(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 257 364 A1

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: 87111197.7

(22) Date of filing: 03.08.87

(51) Int. Cl.[4]: G03G 13/08, G03G 9/10, G03G 15/00

(30) Priority: 06.08.86 JP 183422/86
06.08.86 JP 183423/86

(43) Date of publication of application:
02.03.88 Bulletin 88/09

(84) Designated Contracting States:
DE FR GB

(71) Applicant: KONISHIROKU PHOTO INDUSTRY CO. LTD.
No. 26-2, Nishishinjuku 1-chome Shinjuku-ku
Tokyo 160(JP)

(72) Inventor: Kaneko, Tadashi Konishiroku Photo Ind. Co., Ltd.
2970 Ishikawa-cho
Hachioji-shi Tokyo(JP)
Inventor: Okuyama, Yuki Konishiroku Photo Ind. Co., Ltd.
2970 Ishikawa-cho
Hachioji-shi Tokyo(JP)
Inventor: Arai, Mitsutaka Konishiroku Photo Ind. Co., Ltd.
2970 Ishikawa-cho
Hachioji-shi Tokyo(JP)
Inventor: Yamamoto, Yoko Konishiroku Photo Ind. Co., Ltd.
2970 Ishikawa-cho
Hachioji-shi Tokyo(JP)
Inventor: Ikeuchi, Satoru Konishiroku Photo Ind. Co., Ltd.
2970 Ishikawa-cho
Hachioji-shi Tokyo(JP)

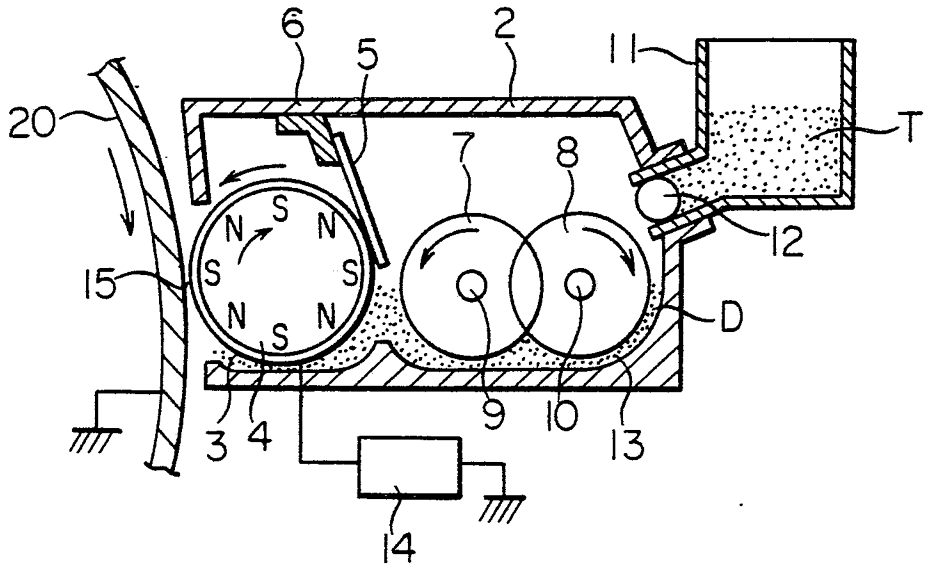
(74) Representative: Türk, Gille, Hrabal
Bruckner Strasse 20
D-4000 Düsseldorf 13(DE)

(54) **Developing method for electrostatic latent image.**

(57) The developing method of the invention is a developing method in which a two component type developer layer comprising toners and carriers is formed on a developer transport drum and the formed developer layer is fed into a developing area where an oscillatory electric field is generated so as to develop an electrostatic latent image on a photoreceptor. The carrier is a resin coated carrier being a particle of magnetic substance coated with a resin containing silicone resin or a resin containing fluororesin in an amount of at least 30 % by weight.

EP 0 257 364 A1

FIG. 1



DEVELOPING METHOD FOR ELECTROSTATIC LATENT IMAGE

FIELD OF THE INVENTION

This invention relates to a developing method for electrostatic latent images and, more particularly, to a developing method for electrostatic latent images formed on a latent image carrying member in electrophotography, electrostatic recording, electrostatic printing and the like by making use of a two-component type developer.

Nowadays, as to the methods for forming a visible image from an image information, the methods such as electrophotography, electrostatic recording and electroprinting are widely utilized, in which visible images are formed through electrostatic latent images.

There are two types of developers used for developing the above-mentioned electrostatic latent images: one is the so-called two-component type developer comprising toners and carriers in the form of mixture and the other is a single component type developer comprising magnetic toners containing mag netic substances, which is used independently without mixing with carriers. In the methods for developing electrostatic latent images by making use of the former developer, that is of the two-component type, toners are frictionally charged by mechanically stirring the toners and carriers. It is, therefore, possible to control both the static chargeability and static charge potential of the toners to a considerable degree by selecting the properties of the carriers, the conditions of stirring and so forth and, further, this developer has a wide selection of colors with which the toners are endowed. The above-mentioned methods are superior to the methods for developing electrostatic latent images by making use of the latter developer of the single component type, from the above-mentioned points.

