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(54) **DEVELOPING APPARATUS.**

(57) A magnetic brush developing apparatus which comprises a nonmagnetic conductive cylindrical developer transfer member and a magnetic roller having a plurality of magnetic poles and disposed inside the developer transfer member, and which transfers the developer on the developer transfer member in accordance with the magnetic field generated by the relative rotation of the transfer member and the roller, wherein the magnetic roller consists of a magnet having a maximum energy product of at least 4 MGOe. It becomes possible to use a fine developer containing a small quantity of magnetic powder and to develop a high quality, full-line color image.

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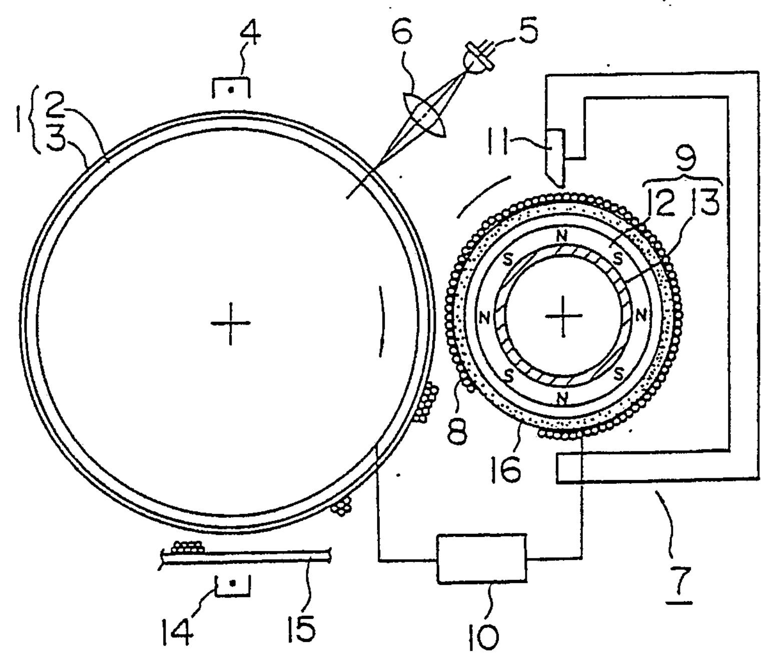

FIG. 1

DEVELOPING DEVICE

FIELD OF THE INVENTION

This invention relates to image recording devices which use an electrophotographic process, and more particularly it relates to developing devices for developing electrostatic latent images formed on a latent image carrier.

BACKGROUND OF THE INVENTION

In commonly known magnetic brush developing devices (one-component magnetic brushes and two-component magnetic brushes) of the prior art, a magnetic roller magnetized with a plurality of magnetic poles is positioned inside a rotating, non-magnetic, conductive, cylindrical developer transport member (also called a developer sleeve) typically made from stainless steel, aluminum or brass, and the developer being held on the developer transport member is transported according to the magnetic field generated by the relative rotation of developer transport member and the magnetic roller. In developing devices of the prior art, a ferrite magnet is used as the magnetic roller. Also, the so-called one-component magnetic developers and two-component magnetic developers are used as the developer in these kind of prior art developing devices.

One-component magnetic developers comprise toner particles made up of a coloring component, which is non-magnetic itself, containing a magnetic powder. In the prior art, this magnetic powder was contained in a percent weight of approximately 50%. In image forming devices, increased resolution is desired, and therefore the particle diameter of developers is becoming smaller, resulting in developer particles with smaller volumetric magnetic quantities.

However, in developing devices of the prior art, the magnetic force formed by the magnetic roller is not sufficiently strong, and therefore developer particles with small volumetric magnetic quantities cannot be securely restrained on the transport member, thus resulting in the appearance of background. When the magnetic powder content is increased, the electrical characteristic of the developer becomes insufficient and the image density becomes insufficient. Further, since the light transmittance of the magnetic powder is low, it is difficult to make a developer that is a subtractive color mix.

In so-called "two-component magnetic developers," the carrier, which is the magnetic particles that do not form the image, is not held on the developer transport member with sufficient restraint since the magnetic field formed by the magnetic roller is not sufficiently strong, and therefore the carrier is consumed when images are formed and the mix ratio of the carrier and toner, which must remain constant, changes. As a result, the amount of toner transported or the charge of the toner varies greatly, and this causes deterioration of image quality such as uneven or lower image density. In order to solve these problems, methods such as periodically completely cleaning the developing device to remove the developer and then replenishing with new developer, continually measuring the carrier and toner mix ratio and supplying carrier as required to maintain the mix ratio constant, and providing a mechanism For narrowing the carrier existing space to prevent the carrier from dissipating the out of the developing device. However, these methods increase running costs and increase the complexity and size of the device.

SUMMARY OF THE INVENTION

The present invention is intended to solve the above problems.

That is, the purpose is to offer a developing device capable of yielding sharp, high-density images even when a one-component magnetic developer is used which has a small amount of magnetic powder and a low magnetic characteristic.

The purpose of the invention is to offer a developing device which permits the use of a developer with a reduced amount of magnetic powder; i.e., a composition whose electrical characteristic is not easily affected by the magnetic powder, and with stabilized frictional electrification and charge injection characteristics, whereby a consistent image density is yielded.

Another purpose of the invention is to offer a developing device which permits the use of developers with a small particle diameter, whereby good area gradation is obtained in addition to the formation of high-resolution images.

Another purpose of the invention is offer a developing device capable of using developers with a reduced amount of magnetic powder; i.e., developers that permit subtractive color mixture with improved light transmittance.

Another purpose of the invention is to offer a developing device capable of using developers that permit subtractive color mixture; i.e., a developing device capable of accommodating full-color image formation devices.

Another purpose is to offer a developing device wherein the carrier of two-component magnetic developers is strongly retained on the developer transport member so that carrier consumption is small during image formation and the carrier and toner mix ratio can be maintained constant, whereby high quality images can be consistently formed over long periods.

Therefore, the invention is a magnetic brush developing device comprising a non-magnetic, conductive cylindrical developer transport member and a magnetic roller mounted inside the developer transport member and magnetized with a plurality of magnetic poles, wherein the developer on the developer transport member is transported according to the magnetic field generated by the relative rotation of the transport member and the magnetic roller, and the magnetic roller is made from a magnet with a maximum energy product of 4 MGOe or greater.

By means of the developing device of the invention, developers with a small particle diameter can be used to facilitate high resolution and good gradation and with a low magnetic powder content to facilitate coloration and stable toner characteristics (charging, fixing, etc.).

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1, FIG. 5 and FIG. 6 are generalized cross sections of an image formation device equipped with the developing device of the invention;

FIG. 2 is a graph depicting the correlation between the magnetic powder content of the developer and the image density measured when magnetic rollers with differing energy products are used;

FIG. 3 is a graph depicting the correlation between the magnetic powder content of the developer and the background image density (appearance of background) measured when magnetic rollers with differing energy products are used; and

FIG. 4 is a graph depicting the correlation between the magnet thickness of the magnetic roller and the magnetic flux density.

DETAILED DESCRIPTION OF THE INVENTION

Developing Device

The developing device of the invention relates to the improvement of magnetic brush developing devices comprising a non-magnetic, conductive cylindrical developer transport member and a magnetic roller mounted inside the developer transport member and magnetized with a plurality of magnetic poles, wherein the developer on the developer transport member is transported according to the magnetic field generated by the relative rotation of the transport member and the magnetic roller.

FIG. 1 is a cross section of an image formation device including the developing device of an embodiment of the invention. Using this figure, the fundamental principle of the image formation device and developing device is explained briefly below. The latent image carrier 1 is a conductive support member 2 on which an organic or inorganic photosensitive layer 3 having photoconductivity has been applied. After the photosensitive layer 3 is charged to the prescribed voltage by a corona charger or other type of charger 4, the light emitted from the light source 5 is scanned using a rotating polygon mirror (not shown in figure) according to the desired image and is then selectively irradiated on the photosensitive layer 3 by the imaging optical system 6, whereby potential contrasts are obtained on the photosensitive layer 3 and an electrostatic latent image is formed on the latent image carrier 1. The developing device 7 comprises the non-magnetic, conductive developer transport member 16 and the cylindrical magnetic roller 9 magnetized with a plurality of magnetic poles in the radial direction and mounted inside the transport member 16 with a space between them in a configuration which allows the transport member 16 and the magnetic roller 9 to rotate relative to each other. In the developing device 7, the developer 8 is transported according to the magnetic field generated by the relative rotation of the developer transport member 16 and the magnetic roller 9, at which time the developer becomes charged by the contact between developer and developer or between toner particles and carrier particles. When the developer 8 comes to the point where the latent image carrier 1 and the developer transport member 16 come near each other, i.e., the developing gap, the developer 8 adheres to the latent image carrier 1 according to the potential of the electrostatic latent image on the latent image carrier 1 and the bias voltage of the developing bias voltage application means 10, and the electrostatic latent image is manifested. The developer 8 which manifests the electrostatic latent image is transferred to the recording paper 15 by the transfer device 14 which uses corona discharge, an electric field, pressure or adhesion and is fixed to the recording paper 15 by a heating or pressurizing means. As a result, the desired image is obtained on the recording paper 15.

