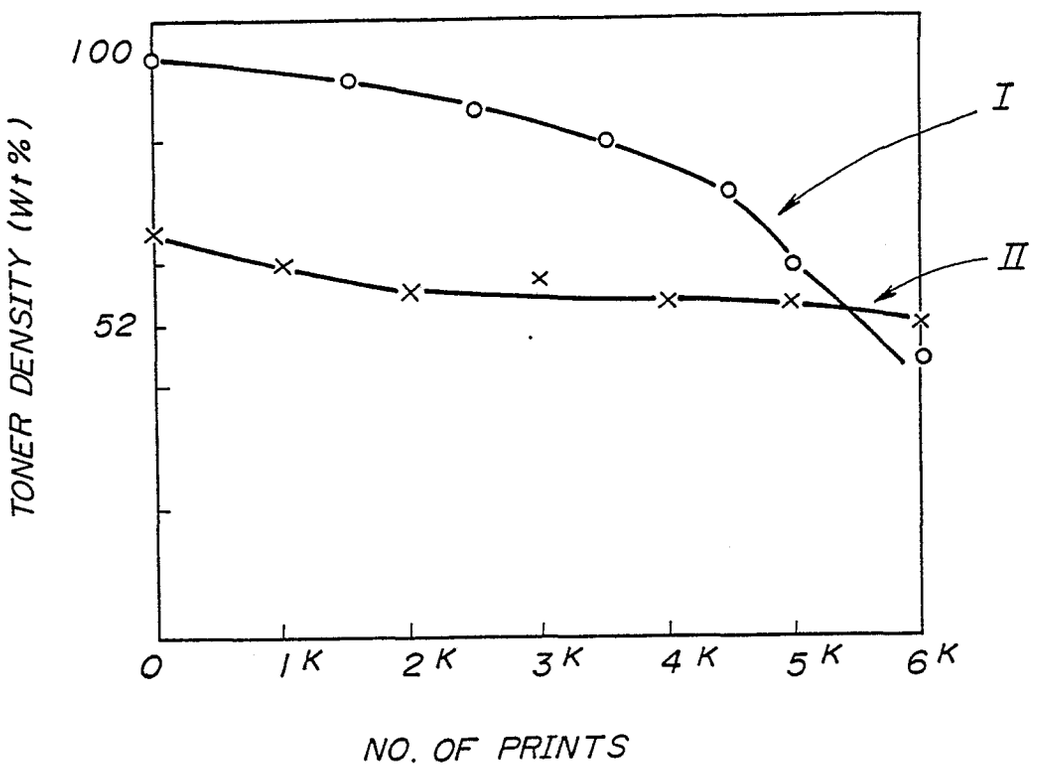

FIG. 7