In the mean time, concerning the methods of forming fixed images through the processes of developing electrostatic latent images by making use of the two-component type developers, there have so far been propsed the techniques for mking toners and carriers smaller in size, from the viewpoint of the improvements in the resolving power and gradation reproduction or the image quality of fixed images.

In Japanese Patent Application Nos. 577446/1983, 96900/1983, 96901/1983, 96902/1983, 96903/1983, 97973/1983 and so forth, for example, there have been disclosed the techniques in which an electrostatic latent image formed on a latent image carrying memmber is developed in a non-contact developing system, by making use of a two-component type developer comprising small-sized carriers having a diameter of not larger than 50 µm and small-sized toner having a diameter of not larger than 20 µm. The above-mentioned non-contact developing system is a system in which a developer layer comprising toners and carriers, which is carried on a developer transport/carrying member, is fed into a developing area so as not to bring the developer layer into direct contact with the latent image carrying member.

However, there are the following problems:

In the case of using small-sized carriers such as mentioned above, toners and carriers may hardly be frictionally charged, because the fluidity of the carriers is liable to be lowered as they are getting smaller in size.

Resultingly, the electrostatic and physical bonding strength of the carriers to a developer transport/carrying member is weakened and, similarly, the elctrostatic and physical bonding strength of the carriers to the toner is also weakened.

Further, the carriers are usually transported by magnetic force with being adhered to the surface of the developer transport/carrying member though, in the case of using small-sized carriers, the adhesion force of the carriers to the developer transport/carrying member is weak.

As the results of the above-mentioned problems, in the course of performing a development process, the carriers or toners will fly about in an apparatus to contaminate the inside thereof, and the toners or carriers will adhere to the non-image areas of the latent image carrying member to produce fog; and, further, the carriers will adhere to the latent image carrying member to make an image unclear.

As a countermeasure to the above-mentioned problems, if the carriers are made larger in particle size so as to prevent the carriers from flying about and so forth, there will raise the following problems; A thin developer layer may hardly be formed on the developer transport/carrying member and the developer layer is liable to be uneven in thickness and, resultingly, the undesirable phenomena such as uneven imaging and imaging failure are taken place in a fixed image ultimately obtained, so that no sharp image may finally be obtained.

Meanwhile, in the course of performing development processes many times in repetition, and in the case of forming a thin developer layer on a developer transport/carrying member, that is, for example, in the case of regulating a developer layer thickness by bringing a thin layer forming member such as a blade into elastic contact with the surface of the developer transport/carrying member, the developer is applied with a strong pressure to make the toner substances adhere to the carriers with a strong physical pressure, that is to say, the so-called filming phenomenon is increased, so as to lower the frictional chargeability between the toners and carriers. Resultingly, various problems will be caused as follows:

Fog will be produced by the weakly charged toners; the toners will fly about; the carriers to which toner substances adhere will adhere to an electrostatic latent image so as to lower the image quality; the carriers will adhere to the electrostatic latent image so as to lower the image quality; a statisfactorily thin layer will hardly be formed on the developer/transport carrying member; and the like problems, so that no sharp image will finally be obtained.

On the other hand, to prevent the production of fog, it may be considered to make greater a minimum gap, that is a development gap, between a latent image carrying member and a developer transport/carrying member in a developing area.

However, in the case that the gap is relatively wider, a counter electrode effect is lowered in development so as to lower the developability, that is, the adhesion property of tonres to an electrostatic latent image is lowered. Resultingly, and excellent development is hardly be performed.

A developability may be improved by generating a relatively greater oscillatory electric field in a development area as well as by making a development gap larger though, in the case of generating such a greater oscillatory electric field as the development gap is made wider, there is such a problem that toners will adhere increasingly to the non-image portions of a latent image carrying member to produce fog and carriers will increasingly fly about to contaminate the inside of an apparatus. Further, it is necessary to insulate a developing unit satisfactorily from electricity and the designing of the units is considerably complicated, because of the generation of the greater oscillatory electric field.

SUMMARY OF THE INVENTION

This invention is based on the circumstances mentioned above.

It is, accordingly, an object of the invention ro provide a developing method in which no contamination is caused inside an apparatus by flying both toners and carriers about, no fog is produced, an excellent development can be performed with a two-component type developer comprising the toner and carriers and, resultingly, a sharp image can be formed so as to be excellent in both resolving power and gradation reproduction.

Another object of the invention is to provide a developing method capable of forming a sharp image without having any uneven imaging and imaging failure.

A further object of the invention is to provide a developing method in which a thin developer layer can stably be formed on a developer transport/carrying member even in repeating development processes many times and, resultingly, excellent images can stably be formed, extending over a long period of time.

The developing method of the invention is a developing method in which a two-component type developer layer comprising toners and carriers is formed on a developer transport/carrying member and the resulted developer layer is fed into a developing area where an oscillatory electric field is generated so as to develop an electrostatic latent image on a latent image carrying member; and is particularly characterized in thinning the developer layer formed on the developer transport/carrying member and in using resin coated carriers comprising the particles of magnetic substances coated with the resins containing silicone resin or fluororesin in an amount of at least 30% by weight or more, for serving as the above-mentioned carriers.