Magnetic Roller

The developing device of the invention is a so-called magnetic brush developing device as described above, and it is distinguished by a magnetic roller made from a magnet with a maximum energy product of 4 MGOe or greater.

When the maximum energy product of the magnetic roller is greater than 4 MGOe, the toner particle diameter can be made smaller in one-component magnetic developers and the magnetic powder content can be made lower as is demonstrated in the embodiments described below. In two-component magnetic developers, consumption of carrier particles can be almost completely eliminated during developing.

Here, any magnetic substance can be used as the magnetic roller in the developing device of the invention as long as its maximum energy product is 4 MGOe or greater, but it is desirable to use a magnetic substance containing a rare earth magnet.

Here, a rare earth magnet refers to a magnet containing one or more rare earth elements (i.e., so-called lanthanoid elements from cerium to lutetium, including lanthanum, yttrium and scandium).

Examples of magnetic substances that can be used in the magnetic roller include those disclosed in Japanese Laid-Open Patent Publications Nos. 60-194503 and 63-289807.

Specific examples of desirable rare earth magnets include those containing at least one of the rare earth elements from cerium to lutetium and more desirably neodymium, praseodymium or samarium and at least one transition metal and more desirably iron, nickel or cobalt. A rare earth magnet containing the typical intermetallic compound Nd-Fe-B is desirable. Further, RCo5 and R2Co17 (where R indicates at least one rare earth element) are desirable examples, particularly where R is samarium. Other desirable examples contain rare earth magnets with a composition described by the following equation.

LTn

(In the equation, L indicates yttrium or a lanthanoid element, T indicates a transition metal, and n can be a number from 4.6 to 8.8)

These magnets are formed into magnetic rollers by appropriate methods. For example, they are formed as roller-shaped sintered bodies or the powders of these magnets are diffused in a resin, etc., and molded into a roller shape by extraction, injection or compression. In the specific production methods for magnets, methods disclosed in the publications noted above can be used. As described below, since a magnetic roller with a hollow structure is used, extraction molding is particularly advantageous as a molding method.

In the molding process, the magnetic material can be positioned in a magnetic field in order to orient the magnetic particles in the optimum direction for magnetization. Also, known methods can be used to magnetize the magnetic roller with a plurality of magnetic poles.

Further, a magnetized magnetic substance can be attached to a roller shaped material to form the magnetic roller.

It is desirable that the magnetic roller of the developing device of the invention have a hollow, cylindrical shape. Particularly when a magnetic roller containing a rare earth magnet is used, a magnetic roller can be obtained having a large magnetic flux density as compared to ferrite magnets of the prior art even if the magnet is thin, as described in embodiment below. By using a hollow cylindrical shape, the magnetic roller is not only compact and lightweight and extremely easy to install and remove, the moment of inertia when the magnetic roller is rotated is small, and therefore it can be rotated quickly, there is no rotational fluctuation when rotated either fast or slow, and the torque required for rotation is small. When a hollow, cylindrical magnetic roller is used, it is desirable to provide a support member 13 on the inside as shown in FIG. 1. This support member should be made from a soft magnetic material to obtain the maximum flux on the magnetic roller surface. When the outside diameter of the magnet is to 28mm, it should be a hollow, cylindrical shape with a thickness of 0.5mm to 5mm. Further, the magnetic roller of the developing device of the invention should have 6 to 20 magnetic poles.

Developer

The so-called one-component magnetic developers and two-component magnetic developers can be used in the developing device of the invention.

Here, one-component developers refer to developers having toner particles that are conductive and magnetic. When a one-component magnetic developer is used in the developing device of the invention, the number average particle diameter for the particles can be made less than 10 μm, thus facilitating high resolution. Also, the volume magnetic susceptibility is decreased when the particles are made smaller, but since the magnetic field generated by the magnetic roller is sufficiently large, the magnetic powder content of the developer particles need not be increased and may even be decreased. For example, in addition to developers with a magnetic powder content of 40 wt%, which could not be transported in prior art developing devices, one-component magnetic developers with a content of less than 20 wt% and in some cases 5 to 10 wt% can be used.

As a result of reducing the magnetic substance content in one-component magnetic developers, it was unexpectedly discovered that the temperature for fixing transfer to the recording paper could be reduced. For example, a fixing transfer temperature of about 170°C is currently required for a developer with a magnetic powder content of 50 wt%, but a developer with a low magnetic powder content can be fixed transferred at a temperature below 140°C. As a result, the power consumption of the developing device can be decreased and deterioration of component materials can be prevented.

Further, as a result of being able to reduce the magnetic powder content, which was the greatest cause of color turbidity, in subtractive color mixture colorants, it is possible to form high resolution images with little color turbidity and excellent gradation.

Two-component magnetic developers are made up of toner which comprises conductive, but non-magnetic, colorant particles that form the image and magnetic particles which do not form the image. The carrier particles in these two-component magnetic developers are retained on the developer transport member with sufficient strength, and so almost no carrier is consumed in the formation of images. Therefore, it becomes possible to maintain the carrier and toner mix ratio constant, thus making it possible to form consistently high quality images over long periods.

In addition, the developing device of the invention makes it possible to use a 1.5-component or pseudo two-component developer in which carrier or another substance for improving the developing characteristic has been added to a one-component developer.

Developer Transport Regulating Member

As shown in FIG. 1, the developing device of the invention may be provided with a developer transport regulating member 11 mounted so it has a fixed gap between it and the developer transport member 16. In the invention, this transport regulating member 11 is made from a magnetic substance. As explained below, since it is desirable that this regulating member 11 generate a strong magnetic field, it should be made from a rare earth magnet. The rare earth magnet may be the same as that used in the magnetic roller.

When a transport regulating member 11 made from a magnetic substance is mounted near the developer transport member 16, a line of magnetic force is formed between the regulating member 11 and the developer transport member 16, and this magnetic force strongly agitates the developer. As a result, cohesion to the developer transport member 16 is inhibited, and the agitation increases the contact friction of the developer so the developer receives a sufficient charge, thus stabilizing its developing characteristic. Further, the agitation by this magnetic force makes it possible to form the developer into a thin, uniform layer. Since the amount of developer is not regulated physically as by prior art transport regulating members, the developer can be formed into a sufficiently uniform thin layer without a highly precise gap (also called a "doctor gap") between the regulating member 11 and the transport member 16. By being able to form the developer on the transport member 16 into a thin layer, excess developer is not supplied to the developing position on the latent image carrier 1 even if the gap between the transport member 16 and the latent image carrier 1 is made narrow. As a result, developing becomes possible even when the developing bias is small. Also, when the developing gap is narrow, the interaction between the latent image pattern formed on the latent image carrier 1 and the developer is enhanced, whereby a finer latent image pattern can be developed for higher resolution developing.

Operation of the Developing Device

Like magnetic brush developing devices of the prior art, the developing device of the invention can be used in image recording devices and can be operated in nearly the same manner as the prior art devices. That is, since the developer is transported during developing by the magnetic field generated by the relative rotating action of the magnetic roller and the developer transport member, both may be rotated or one may be fixed and the other rotated.

Since the magnetic field generated by the magnetic roller in the developer device of the invention is strong, sufficient developer to facilitate developing can be transported by the rotation of only the magnetic roller. The rotation drive system for developer transport need only be provided for the magnetic roller, thus making it possible to simplify the configuration.

The developing device of the invention is further described below with actual embodiments.

Embodiment 1

Magnets with the following compositions were produced with a hollow structure having an outside diameter of 18 mm and an inside diameter of 14 mm.

Magnet A (sintered isotropic ferrite magnet):

Composition:

$$SrO \cdot 6Fe_2O_3$$

Maximum energy product: 1 MGOe

Magnet B (extraction-molded isotropic neodymium magnet)

Composition:

$$Nd_{12}Fe_{77.8}Co_{4.3}B_{5.9}$$

Maximum energy product: 4 MGOe

Magnet C (extraction-molded samarium-cobalt magnet)

Composition:

$$Sm(Co_{bal}Cu_{0.08}Fe_{0.22}Zr_{0.028})_{8.35}$$

Maximum energy product: 10 MGOe

Magnet D (extraction-molded sintered samarium-cobalt magnet)

Composition:

$$Sm_2(Co_{0.8}Fe_{0.2})_{17}$$

Maximum energy product: 27 MGOe

We formed images using the above magnets as the magnetic rollers of developing devices such as that shown in FIG. 1. We used developers made up of ferrite particles as the magnetic powder, carbon black and other additives mixed with a styrene acrylic resin. We varied the content of the ferrite particles and measured the image density and background image density (appearance of background). The results are shown in FIG. 2 and FIG. 3.