According to the developing method of the invention, the carrier surfaces are smoothed out, because the carriers forming two-component type developer are the resin-coated carriers comprising magnetic particles coated with a resin containing a silicone resin having a low surface energy as its property. For this reason, there is little fear to occur the so-called tonre filming phenomenon, that is a phenomenon that toner substances adhere to carrier surfaces to hinder the frictional chargeability of the carriers, in a frictional charge between toners and carriers. Therefore, the toners may be endowed stably with a frictional charge having proper polarity and charged volume.

In the case that the carriers forming a two-component type developer are resin-coated carriers comprising magnetic particles coated with resins containing fluororesing in an amount of not less than a specific proportion, the carrier surfaces are smoothed out, because a fluororesin is low in critical surface tension as its property. For this reason, there is little fear to occur the so-called toner filming phenomenon, that is a phenomenon that toner substances including, for example, coloring agents such as Carbon Black and so forth, surface releasing agents, etc., adhere to carrier surfaces to hinder the frictional changeability of the carriers, in a frictional charge between toners and carriers. Therefore, the toners may be endowed stably with a frictionally charge having proper polarity and charged amount. For this reason, the production of weakly charged toners is considerably reduced to hold the toners and carriers stably on a developer transport/carrying member. Resultingly, it is possible to form excellent images without producing any fog and to prevent toners and carriers from flying about so as not to contaminate inside an apparatus.

The order of frictional chargeability of a fluororesin is the most negative among resins and, accordingly, the carriers coated with resins containing the fluororesin are also excellent in negative chargeability. Therefore, in the toners used with the carriers in combination, it is not particularly required to use any charge controller or fine grained additive such as dyes so as to provide the toners with a positive chargeability. Resultingly, the troubles caused when using the charge controllers and the like may be prevented. Besides, the frictional chargeability of toners may be controlled to a considerable degree by selecting a fluororesin content in the resins for coating carriers. It is, therefore, possible to prepare developers suitable for the developing method of the invention.

Satisfactory fluidity of developers may be obtained even when the carriers are made fine in size, because carrier surfaces are smoothed as mentioned above. Resultingly, a uniform and thin developer layer may be formed on a developer transport/carrying member. Further, the adhesion property of toners to a latent image formed on a latent image carrying member becomes excellent, because the thin developer layer is processed in a developing area where the above-mentioned oscillatory electric field is generated while applying the function of the oscillatory electric field. Resultingly, excellent images may be formed without any uneven imaging and imaging failure.

In addition, the surface releasing property of the carriers becomes excellent, because the carrier surface is smoothed. When a thin developer layer is formed, for example, by bringing a thin layer forming member such as a blade into pressure contact elastically with a developer transport/carrying member, it is possible to prevent carriers from adhering to the thin layer forming member so as to prevent the thickness regulating function of the thin layer forming member from being interfered by the carrier adhesion. Also, when the developer transport/carrying member is received a strong pressure by the thin layer forming member, it is possible to prevent carriers from adhering physically and strongly to toners. Therefore, a thin developer layer may stably be formed on the developer transport/carrying member. Resultingly, the toner filming phenomenon in which toner substances adhere to carriers may be prevented and an excellent frictional chargeability between toners and carriers may stably be displayed. Thus, sharp images may be formed many times in repetition without any contamination caused in an apparatus by toner and carrier flying.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an illustrative sectional view showing an example of a developing unit which may be used in the embodiment of the invention;

Figs. 2(a) and 2(b) are an illustrative perspective view and an illustrative front view each showing an ecample of a stirring member, respectively;

Fig. 3 is a schematic illustration showing a monochromatic image forming unit;

Fig. 4 is a graph exhibiting the relation between a thin de veloper layer forming member and a developer transport/carrying member and a quantity of developer transported;

Fig. 5 is a schematic illustration showing an example of a multicolor image forming unit;

Fig. 6 is a flow chart for illustrating a multicolor image forming process;

Fig. 7 is a time cahrt showing the operations of each component of the multicolor image forming unit;

Fig. 8 is a schematic illustration showing another example of the multicolor image forming unit; and

Fig. 9 is a schematic illustration showing an example of a laser optical system.

DETAILED DESCRIPTION OF THE INVENTION

In this invention, a developer layer having a two-component type developer comprising toners and carriers is formed on a developer transport/carrying member. The developer layer is supplied to a developing area where an oscillatory electric field is generated and an electrostatic latent image on a latent image carrying member is developed. In the above-mentioned developing method, the developer layer formed on the developer transport/carrying member is thinned and a resincoated carrier comprising magnetic particles coated with a resin containing a silione resin is used for the carriers.

In the invention, it is required that a developer layer on a developer transport/carrying member is thinned. The thickness of the thin layer is preferably not more than 2,000 μm, more preferably not more than 1,000 μm and particularly from 10 to 500 μm.

A dvelopment process is carried out in such a manner that a developer layer, which is considerably thinned as mentioned above, is transported into a developing area where an oscillatory electric field is generated so as to bring the developer layer into contact or, preferably, non-contact with a latent image carrying member and the oscillatory electric field is applied to the developer layer. In the developing area, a minimum gap between the latent image carrying member and the developer transport/carrying member (hereinafter called a "development gap") is desired to be as narrow as possible, provided that the developer layer may be transported into the developing area so that the developer layer may not come into contact with the latent image carrying member. To be more concrete, the development gap is preferably selected from the range of gap of from 100 to 1,000 μm, for example.

The term, a developing area, mentioned herein means an area to which toners transported by a developer transport/carrying member may be able to transfer when an electrostatic latent image on a latent image carrying member receives an electrostatic force.

The term, a development gap, means a closest space between a latent image carrying member and a developer transport/carrying member in the above-defined developing area.

The carriers used in the invention area resin-coated car riers comprising magnetic particles coated with a resin containing a silicone resin or a fluororesin in a proportion of not less than 30% by weight. For example, the thickness of the coated layer is preferably from 0.1 to 10 μm on average, more preferably from 0.3 to 4 μm and particularly from 0.3 to 2 μm. When thinning the coated layer as mentioned above, the developer layer on the developer transport/carrying member may satisfactorily be thinned.

In the case of using a resin containing a silicone resin to form a resin-coated carrier, the resin may be comprised of either only a silicone resin or both of the silicone resin and a highly compatible resin used in combination for more improving the properties of the silicone resin.

There is no special limitation to the developer transport/carrying members for transporting a thin developer layer to a developing area. The developer transport/carrying members having the same construction as in the conventional types which are capable of applying a bias voltage, may also be used. In particular, there may preferably be used those provided with a magnetic roll having a plurality of magnetic poles to the inside of a cylindrical developing sleeve on which a developer layer is carried. In such developer transport/carrying members as mentioned above, a developer layer carried on the surface of the developing sleeve is transported in undulations like waves by the rotation of the magnetic roll. Thereby, new developers are transported one after another and, in addition, even if there are aome irregularities in thickness of the developer layer on the developing sleeve surface, the adverse influence may be compensated by the above-mentioned wave-like undulations, so that no practical problem may be raised.

In the invention, a developer layer formed on a developer transport/carrying member is thinned. In order to develop an electrostatic latent image with an optimum efficiency by making used of the thin developer layer, it is preferred to take the following measures:

(a) A magnetic roll is rotated at a high speed,

(b) An A.C. bias voltage is applied to a developing sleeve,

(c) A development gap, i.e., the closest space between a latent image carrying member and a developing sleeve is narrowed, and so forth.

In the invention, the non-contact and contact development systems may be used either. Particularly, the non-contact development system is preferably used. The reasons are that a development gap may satisfactorily be narrowed, because a developer layer formed on a developer transport/carrying member is thinned as mentioned before so as to lower a bias voltage required for generating an oscillatory electric field by which toners are properly flown from the developer transport/carrying member to the latent image carrying member in a non-contact developing area, and that there are also the advantages of reducing undesirable toner flying about and preventing the bias voltage from leaking out of the developing speeve surface, because a satisfactory oscillatory electric field may be generated by the relatively low bias voltage.

In addition to the above, in the case of narrowing the development gap, an electric field strength is increased when the field is generated in a developing area by an electrostatic latent image formed on a latent image carrying member and, resultingly, not only the delicate changes of gradation but fine patterns may excellently be developed.

In the case of thinning a developer layer which is to be carried on a developer transport/carrying member, an amount of toners transported to a developing area is usually reduced and, resultingly, there is the possibility of reducing the amount of toners adhered to an electrostatic latent image on the developer transport/carrying member. To avoid this, it is preferred to rotate a developing sleeve at a high speed so as to increase the amount of toners transported to the developing area. On the other hand, when a linear velocity of the developing sleeve exceeds ten times that of the latent image carrying member, a velocity component of the toners transported to the developing area, the velocity component is parallel to the surface subjected to a latent image development of the latent image carrying member, becomes greater and, resultingly, there is the possibility of showing a directivity in development so that an image quality may be worsened.

Taking the above-mentioned circumstances into considerations, it is preferred that toners are present in a proportion of the order of at least 0.04 mg/cm^2 in a developer layer carried on a developing sleeve.

For exampl,e, it is preferable to satisfy the following requirements, wherein V_s (mm/s) represents a linear velocity of a developing sleeve, V_d (mm/s) represents a linear velocity of a latent image carrying member, and m_t (mg/cm^2) represents an amount of toners per unit area of a developer layer carried on the developing sleeve:

$|V_s/V_d| \bullet m_t \geq 0.4$ (mg/cm^2) $|V_s/V_d| \leq 10$

In the case of further improving a development efficiency, it is preferable to satisfy the following requirements;

$|V_s/V_d| \bullet m_t \geq 0.5$ (mg/cm^2) $|V_s/V_d| \leq 8$

It was found from the results of the experiments that it is more preferable to satisfy the following requirements:

$|V_s/V_d| . m_t \geq 0.5$ (mg/cm^2) $|V_s/V_d| \leq 5$

In the relation between an amount of toners per unit volume of the toners forming a developer layer carried on a developing sleeve [which is called A (mg/cm^3)], it is prefer able that a ratio of A/B is from 0.5 to 2.