An OD value of 1.2 or greater was obtained for the image density of solid images for all magnets A to D by adjusting the developing bias voltage. However, when the magnetic powder content of the developer was 30 wt% or less, the magnetic brush could not be easily formed with magnet A and developing could not be performed. When the magnetic powder content exceeded 40 wt% with magnets B and C, however, the magnetic brush became inflexible, resulting in hard images with streaks, but good images could be formed with contents ranging from below 40 wt% to very low.

The background image density was hardly affected by any adjustments in the developing bias voltage, but it was markedly dependent on the maximum energy product of the magnetic roller when the magnetic powder content of the developer dropped below 40 wt%. The adherence of a large amount of developer to the background (appearance of background) occurred with magnet A, but images with little appearance of background could be formed with magnets B to D even with magnetic powder contents of less than 20 wt%.

Embodiment 2

Magnets with the following compositions were produced with a hollow structure having an outside diameter of 18 mm and a thickness ranging from 0.5 to 5mm.

Nd-Fe-B magnet (extraction molded)
Composition:

$$Nd_{12}Fe_{77.8}Co_{4.3}B_{5.9}$$

Sr-Fe magnet (sintered and machined molded)
Composition:

$$SrO \cdot 6Fe_2O_3$$

These magnetic rollers were inserted in sleeves made from Stainless Steel and having an outside diameter of 20 mm, and the peak magnetic flux density was measured on the surface of the sleeve. The results are shown in FIG. 4.

According to FIG. 4, rare earth magnets have a large magnetic flux density even when in a thin, hollow cylindrical shape.

Unless stated otherwise, the magnetic rollers 9 in the following embodiments and comparison examples had an outside diameter of 18 mm and were 2 mm thick and the developer transport members 16 had an outside diameter of 20 mm.

Embodiment 3

In a developing device such as that shown in FIG. 1, the magnetic roller 9 was configured from an injection-molded rare earth samarium-cobalt magnet (composition:

$$Sm(Co_{bal}Cu_{0.08}Fe_{0.22}Zr_{0.028})_{8.:}$$

) with a maximum energy product of 4 MGOe. A one-component magnetic developer made up of 30 wt% ferrite particles (saturation magnetization: 88 emu/g), 4 wt% carbon black, and 1 wt% other additives mixed with a styrene acrylic resin and having a number average particle diameter of 8 μm and saturation magnetization of 26 emu/g was used as the developer 8. Images were formed by impressing a developing bias voltage of -500 V to develop the images and transferring and fixing the images to regular paper. An adequate magnetic brush for transport of developer 8 was formed on the developer transport member 16, high contrast images were obtained with a maximum OD value of 1.5 and no appearance of background, a high 600 DPI resolution was obtained which was capable of accurately forming characters as small as 3 points, and an area gradation of 64 levels was obtained in picture elements as small as 0.5 mm square.

Embodiment 4

In a developing device such as that shown in FIG. 1, the magnetic roller 9 was configured from a compression-molded rare earth samarium-cobalt magnet (composition:

$$Sm(Co_{bal}Cu_{0.08}Fe_{0.22}Fe_{0.22}Zr_{0.028})_{8.35}$$

) with a maximum energy product of 10 MGOe. A one-component magnetic developer made up of 20 wt% ferrite particles (saturation magnetization: 88 emu/g), 4 wt% carbon black, and 1 wt% other additives mixed with a polyester resin and having a number average particle diameter of 8 μm and saturation magnetization of 18 emu/g was used as the developer 8. Images were formed by impressing a developing bias voltage of

-500 V to develop the images and transferring and fixing the images to regular paper. An adequate magnetic brush for transport of developer 8 was formed on the developer transport member 16, high contrast images were obtained with a maximum OD value of 1.5 and no appearance of background, a high 600 DPI resolution was obtained which was capable of accurately forming characters as small as 3 points, and an area gradation of 100 levels was obtained in picture elements as small as 0.5 mm square.

Embodiment 5

In a developing device such as that shown in FIG. 1, the magnetic roller 9 was configured from an extraction-molded rare earth praseodymium magnet (composition:

$$Pr_{17}Fe_{76.5}B_{5}Cu_{1.5}$$

) with a maximum energy product of 10 MGOe. A one-component magnetic developer made up of 20 wt% ferrite particles (saturation magnetization: 88 emu/g), 4 wt% carbon black, and 1 wt% other additives mixed with a polyester resin and having a number average particle diameter of 5 μm and saturation magnetization of 18 emu/g was used as the developer 8. Images were formed by impressing a developing bias voltage of -500 V to develop the images and transferring and fixing the images to regular paper. An adequate magnetic brush for transport of developer 8 was formed on the developer transport member 16, high contrast images were obtained with a maximum OD value of 1.4 and no appearance of background, a high 600 DPI resolution was obtained which was capable of accurately forming characters as small as 3 points, and an area gradation of 100 levels was obtained in picture elements as small as 0.5 mm square.

Embodiment 6

In a developing device such as that shown in FIG. 1, the magnetic roller 9 was configured from a cast rare earth praseodymium magnet (composition:

$$Pr_{17}Fe_{76.5}B_{5}Cu_{1.5}$$

) with a maximum energy product of 27 MGOe. A one-component magnetic developer made up of 10 wt% ferrite particles (saturation magnetization: 88 emu/g), 4 wt% carbon black, and 1 wt% other additives mixed with a polyester resin and having a number average particle diameter of 8 μm and saturation magnetization of 9 emu/g was used as the developer 8. Images were formed by impressing a developing bias voltage of -400 V to develop the images and transferring and fixing the images to regular paper. An adequate magnetic brush for transport of developer 8 was formed on the developer transport member 16, high contrast images were obtained with a maximum OD value of 1.4 and no appearance of background, a high 600 DPI resolution was obtained which was capable of accurately forming characters as small as 3 points, and an area gradation of 100 levels was obtained in picture elements as small as 0.5 mm square.

Embodiment 7

In a developing device such as that shown in FIG. 1, the magnetic roller 9 was configured from a sintered rare earth neodymium-iron magnet (composition:

$$Nd_{12}Fe_{77.8}Co_{4.3}B_{5.9}$$

) with a maximum energy product of 27 MGOe. A one-component magnetic developer made up of 10 wt% ferrite particles (saturation magnetization: 88 emu/g), 4 wt% carbon black, and 1 wt% other additives mixed with a polyester resin and having a number average particle diameter of 8 μm and saturation magnetization of 9 emu/g was used as the developer 8. Images were formed by impressing a developing bias voltage of -400 V to develop the images and transferring and fixing the images to regular paper. An adequate magnetic brush for transport of developer 8 was formed on the developer transport member 16, high contrast images were obtained with a maximum OD value of 1.4 and no appearance of background, a high 600 DPI resolution was obtained which was capable of accurately forming characters as small as 3 points, and an area gradation of 100 levels was obtained in picture elements as small as 0.5 mm square.

Comparison Example 1

In a developing device such as that shown in FIG. 1, the magnetic roller 9 was configured from a sintered isotropic ferrite magnet (composition:

$$SrO \cdot 6Fe_2O_3$$

) with a maximum energy product of 1 MGOe. A one-component magnetic developer made up of 30 wt% ferrite particles (saturation magnetization: 88 emu/g), 4 wt% carbon black, and 1 wt% other additives mixed with a polyester resin and having a number average particle diameter of 8 μm and saturation magnetization of 26 emu/g was used as the developer 8. Images were formed by impressing a developing bias voltage of -400 V to develop the images and transferring and fixing the images to regular paper. A magnetic brush was formed on the developer transport member 16, and high-density solid images with a maximum OD value of 1.5 were obtained, but they were of low quality with an excessive appearance of background.

Comparison Example 2

In a developing device such as that shown in FIG. 1, the magnetic roller 9 was configured from a sintered isotropic ferrite magnet (composition:

$$SrO \cdot 6Fe_2 \cdot O_3$$

) with a maximum energy product of 1 MGOe. A one-component magnetic developer made up of 50 wt% ferrite particles (saturation magnetization: 88 emu/g), 4 wt% carbon black, and 1 wt% other additives mixed with a polyester resin and having a number average particle diameter of 8 μm and saturation magnetization of 44 emu/g was used as the developer 8. Images were formed by impressing a developing bias voltage of -500 V to develop the images and transferring and fixing the images to regular paper. A magnetic brush was formed on the developer transport member 16, and high-density solid images with a maximum OD value of 1.5 and no appearance of background were obtained, but the resolution was limited to 300 DPI and sufficient area gradation could not be achieved.

Comparison Example 3

In a developing device such as that shown in FIG. 1, the magnetic roller 9 was configured from a sintered isotropic ferrite magnet (composition:

$$SrO \cdot 6Fe_2O_3$$

) with a maximum energy product of 1 MGOe. A one-component magnetic developer made up of 50 wt% ferrite particles (saturation magnetization: 88 emu/g), 4 wt% carbon black, and 1 wt% other additives mixed with a polyester resin and having a number average particle diameter of 12 μm and saturation magnetization of 44 emu/g was used as the developer 8. Images were formed by impressing a developing bias voltage of -500 V to develop the images and transferring and fixing the images to regular paper. A magnetic brush was formed on the developer transport member 16, and only low-density solid images with a maximum OD value of 1.1 could be obtained.

Comparison Example 4

In a developing device such as that shown in FIG. 1, the magnetic roller 9 was configured from a sintered samarium-cobalt magnet (composition:

$$Sm_2(Co_{0.8} \cdot Fe_{0.2})_{17}$$

) with a maximum energy product of 27 MGOe. A one-component magnetic developer made up of 50 wt% ferrite particles (saturation magnetization: 88 emu/g), 4 wt% carbon black, and 1 wt% other additives mixed with a polyester resin and having a number average particle diameter of 8 μm and saturation magnetization of 44 emu/g was used as the developer 8. When images were formed by impressing a developing bias voltage of -500 V to develop the images and transferring and fixing the images to regular paper, an inflexible magnetic brush was formed on the developer transport member 16, and only low-density solid images with OD values varying markedly around 0.5 could be obtained.

Embodiment 8

In a developing device such as that shown in FIG. 1, the magnetic roller 9 was configured from an injection-molded rare earth samarium-cobalt magnet (composition:

$$Sm(Co_{bal}Cu_{0.08}Fe_{0.22}Zr_{0.022})_{8.3}$$

) with a maximum energy product of 6 MGOe. A one-component magnetic developer made up of 30 wt% ferrite particles (saturation magnetization: 88 emu/g) with good light transmittance, 4 wt% yellow colorant, and 1 wt% other additives mixed with a polyester resin and having a number average particle diameter of 6 μm and saturation magnetization of 26 emu/g was used as the developer 8. Images were formed by impressing a developing bias voltage of -450 V to develop the images and transferring and fixing the images to regular paper. A magnetic brush of yellow developer was formed on the developer transport member 16, high contrast images were obtained with a maximum OD value of 1.5, little turbidity and no appearance of background, and an area gradation of 100 levels was obtained in picture elements as small as 0.5 mm square.

Embodiment 9

In a developing device such as that shown in FIG. 1, the magnetic roller 9 was configured from an injection-molded rare earth samarium-cobalt magnet (composition:

$$Sm(Co_{bal}Cu_{0.08}Fe_{0.22}Zr_{0.022})_{8.35}$$

) with a maximum energy product of 6 MGOe. A one-component magnetic developer made up of 30 wt% ferrite particles (saturation magnetization: 88 emu/g) with good light transmittance, 4 wt% magenta colorant, and 1 wt% other additives mixed with a polyester resin and having a number average particle diameter of 6 μm and saturation magnetization of 26 emu/g was used as the developer 8. Images were formed by impressing a developing bias voltage of -450 V to develop the images and transferring and fixing the images to regular paper. A magnetic brush of magenta developer was formed on the developer transport member 16, high contrast images were obtained with a maximum OD value of 1.5, little turbidity and no appearance of background, and an area gradation of 100 levels was obtained in picture elements as small as 0.5 mm square.

Embodiment 10

In a developing device such as that shown in FIG. 1, the magnetic roller 9 was configured from an injection-molded rare earth samarium-cobalt magnet (composition:

$$Sm(Co_{bal}Cu_{0.08}Fe_{0.22}Zr_{0.022})_{8.3}$$

) with a maximum energy product of 6 MGOe. A one-component magnetic developer made up of 30 wt% ferrite particles (saturation magnetization: 88 emu/g) with good light transmittance, 4 wt% cyan colorant, and 1 wt% other additives mixed with a polyester resin and having a number average particle diameter of 6 μm and saturation magnetization of 26 emu/g was used as the developer 8. Images were formed by impressing a developing bias voltage of -450 V to develop the images and transferring and fixing the images to regular paper. A magnetic brush of cyan developer was formed on the developer transport member 16, high contrast images were obtained with a maximum OD value of 1.5, little turbidity and no appearance of background, and an area gradation of 100 levels was obtained in picture elements as small as 0.5 mm square.

Embodiment 11

A number of developing devices such as that shown in FIG. 1 were prepared wherein the magnetic roller 9 was configured from an injection-molded rare earth samarium-cobalt magnet (composition:

$$Sm(Co_{bal}Cu_{0.08}Fe_{0.22}Fr_{0.22})_{8.35}$$

) with a maximum energy product of 6 MGOe. Full-color images were formed using the yellow developer of embodiment 8, the magenta developer of embodiment 9 and the cyan developer of embodiment 10. As a result, full-color images were obtained with a maximum OD value of 1.5, some turbidity, no appearance of background, and a high 64 levels of gradation for each color.

Embodiment 12

A number of developing devices such as that shown in FIG. 1 were prepared wherein the magnetic roller 9 was configured from a sintered rare earth neodymium-iron magnet (composition:

$$Nd_{12}Fe_{77.8}Co_{4.3}B_{5.9}$$

) with a maximum energy product of 28 MGOe. Yellow, magenta and cyan one-component magnetic developers made up of 10 wt% ferrite particles (saturation magnetization: 88 emu/g) with good light transmittance, 4 wt% yellow, magenta or cyan colorant, respectively, and 1 wt% other additives mixed with a polyester resin and having a number average particle diameter of 6 μm and saturation magnetization of 9 emu/g were used as the developers. Images were formed by impressing a developing bias voltage of -400 V to develop the images and transferring and fixing the images to regular paper. A magnetic brush of each of the developers was formed on the developer transport member 16, and full-color images were obtained with a maximum OD value of 1.5, little turbidity, no appearance of background, and a high gradation for each color.

Comparison Example 5

A number of developing devices such as that shown in FIG. 1 were prepared wherein the magnetic roller 9 was configured from a sintered isotropic ferrite magnet (composition:

$$SrO\cdot 6Fe_2O_3$$

) with a maximum energy product of 1 MGOe. Yellow, magenta and cyan one-component magnetic developers made up of 50 wt% ferrite particles (saturation magnetization: 88 emu/g) with good light transmittance, 4 wt% yellow, magenta and cyan colorant, respectively, and 1 wt% other additives mixed with a polyester resin and having a number average particle diameter of 6 μm and saturation magnetization of 44 emu/g were used as the developers. Each of the color developers had turbidity, and when these developers were used to form images by impressing a developing bias voltage of -500 V to develop the images and transferring and fixing the images to regular paper, a magnetic brush was formed on the developer transport member 16, and high-density solid images were obtained with a maximum OD value of 1.5, but they had almost no gradation and were dark and of low quality.

Embodiment B1

In a developing device such as that shown in FIG. 1, the magnetic roller 9 was configured from an injection-molded samarium-cobalt magnet (composition:

$$Sm(Co_{bal}Cu_{0.08}Fe_{0.22}Zr_{0.028})_{8.35}$$

) with a maximum energy product of 6 MGOe. Images were formed by using a two-component magnetic developer comprising a toner A made up mainly of a styrene acrylic resin and colorant and a carrier B made up of ferrite magnetic particles to develop the images and then transferring and fixing them to regular paper. Images equivalent to 10 000 regular A4-size sheets were continuously formed, but the images obtained were of the same high resolution and high quality as the first sheet. Also, no decrease in carrier was observed.

Embodiment B2

In a developing device such as that shown in FIG. 1, the magnetic roller 9 was configured from a compression-molded samarium-cobalt magnet (composition:

$$Sm(Co_{bal}Cu_{0.08}Fe_{0.22}Zr_{0.028})_{8.35}$$

) with a maximum energy product of 10 MGOe. Images were formed by using a two-component magnetic developer comprising a toner A made up mainly of a polyester resin and colorant and a carrier B made up of ferrite magnetic particles to develop the images and then transferring and fixing them to regular paper. Images equivalent to 30 000 regular A4-size sheets were continuously formed, but the images obtained were of the same high resolution and high quality as the first sheet. Also, no decrease in carrier was observed.

Embodiment B3

In a developing device such as that shown in FIG. 1, the magnetic roller 9 was configured from an extraction-molded praseodymium magnet (composition:

$$Pr_{17}Fe_{76.5}B_{5}Cu_{1.5}$$

) with a maximum energy product of 8 MGOe. Images were formed by using a two-component magnetic developer comprising a toner A made up mainly of a polyester resin and colorant and a carrier B made up of ferrite magnetic particles to develop the images and then transferring and fixing them to regular paper. Images equivalent to 30 000 regular A4-size sheets were continuously formed, but the images obtained were of the same high resolution and high quality as the first sheet. Also, no decrease in carrier was observed.

Embodiment B4

In a developing device such as that shown in FIG. 1, the magnetic roller 9 was configured from a cast praseodymium magnet (composition:

$$Pr_{17}Fe_{76.5}B_{5}Cu_{1.5}$$

) with a maximum energy product of 28 MGOe. Images were formed by using a two-component magnetic developer comprising a toner A made up mainly of a polyester resin and colorant and a carrier B made up of ferrite magnetic particles to develop the images and then transferring and fixing them to regular paper. Images equivalent to 50 000 regular A4-size sheets were continuously formed, but the images obtained were of the same high resolution and high quality as the first sheet. Also, no decrease in carrier was observed.