When performing a development process in accordance with the above-mentioned preferable requirements, the toners contained in a developer layer carried ona developing sleeve may be made efficiently adhere to an electrostatic latent image formed on a latent image carrying member and a stable development may be made and, resultingly, it is possible to reproduce images having extraordinarily excellent image qualities.

There is no special limitation to the means for forming such a thin developing layer as mentioned before on a developing sleeve, and the means having a variety of constitutions may be used. To be more concrete, the examples thereof include a means in which the thickness of a developer layer are regulated by bringing a thin layer forming member such as a blade into pressure contact elastically with the surface of a developing sleeve and, preferably, a means in which the thicknesses of a developer layer are regulated by arranging a regulating plate made of a magnetic substance and a developing sleeve so as to keep a specific gap between them, that is, for example, a means in which the thicknesses of a developer layer are regulated by arranging a magnetic bar close to a developing sleeve and then by generating a rotating magnetic field on the magnetic bar, or other means having been well-known.

From the viewpoint of preventing impurities remaining in a developer, such as dust, fibers, paper dust, aggregates of toners of carriers and the like, from stealing into a developing area, it is particularly preferable to use a thin layer forming member haivng a pressure plate brought into pressure contact lightly and elastically with a developing sleeve. In this type of thin layer forming members, it is preferable that the edge of the elastic pressure plate is brought into the developing sleeve toward the upper stream side of the rotation of the developing sleeve. With this type of the members, a thin developer layer may be formed by passing a developer through the gap between this elastic pressure plate and the developing sleeve.

Fig. 4 is a diagram illustrating the relation of a gap between the edge of an elastic pressure plate and a developing sleeve (The gap sizes are inproportion to aperture areas) to a quantity per unit area of a developer carried on the developing sleeve, in the case of using the above-mentioned elastic pressure plate.

As is seen from the figure, a quantity per unit area of a developer carried on a developing sleeve shows a stable value regardless of the sizes of a gap, when the gap between the edge of an elastic plate and the developing sleeve exceeds a specific size. In such a stable condition, toners sufficient for developing an electrostatic latent image may be transported into a developing area.

As is understood from the conclusion obtained from Fig. 4, when a gap between the edge of an elastic plate and a developing sleeve is set to not narrower than 0.08 mm, a specific quantity of toners may be transported into a developing area, even if a setting accuracy or a mechanical accuracy is scattered. In addition, it is more preferable when the gap between the edge of the elastic plate and the developing sleeve is set to not narrower than 0.1 mm, because the stability may be more improved.

However, in order to form a thin developer layer, there is an upper limit for preferably keeping a gap between the edge of the elastic plate and the developing sleeve, that is, a gap of not wider than 5 mm. If exceeding 5 mm, there is some fear of making the thickness of a developing layer uneven.

Fig. 1 is an illustration showing an example of a developing unit suitable for performing the developing method of the invention.

In Fig. 1, reference numeral 20 is a latent.image carrying member of, for example, a rotary drum type; 2 is a housing; 3 is a developing sleeve; 4 is a magnetic roll having a magnetic polarity of eight-pole type in total arranged N and S poles alternately around the circumference of the roll; and a developer transport/carrying member is comprised of the developing sleeve 3 and the magnetic roll 4.

Further in Fig.1, 5 is a thin layer forming member; 6 is a member for fixing thin layer forming member 5; 7 is a pri mary stirring member; 8 is a secondary stirring member; 9 and 10 are the shaft for rotating the above-mentioned stirring members 7 and 8, respectively; 11 is a vessel of replenishing toners; 12 is a roller of replenishing toners; 13 is a developer reservoir; 14 is a bias power source; 15 is a developing area; T is a toner; and D is a developer.

In the above-given developing unit, developer D is well stirred and mixed up in developer reservoir 13 by both of primary stirring member 7 rotating in the direction of the arrow and secondary stirring member 8 rotating in the direction opposite to the rotation of primary stirring member 7 so as to overlap the stirring areas of the both stirring members without colliding against each other and the developer D is then made adhere to the surface of developing sleeve 3 by the transportation force produced by both of developing sleeve 3 rotating in the direction of the arrow and magnetic roll 4 rotating in the direction opposite to the rotation of the developing sleeve 3.

Plate-like thin layer forming member 5 comprising an elastic material brings one side of the plate close to the edge into pressure contact with the surface of developing sleeve 3. This thin layer forming member 5 is held by fixing member 6 extended from housing 2. By this thin layer forming member 5, the thicknesses of a developer layer being transported into developing area 15 are regulated to thin the de veloper layer.

The developer layer thinned in this manner is transported into developing area 15 as the layer is facing to an electrostatic latent image formed on latent image carrying member 20 rotating in the direction of the arrow, preferably through a narrow gap, so to say, so as not to come into contact with each other. In the developing area 15, while the thin developer layer is being subjected to the oscillatory electric field generated by bias power source 14 containing a.c. components, only the toners held in the developer layer selectively and statically adhere to the electrostatic latent image, so that a toner image is formed.

A thickness of a developer layer may be measured in the following manner, for example. With a "Nikon Profile Projector" (manufactured by Nippon Kogaku Co.), the position of the image of a developing sleeve projected on a screen and the position of the image of athin developer layer formed on the developing sleeve projected on the screen are compared with each other to obtain the thickness of the developer layer.