Embodiment B5

In a developing device such as that shown in FIG. 1, the magnetic roller 9 was configured from a sintered neodymium-iron magnet (composition:

$$Nd_{12}Fe_{77.8}Co_{4.3}B_{5.7}$$

) with a maximum energy product of 27 MGOe. Images were formed by using a two-component magnetic developer comprising a toner A made up mainly of a styrene acrylic resin and colorant and a carrier B made up of ferrite magnetic particles to develop the images and then transferring and fixing them to regular paper. Images equivalent to 10 000 regular A4-size sheets were continuously formed, but the images obtained were of the same high resolution and high quality as the first sheet. Also, no decrease in carrier was observed.

Comparison Example B1

In a developing device such as that shown in FIG. 1, the magnetic roller 9 was configured from a sintered isotropic ferrite magnet composition:

$$SrO \cdot 6Fe_2O_3$$

) with a maximum energy product of 1 MGOe. Images were formed by using a two-component magnetic developer comprising a toner A made up mainly of a styrene acrylic resin and colorant and a carrier B made up of ferrite magnetic particles to develop the images and then transferring and fixing them to regular paper. Images equivalent to 10 000 regular A4-size sheets were continuously formed, but uneven image density gradually became marked and a deterioration of image quality such as blurring was observed in the images obtained. Also, a decrease in carrier was observed.

Embodiment B6

In a developing device such as that shown in FIG. 1, the magnetic roller 9 was configured from a compression-molded samarium-cobalt magnet (composition:

$$Sm(Co_{bal}Cu_{0.08}Fe_{0.22}Zr_{0.025})_{8.35}$$

) with a maximum energy product of 10 MGOe. Images were formed by using a two-component magnetic developer comprising a toner A made up mainly of a polyester resin and colorant and a carrier B made up of ferrite magnetic particles (resin diffused) to develop the images and then transferring and fixing them to regular paper. Images equivalent to 20 000 regular A4-size sheets were continuously formed, but the images obtained were of the same high resolution and high quality as the first sheet. Also, no decrease in carrier was observed.

Embodiment B7

In a developing device such as that shown in FIG. 1, the magnetic roller 9 was configured from a cast praseodymium magnet (composition:

$$Pr_{17}Fe_{76.5}B_5Cu_{1.5}$$

) with a maximum energy product of 28 MGOe. Images were formed by using a two-component magnetic developer comprising a toner A made up mainly of a polyester resin and colorant and a carrier B made up of ferrite magnetic particles (resin diffused) to develop the images and then transferring and fixing them to regular paper. Images equivalent to 50 000 regular A4-size sheets were continuously formed, but the images obtained were of the same high resolution and high quality as the first sheet. Also, no decrease in carrier was observed.

Comparison Example B2

In a developing device such as that shown in FIG. 1, the magnetic roller 9 was configured from a sintered isotropic ferrite magnet (composition:

$$SrO \cdot 6Fe_2O_3$$

) with a maximum energy product of 1 MGOe. Images were formed by using a two-component magnetic developer comprising a toner A made up mainly of a polyester resin and colorant and a carrier B made up of ferrite magnetic particles (resin diffused) to develop the images and then transferring and fixing them to regular paper. Images equivalent to 5 000 regular A4-size sheets were continuously formed, but uneven image density gradually became marked and a deterioration of image quality such as blurring was observed in the images obtained. Also, a decrease in carrier was observed.

Embodiment B8

In a developing device such as that shown in FIG. 1, the magnetic roller 9 was configured from a compression-molded samarium-cobalt magnet (composition:

$$Sm(Co_{bal}Cu_{0.08}Fe_{0.22}Zr_{0.028})_{8.35}$$

) with a maximum energy product of 9 MGOe. Images were formed by using a so-called 1.5-component magnetic developer comprising a carrier B made up of ferrite magnetic particles mixed with a one-component developer which was a magnetic toner A made up mainly of a polyester resin, colorant and ferrite particles to develop the images and then transferring and fixing them to regular paper. Images equivalent to 30 000 regular A4-size sheets were continuously formed, but the images obtained were of the same high resolution and high quality as the first sheet. Also, no decrease in carrier was observed.

Embodiment B9

In a developing device such as that shown in FIG. 1, the magnetic roller 9 was configured from a cast praseodymium magnet (composition:

$$Pr_{17}Fe_{76.5}B_5Cu_{1.5}$$

) with a maximum energy product of 28 MGOe. Images were formed by using a so-called 1.5-component magnetic developer comprising a carrier B made up of ferrite magnetic particles mixed with a one-component developer which was a toner A made up mainly of a polyester resin and colorant to develop the images and then transferring and fixing them to regular paper. Images equivalent to 60 000 regular A4-size sheets were continuously formed, but the images obtained were of the same high resolution and high quality as the first sheet. Also, no decrease in carrier was observed.

Comparison Example B3

In a developing device such as that shown in FIG. 1, the magnetic roller 9 was configured from a sintered isotropic ferrite magnet (composition:

$$SrO \cdot 6Fe_2O_3$$

) with a maximum energy product of 1 MGOe. Images were formed by using a so-called 1.5-component magnetic developer comprising a carrier B made up of ferrite magnetic particles mixed with a one-component developer which was a toner A made up mainly of a polyester resin and colorant to develop the images and then transferring and fixing them to regular paper. Images equivalent to 20 000 regular A4-size sheets were continuously formed, but uneven image density gradually became marked and a deterioration of image quality such as blurring was observed in the images obtained. Also, a decrease in carrier was observed.

Embodiment C1

In a developing device such as that shown in FIG. 5, the magnetic roller 9 was configured from an injection-molded samarium-cobalt magnet (composition:

$$Sm(Co_{bal}Cu_{0.08}Fe_{0.22}Zr_{0.028})_{8.35}$$

), and sufficient developer supply on the developer transport member was achieved even when the magnet was divided up into 12 magnetic poles. When the magnetic roller 9 was rotated at 1 000 rpm with the developer transport member 16 in a fixed position, movement of the developer by the rotation of the magnetic brush occurred on the developer transport member and an amount of developer sufficient for developing was carried to the developing position so satisfactory developing could be performed.

When a one-component magnetic developer was placed in the reservoir 10 and 10 000 images were formed on recording paper using the above configuration, no cohesion of developer on the developer transport member 16 was observed and images could be formed with consistent recording density and reproduction of fine lines.

Comparison Example C1

Images were formed using the same configuration as that in embodiment 1 except that a ferrite magnet was used as the magnetic roller 9.

When a one-component non-magnetic developer was placed in the reservoir 10 and 10 000 images were formed on recording paper using the above configuration, cohesion of developer on the developer transport member 16 was observed and images could not be formed with consistent recording density and reproduction of fine lines.

Embodiment C2

In a developing device such as that shown in FIG. 5, the magnetic roller 9 was configured from an iron pipe (soft magnetic support member 13) with an outside diameter of 16 mm inserted in an injection-molded 1-mm-thick samarium-cobalt magnet (composition:

$$Sm(Co_{bal}Cu_{0.08}Fe_{0.22}Zr_{0.028})_{8.35}$$

) with an outside diameter of 18 mm, and the magnetic roller was divided up into 12 magnetic poles only from the peripheral direction. Sufficient developer supply was achieved on the developer transport member 16. When the magnetic roller 9 was rotated at 1 000 rpm with the developer transport member 16 in a fixed position, movement of the developer by the rotation of the magnetic brush occurred on the developer transport member and an amount of developer sufficient for developing was carried to the developing position so satisfactory developing could be performed.

When a one-component magnetic developer was placed in the reservoir 10 and 10 000 images were formed on recording paper using the above configuration, no cohesion of developer on the developer transport member 16 was observed and images could be formed with consistent recording density and reproduction of fine lines.

Embodiment C3

Images were formed using a developing device with the same configuration as that in embodiment 1 except that the magnetic roller 9 was configured from a cast 2-mm-thick praseodymium magnet (composition:

$$Pr_{17}Fe_{76.5}B_5Cu_{1.5}$$

) with an outside diameter of 18 mm. Sufficient developer supply was achieved on the developer transport member 16 even when the magnet was divided up into 16 magnetic poles. When the magnetic roller 9 was rotated at 1 000 rpm with the developer transport member 16 in a fixed position, movement of the developer by the rotation of the magnetic brush occurred on the developer transport member and an amount of developer sufficient for developing was carried to the developing position so satisfactory developing could be performed. By dividing the magnetic roller 9 into 16 magnetic poles, the same effect is achieved as when the magnetic roller is rotated quickly. Uneven developing due to compression of developer on the developer transport member is inhibited by rotating the magnetic roller quickly or using another magnetic pole arrangement.

When a one-component magnetic developer was placed in the reservoir 10 and 50 000 images were formed on recording paper using the above configuration, no cohesion of developer on the developer transport member 16 was observed and images could be formed with consistent recording density and reproduction of fine lines.

Embodiment C4

Images were formed using a developing device with the same configuration as that in embodiment 1 except that the magnetic roller 9 was configured from a sintered 2-mm-thick neodymium magnet (Composition:

$$Nd_{12}Fe_{77.8}Co_{4.3}B_{5.9}$$

) with an outside diameter of 18 mm. Sufficient developer supply was achieved on the developer transport member 16 even when the magnet was divided up into 20 magnetic poles. When the magnetic roller 9 was rotated at 1 000 rpm with the developer transport member 16 in a fixed position, movement of the developer by the rotation of the magnetic brush occurred on the developer transport member and an amount of developer sufficient for developing was carried to the developing position so satisfactory developing could be performed.

When a one-component magnetic developer was placed in the reservoir 10 and 50 000 images were formed on recording paper using the above configuration, no cohesion of developer on the developer transport member 16 was observed and images could be formed with consistent recording density and reproduction of fine lines.

Embodiment C5

Images were formed using a developing device with the same configuration as that in embodiment 4 except that the magnetic roller 9 was divided up into 40 magnetic poles and the magnetic roller 9 was rotated at 300 rpm. Sufficient developer supply was achieved on the developer transport member even when the magnet was divided up into 40 magnetic poles. When the magnetic roller was rotated at 300 rpm with the developer transport member in a fixed position, movement of the developer by the rotation of the magnetic brush occurred on the developer transport member and an amount of developer sufficient for developing was carried to the developing position so satisfactory developing could be performed.

When a one-component magnetic developer was placed in the reservoir 10 and 50 000 images were formed on recording paper using the above configuration, no cohesion of developer on the developer transport member 16 was observed and images could be formed with consistent recording density and reproduction of fine lines.

Embodiment D1

In a developing device such as that shown in FIG. 5, the magnetic roller 9 was configured from an injection-molded samarium-cobalt magnet (composition:

$$Sm(Co_{bal}Cu_{0.08}Fe_{0.22}Zr_{0.028})_{8.35}$$

), and an iron magnetic developer transport regulating member 11 was positioned opposite the developer transport member 16 with a doctor gap of 400 μm between them. The developer 8 was strongly agitated by the magnetic field formed by the magnetic roller 9 and the transport regulating member 11 where the developer transport member 16 and the magnetic developer transport regulating member 11 were positioned opposite each other, thus forming the developer layer into a thin layer.

When a one-component magnetic developer was placed in the reservoir 10 and 10 000 images were formed on recording paper using the above configuration, no cohesion of developer on the developer transport member 16 was observed and images could be formed with consistent recording density and reproduction of fine lines.

Comparison Example D1

Images were formed using a configuration like that in embodiment 1 except that a stainless steel transport regulating member was positioned as the developer transport regulating member 11.

When a one-component magnetic developer was placed in the reservoir 10 and 10 000 images were formed on recording paper using the above configuration, cohesion of developer on the developer transport member 16 was observed, excess developer was supplied to the developing gap and images could not be formed with consistent recording density and reproduction of fine lines.

APPLICABILITY TO INDUSTRY

The developing device of the present invention can be widely used in image recording means employing an electrophotographic process, and more particularly it is widely applicable to developing devices for printers, * copiers and facsimile machines.

FIG. 1

1 Latent image carrier
2 Conductive support member
3 Photosensitive layer

4 Charger 5 Light source 6 Imaging optical system

7 Developing device 8 Developer

9 Magnetic roller
12 Magnet
13 Support member

10 Developing bias voltage application means

*If this word "copiers" is registered as trademark, please change it to the other word.

11 Transport amount regulating member

14 Transfer device 15 Recording paper

16 Developer transport member

FIG. 2

Image density Magnetic powder content of developer (wt%)

FIG. 3

Image density in background

Magnetic powder content of developer (wt%)

FIG. 4

Magnetic flux density (gauss) ¥1000

Magnet Thickness vs. Magnetic Flux Density

Magnet thickness (cm)

FIG. 5

1 Latent image carrier
2 Conductive support member
3 Photosensitive layer

4 Charger 5 Light source 6 Imaging optical system

7 Developing device 8 Developer

9 Magnetic roller

10 Developing bias voltage application means

11 Transport amount regulating member

14 Transfer device 15 Recording paper

16 Developer transport member 17 Reservoir

FIG. 6

1 Latent image carrier
2 Conductive support member

3 Photosensitive layer

4 Charger 5 Light source 6 Imaging optical system

7 Developing device 8 Developer

9 Magnetic roller
12 Magnet
13 Soft magnetic support member

10 Developing bias voltage application means

11 Transport amount regulating member

14 Transfer device 15 Recording paper

16 Developer transport member 17 Reservoir

Claims

1. A magnetic brush developing device comprising a non-magnetic, conductive cylindrical developer transport member and a magnetic roller mounted inside the developer transport member and magnetized with a plurality of magnetic poles, wherein the developer on the developer transport member is transported according to the magnetic field generated by the relative rotation of the transport member and the magnetic roller, and the magnetic roller is made from a magnet with a maximum energy product of 4 MGOe or greater.

2. The developing device of claim 1 wherein the magnetic roller contains a rare earth magnet.

3. The developing device of claim 2 wherein the magnetic roller contains a rare earth magnet made up of at least one rare earth element and at least one transition metal element.

4. The developing device of claim 3 wherein the magnetic roller contains a rare earth magnet made up of an intermetallic compound such as Nd-Fe-B.

5. The developing device of claim 3 wherein the magnetic roller contains a rare earth magnet with a composition such as RCo5 and R2Co17. (where R indicates at least one rare earth element).

6. The developing device of claim 5 wherein R is samarium.

7. The developing device of claim 3 wherein the magnetic roller contains a rare earth magnet with a composition described by the following equation.

   LTn

   (In the equation, L indicates yttrium or a lanthanoid element, T indicates a transition metal, and n can be a number from 4.6 to 8.8)

8. The developing device of any of the claims 3 to 7 wherein the magnetic roller is produced by extraction molding.

9. The developing device of claim 8 wherein the magnetic roller is a hollow shape.

10. The developing device of any of the claims 1 to 9 wherein the developer used is made up of, magnetic toner particles.

11. The developing device of claim 10 wherein the number average particle diameter of the developer particles is less than 10 μm and the magnetic powder content is less than 40 wt%.

12. The developing device of any of the claims 1 to 9 wherein the developer used is a two-component type comprising a toner made up of, but non-magnetic, colorant particles which form the image and magnetic particles which do not form the image.

13. The developing device of any of the claims 1 to 12 wherein a developer transport regulating member made from a magnetic substance is provided opposite the developer transport member with a fixed gap between them.

14. The developing device of claim 13 wherein the developer transport regulating member is a rare earth magnet.

15. The developing device of any of the claims 1 to 14 wherein the developer is transported by rotating both the developer transport member and magnetic roller.

16. The developing device of any of the claims 1 to 14 wherein the developer is transported by fixing the developer transport member in place and rotating the magnetic roller.