Thin layer forming member 5 may be made of, for example, a magnetic or non-magnetic metal, a metal compound, a plastic, rubber and so forth. This member 5 is endowed with elasticity by fixing one end of the member 5 with fixing member 6. It is preferable that the thickness of this member 5 is very thin and uniform in thickness, that is from 50 to 500 μm.

An amount of carrier transported is regulated in such a manner that the above-mentioned thin layer forming member 5 brings one side close to the edge thereof into contact elastically with developing sleeve 3 and, preferably, the carriers may be passed one after anothre through the contact position of the thin layer forming member 5 with developing sleeve 3. The impurities remaining in developer D, aggregates of carriers or toners and so forth are prevented from stealing into developing area 15 by the thin layer forming member 5. Therefore, every developer layer transported into developing area 15 becomes thin, uniform and stable in thickness.

In the developing method of the invention, there uses a resin-coated carrier which is coated with a resin containing a silicone resin or a resin containing a fluororesin in a specific proportion or more. Therefore, the surface of the carrier is excellently smoothed even if the carrier is small-sized, because of the coated layer. The fluidity of the carrier is thereby improved. Accordingly, the thickness regulating function of the thin layer forming member 5 is satisfactorily displayed and, resultingly, every developer layer transported into developing area 15 may be satisfactorily uniformed and thinned in thickness. Further, the surface lubricity of the carrier is also excellent because of the coated layer. Therefore, the so-called filming phenomenon, that is, an adhesion of toner substances to carriers, may be prevented, even if the developer layer is applied with a strong pressure by thin layer forming member 5.

An amount of developer transported into developing area 15 may satisfactorily be controlled by changing the pressure and contact angles applied from thin layer forming member 5 to developing sleeve 3.

In toners and carriers forming a developer, it is generally advantageous that they are small-sized, because an image obtainable is high in resolving power and excellent in gradation reproduction. For example, even in the case of using a two-component type developer comprising toners having a weight average particle size of not larger than 5 µm and carriers having a weight average particle size of not larger than 50 µm and further not larger than 30 µm, any impurities, particle aggregates and so forth may automatically be removed from the developer so as to form a uniformed and thinned developer layer. In addition, even in the case of using a developer comprising toners and small-sized carriers having a weight average particle size of the same order as that of the toners, any impurities may be prohibited from stealing into the resulting developer layer by thin layer forming member 5 similar to the above-mentioned example, so that a uniformed and thinned developed layer may be formed.

On the other hand, in order to prevent carriers from adhering to latent image carrying member 20, it is preferable to use carriers having relatively larger particle size, because the carriers may be attracted to the surface of a developer transport/carrying member by an intensive magnetic force.

Taking the above-mentioned circumstances into consideration, it is advantageous to use a carrier having a weight average particle size of the order of from 50 to 100 µm. In this case, a satisfactorily uniform and thin developer layer may be formed by thin layer forming member 5 and a carrier may also satisfactorily be prevented from adhering to latent image carrying member 20. In contrast to the above, when using carriers having an excessively large weight average particle size, brush-like ears (i.e., a magnetic brush) of the carriers held in a developer layer are heightened and the layer is made coarse, so that hte developability is lowered.

In order to make carriers receivable an intensive magnetic force even if they are small-sized, a magnetization of the carriers is preferably from 10 to 200 emu/g, more preferably from 10 to 100 emu/g and, particularly from 15 to 30 emu/g. If the magnetization of the carriers is too little, there may be some instance where none of excellent magnetic bruches may be formed. If the magnetization is too great, there may be some instances where an oscillatory electric field may not function well, so that an excellent image may hardly be formed.

Figs. 2(a) and 2(b) are a perspective view and a front view each for illustrating an example of the detailed unit structure of stirring members 7 and 8.

In the drawings, 7a, 7b and 7c are stirring blades of primary stirring member 7 and 8a, 8b and 8c are the stirring blades of secondary stirring member 8, respectively. There is no special limitation to the detailed forms of the blades, however, it is preferable to select a blade form from the square, tabular, eliptic and the like forms. These stirring blades are arranged at an angle and/or position different from each other blades and fixed to rotating shafts 9 and 10, respectively. These stirring members 7 and 8 are so arranged as to overlap each other member in a stirring area without colliding each othre blades. In Fig. 1, therefore, a stirring may satisfactorily be performed in the direction of the right to left. At the same time, each stirring blade is slanted to the corresponding rotating shaft and fixed. In Fig. 1, therefore, a stirring may also satisfactorily be performed in the direction of back and forth. Accordingly, toners T are replenished from toner replenishing vessel 11 through replenishing roller 12 so that they are uniformly mixed up with developer D within a short time.

Toners and carriers are frictionally charged well by the above-mentioned stirring members 7 and 8 and the resulting developers are allowed to adhere to and held on developing sleeve 3 by magnetic force and a thin developer layer is then formed by thin layre forming member 5.