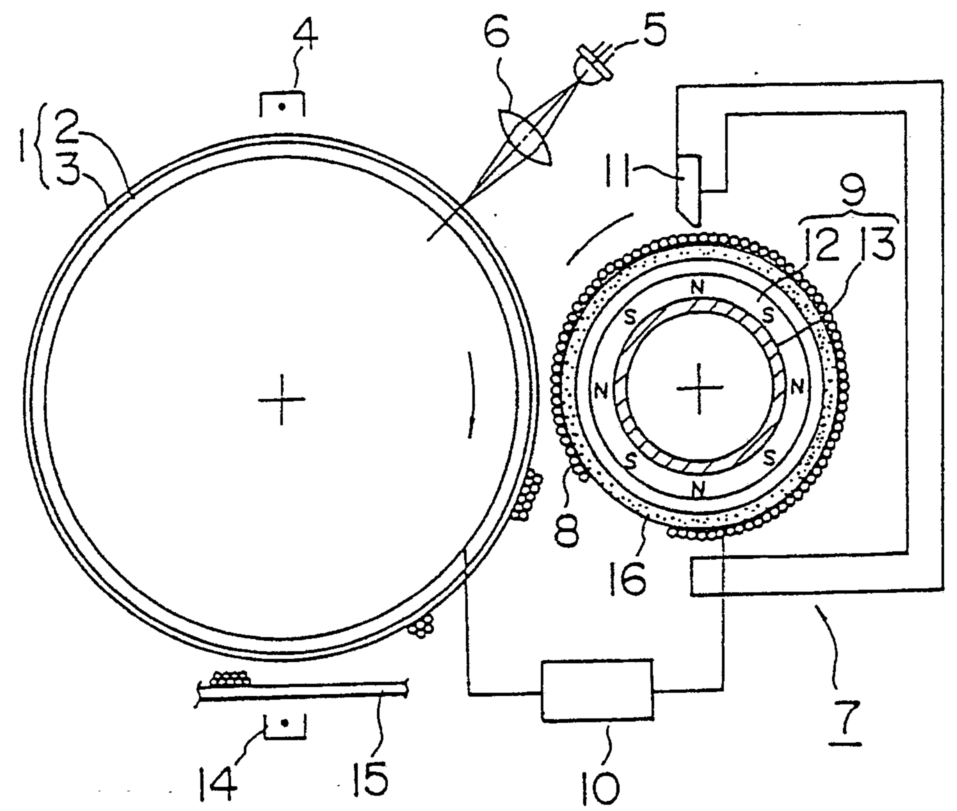

FIG. 1

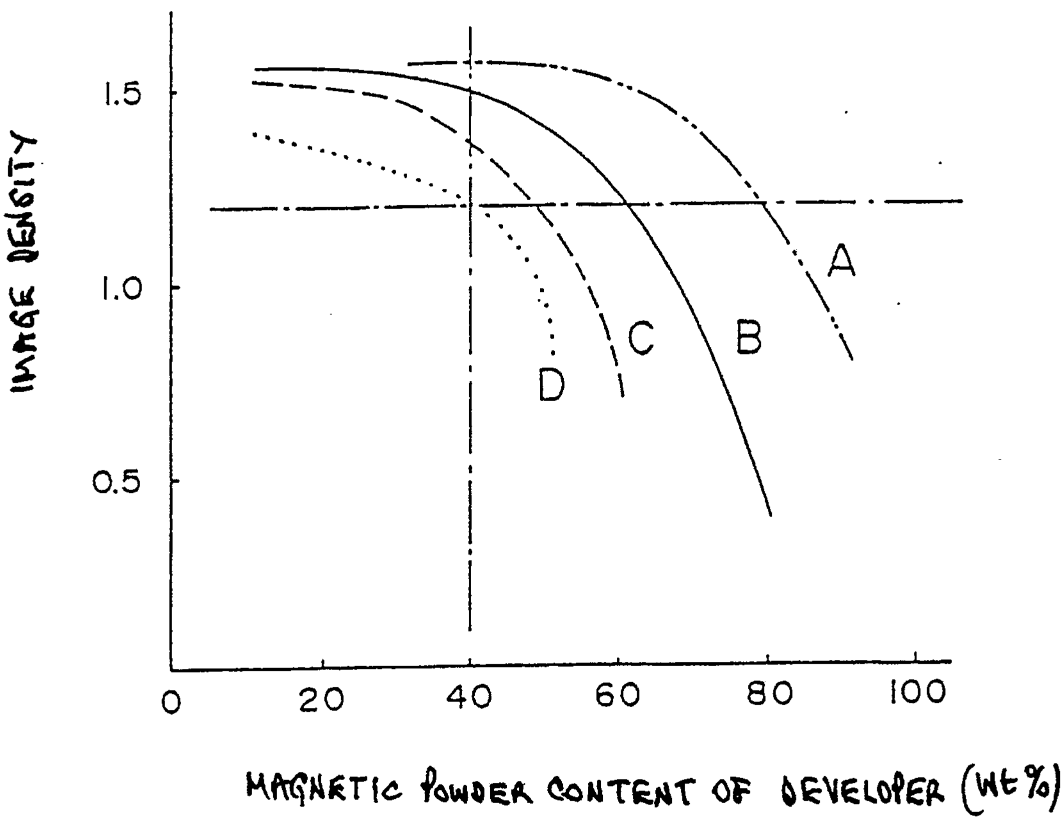
IMAGE DENSITY
1.5
1.0
0.5
0
20
40
60
80
100
A
B
C
D
MAGNETIC POWDER CONTENT OF DEVELOPER (Wt%)

F I G. 2

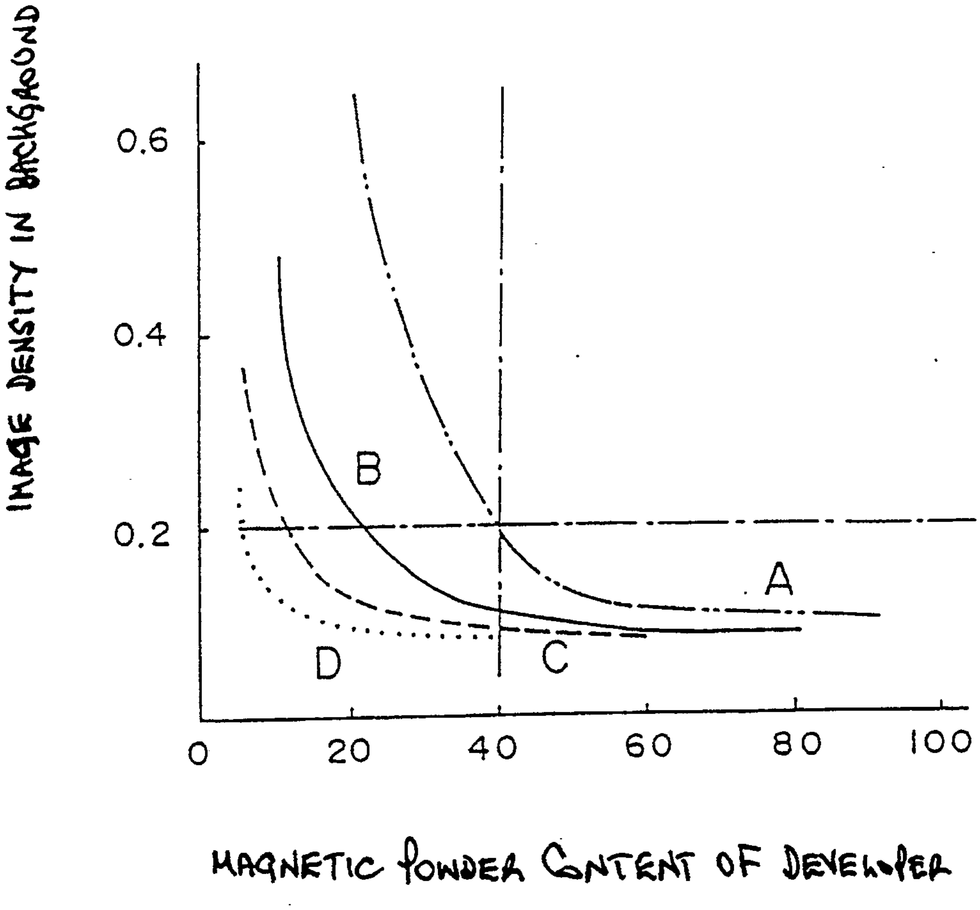
IMAGE DENSITY IN BACKGROUND
0.6
0.4
0.2
B
A
D
C
0
20
40
60
80
100
MAGNETIC POWDER CONTENT OF DEVELOPER

FIG. 3

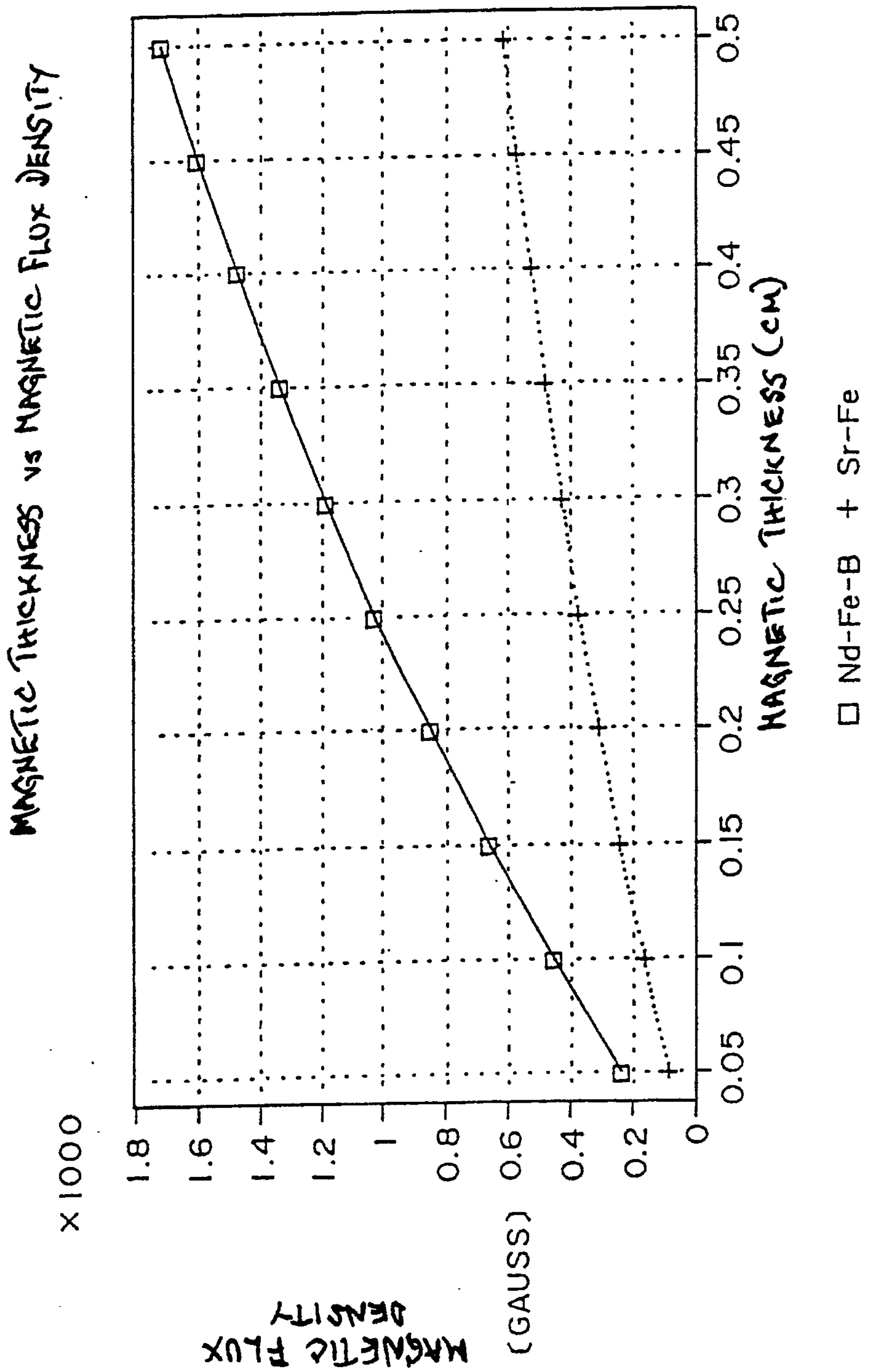
MAGNETIC THICKNESS vs MAGNETIC FLUX DENSITY
MAGNETIC FLUX DENSITY (GAUSS)
×1000
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
MAGNETIC THICKNESS (CM)
Nd-Fe-B
Sr-Fe

FIG. 4

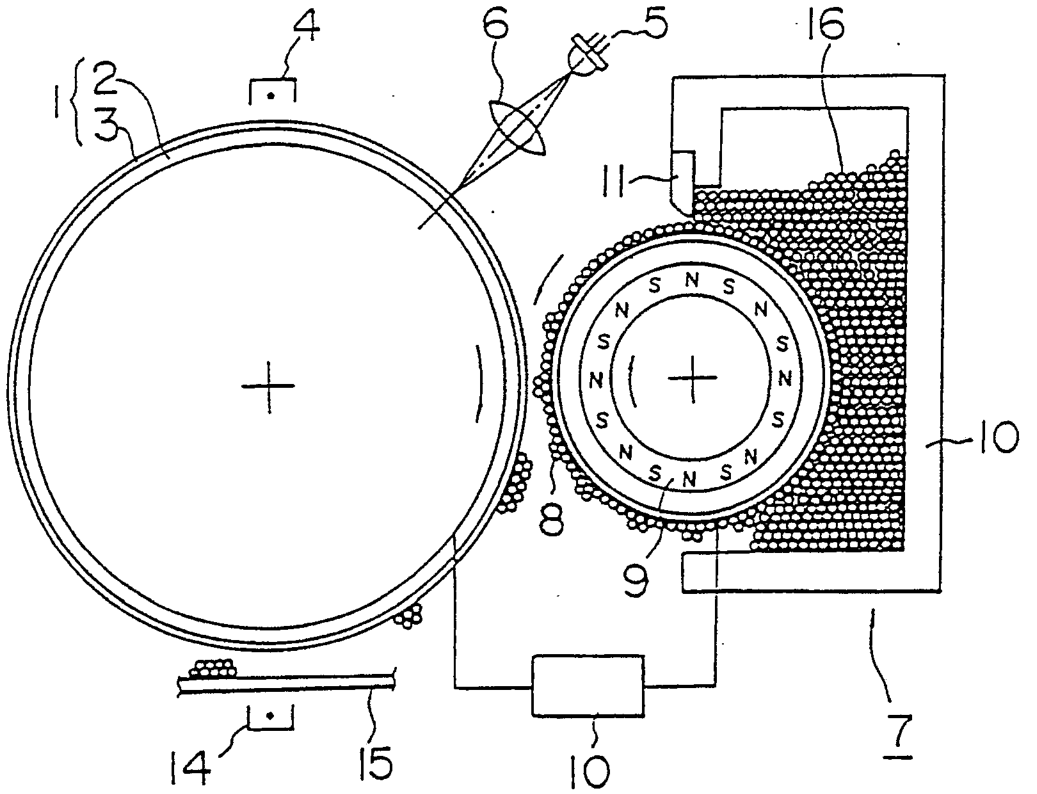

FIG. 5

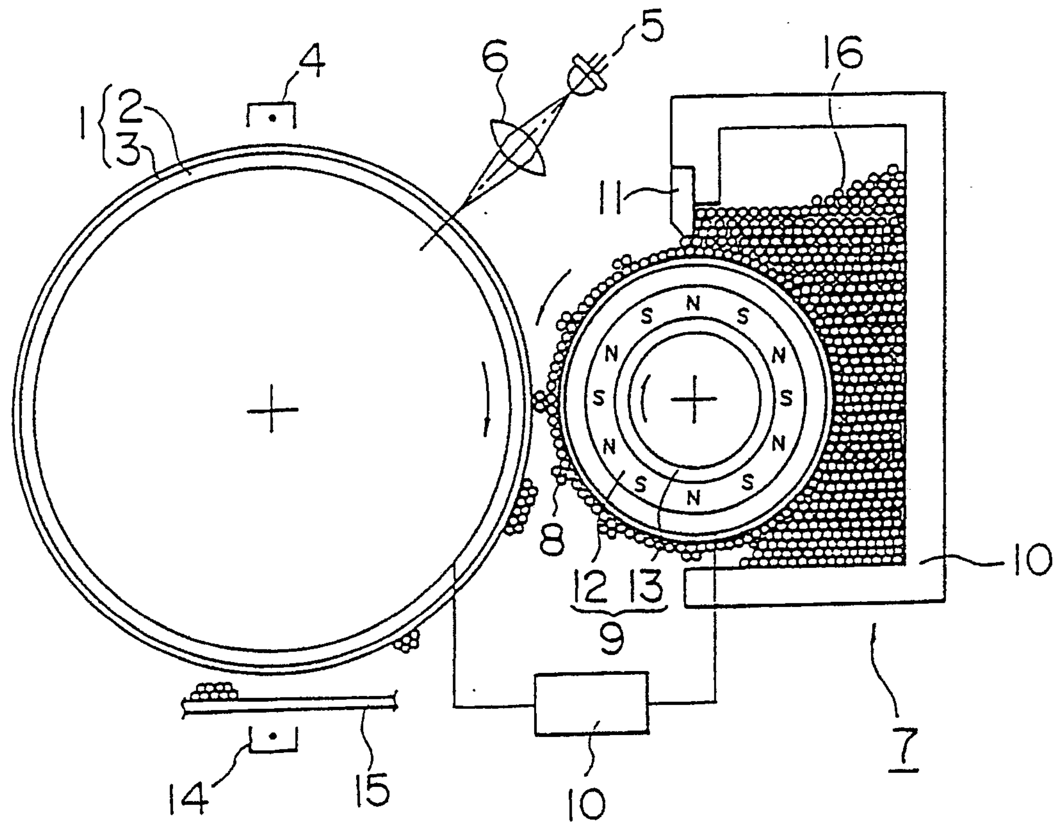

FIG. 6

INTERNATIONAL SEARCH REPORT

International Application No PCT/JP90/00809

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl^5 G03G15/09, H01F7/02

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC	G03G15/09, H01F1/04-1/08

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

Jitsuyo Shinan Koho	1926 - 1989
Kokai Jitsuyo Shinan Koho	1971 - 1989

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	JP, A, 60-216512 (Suwa Seikosha K.K.), 30 October 1985 (30. 10. 85), Claim, line 9, column 6, line 5 to last line, column 4 (Family: none)	1-3, 5, 6 8-12, 15, 16
Y	JP, A, 60-216512 (Suwa Seikosha K.K.), 30 October 1985 (30. 10. 85), (Family: none)	4, 10-16
Y	JP, A, 59-46008 (Sumitomo Tokushu Kinzoku K.K.), 15 March 1984 (15. 03. 84), Claim, lines 14 to 15, column 7 US, A, 4770723 & EP, A2, 101552	4
Y	JP, A, 57-72162 (Suwa Seikosha K.K.), 6 May 1982 (06. 05. 82), Claim 4 (Family: none)	7
Y	JP, A, 55-93177 (Canon Inc.), 15 July 1980 (15. 07. 80), Claims 1 to 2 & US, A, 4391512 & DE, A1, 3000195	13

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
September 7, 1990 (07. 09. 90)	September 25, 1990 (25. 09. 90)
International Searching Authority	**Signature of Authorized Officer**
Japanese Patent Office	

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

Y	JP, A, 59-26764 (Ricoh Co., Ltd.), 13 February 1984 (13. 02. 84), Line 20, column 1 to line 2, column 2 (Family: none)	14

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [1]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers ...., because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claim numbers ...., because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claim numbers ...., because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [2]

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.