While being transported toward a specific direction by the rotation of the developing sleeve 3, the thin developer layer receives a magnetic bias having a oscillatory component and derived from the reverse rotation of the magnetic roll 4 and performs unique, such as rolling, on the developing sleeve 3. Accordingly, the toner particles satisfactorily adheres to an electrostatic latent image formed on the latent image carrying member 20 especially if the thin developer layer transported to the developing area receives the influence of the oscillatory electric field on a non-contact basis in relation to the electrostatic latent image.

According to the invention, the thickness of developer layer is favorably set extremely small, or more specifically, at 10 to 500 μm. This arrangement enables to narrow the development gap between the latent image carrying member 20 and the developing sleeve, for example, to 500 μm, and accordingly, ensures development in compliance with the so-called non-contact developing system.

Such a narrower development gap enhances the electric field strength in the developing area 15. This in turn enables satisfactory development operation even if the bias voltage applied onto the developing sleeve 3 is smaller, and, advantageously, reduces the leakage of bias voltage, and other disadvantages. Furthermore, the resultant greater contrast in the elevtrostatic latent image generally improves the resolu tion and quality of an image obtainable from the development operation.

With this example, when the development is effected by the non-contact development system, only the toner power is selectively allowed to jump to an electrostatic latent image to be developed. This arrangement in turn prevents the carrier powder from adhering to the electrostatic latent image area, thus precluding the possibility of the deteriorated image quality. Additionally, since a magnetic brush never rubs the electrostatic latent image area, and, naturally does not damage the surface of electrostatic image carrying member or cause a brush pattern phenomenon, resulting in improved image resolution and gradation reproducibility, and a sufficient amount of toner being adhered to the electrostatic latent image. Furthermore, the developing method of the invention may be favorably used for the multicolor development system in which the development process is repeatedly effected on an latent image carrying member where a toner image is formed.

The developer used in embodying the invention is a two-component developer comprising a toner, as well as a resin-coated carrier composed of magnetic particles each of which being coated with resin involving silicone resin or fluororesin resin in an amount of at least 30 weights.

A toner comprises fine particles each composed of binder resin containing a toner component such as a coloring agent.

The preferred binder resins used for toner include polyester resin, styrene-acryl resin, and the like.

The polyester resin favorably used as the binder resin of toner is prepared by the condensation polymerization of alcohol monomer and carboxylic monomer. The examples of such an alcohol monomer are as follows: diols such as ethylene glycol, diethylene glycol, triethylene glycol, 1,2-propylene glycol, 1,3-propylene glycol, 1,4-butanediol, neopentyl glycol, 1,4-butenediol and the like; etherified bisphenols such as 1,4-bis(hydroxymethyl) cyclohexane, bisphenol A, hydrogenated bisphenol A, polyoxyethylene bisphenol A, polyoxypropylene bisphenol A and the like; other bivalent alcohol monomers. The exmaples of such a bivalent carboxylic monomer are as follows; maleic acid, fumaric acid, methaconic acid, citraconic acid, itaconic acid, glutaconic acid, phthalic acid, isophthalic acid, isophthalic acid, cyclohexanedicarboxylic acid, succinic acid, adipic acid, sebatic acid, malonic acid; anhydrides, lower alkyl esters, and linolenic dimers of these acids; other bivalent organic acid monomera.

As a polyester resin favorably used as the binder resins of toner, polymers having multifunctional monomeric components, larger than trifunctional ones, are also favorably used in addition to the polymers comprising the above bifunctional monomers. The examples of multivalent alcohol monomers, or the above multifunctional monomers, whose valence being larger than trivalence, are as follows: sorbitol, 1,2,3,6-hexanetetrol, 1,4-sorbitan, pentaerythritol, dipentaerythritol, tripentaerythritol, saccharose, 1,2,4-butanetriol, 1,2,5-pentanetriol, glycerol, 2-methylpropanetriol, 2-methyl-1,2,4-butanetriol, trimethylolethane, trimethylolpropane, 1,3,5-trihydroxymethylbenzene, and the like.

The examples of multivalent carboxylic monomers whose valence being larger than trivalence, are as follows: 1,2,4-benzenetricarboxylic acid, 1,3,5-benzenetricarboxylic acid, 1,2,4-cyclohexanetricarboxylic acid, 2,5,7-naphthalenetricarboxylic acid, 1,2,4-naphthalenetricarboxylic acid, 1,2,4-butanetricarboxylic acid, 1,2,5-hexanetricarboxylic acid, 1,3-dicarboxyl-2-methyl-2-methylenecarboxylpropane, tetra (methylenecarboxy)-methan, 1,2,7,8-octanetetracarboxylic acid, empoltrimer acid; anhydrides of these acids; and others.

As the above-mentioned styrene-acryl resin, the resins not only having an Mw/Mn ratio, which is a ratio between weight-average molecular-weight Mw and number-average molecular-weight Mn, of mor than 3.5 but containing α, β-unsaturated ethylene monomer, which was disclosed for example in Japanese Patent O.P.I. Publication No. 134652/1975, as a component are favorably used. The typical examples of such α, β-unsaturated ethylene monomer are as follows: aromatic vinyl monomers such as styrene, o-methylstyrene, p-methylstyrene, α-methylstyrene, p-ethylstyrene, 2,4-dimethylstryrene, p-n-butylstyrene, p-tert-butylstyrene, p-n-hexylstyrene, p-n-oxtylstyrene, p-n-nonylstyrene, p-n-decylstyrene, p-n-dodecylstyrene, p-methoxystyrene, p-phenylstyrene, p-chlorostyrene, 3,4-dichlorostyrene and the like; acrylic esters such as methyl acrylate, ethyl acrylate, n-butyl acrylate, isobutyl acrylate, propyl acrylate, n-octyl acrylate, dodecyl acrylate, lauryl acrylate, 2-ethylhexyl acrylate, stearyl acrylate, 2-chloroethyl acrylate, phenyl acrylate, methyl α-chloroacrylate and the like; methacrylic esters such as methyl methacrylate, ethyl methacrylate, propyl methacrylate, n-butyl methacrylate, isobutyl methacrylate, n-octyl methacrylate, dodecyl methacrylate, lauryl methacrylate, 2-ethylhexyl methacrylate, stearyl methacrylate, phenyl methacrylate, dimethylaminoethyl methacrylate, diethylaminoethyl and the like; vinyl halides such as vinyl chloride, vinylidene chloride, vinyl fluoride and the like; nivyl esters such as vinyl acetate, vinyl propionate, vinyl benzoate, vinyl butyrate and the like; and others.

The values of number-average molecular-weight Mn and weight-average molecular-weight Mw in a specific polymer may be measured by various methods. Though the measured results differ depending upon a measuring method, the number-average molecular-weight Mn as well as the weight-average molecular-weight Mw in this specification are defined as the values determined by the following method.

In other words, each of these values is a value determined by a gel permeation chromatography with the following conditions; a solvent (tetrahydrofuran) is allowed to flow at a rate of 1.2 mℓ per minute with a temperature of 40°C, whereby 3 mg tetrahydrofuran solution of a density 0.2 g/20 mℓ containing a sample is added for the measuring operation. In determining the molecular weight of a sample, measuring conditions are selected so that the counted number of the molecular weight of the sample provides a linear relation with the logarithmic numbers on the analitical curve formed from the measuring results with various types of monodispersion polystyrene reference samples.

Additionally, the reliability of the measuring result is confirmed when a NBS 706 polystyrene reference sample satisfys the following expressions under the above-mentioned measuring conditions.

Weight-average molecular-weight Mw = 28.8×10^4

Number-average molecular-weight Mn = 13.7×10^4

As a GPC column used for this purpose, any columns may be used as for as they satisfy the above conditions. More specifically, a TSK_GE, GMH (manufactured by Toyo Soda Mfg. Co., Ltd.) or the like may be used.

A preferred binder resin used for toner has a softening point Tsp of 80 to 150°C, or, more specifically, 100 to 140°C. A glass transition point Tg of the similar resin is favorably 40 to 80°C, or in particular, 50 to 70°C. By using such a binder resin, a toner having both low-temperature fixing property as excellent anti-blocking property is obtained, and accordingly, a satisfactory developing operation is achieved, enabling a final image to be rapidly formed.

Unless otherwise specified, the softening point Tsp refers to a temperature determined in the following manner: using a flow tester Model CFT-500 manufactured by Shimazu Seisakusho Ltd., the measurement was recorded with measuring conditions of 20 kg/cm^2 load, 1 mm nozzle diameter, 1 mm nozzle length, 80°C pre-heating for 10 minutes, 6°C/min heating rate, and 1 cm^3 (weight represented by intrinsic specific gravity × 1 cm^3), wherein, by assuming the height of S curve in the characteristic curve (softening fluidization curve) representing the correlation between the amount of plunger drop in the flow tester and the corresponding temperature is h, the softening point is determined by reading a temperature corresponding to h/2.

The glass transition point is a value determined in the following manner: using a differential scanning calorimeter Model Low-temperature DSC manufactured by Rigaku Denkisha Co., Ltd., a measuring operation is performed at a heating rate of 10°C/min, whereby the glass transition point is read from the temperature on an intersection, in a DSC thermogram, between the extension of baseline below the glass transition point and the tangent line representing a maximum slope from the initial rising portion to summit of a peak.

The toner used in the invention comprises binder resin particles containing a coloring agent, as well as other toner component added in compliance with a requirement.

The examples of useful coloring agent are as follows: Carbon Black, Nigrosine Dye (C.I. No. 50415B), Aniline Blue (C.I. No. 50405), Chalcoil Blue (C.I. No. Azoic Blue 3), Chrome Yellow (C.I. No. 14090), Ultramarine Blue (C.I. No. 77103), DuPont Oil Red (C.I. No. 26105), Quinoline Yellow (C.I. No. 47005), Methylene Blue Chloride (C.I. No. 52015), Phthalocyanine Blue (C.I. No. 74160), Malachite Green Oxalate (C.I. No. 42000), Lamp Black (C.I. No. 77266), Rose Bengal (C.I. No. 45435), and mixtures involving any of the above agents, and others.

Sufficient proportion of such a coloring agent is favorably incorporated into a toner so as to form a satisfactorily dense image. The amount of such agent is usually 1 to 20 parts weight per 100 parts weight toner.

To prevent the filming of toner substance on a carrier, various surface releasing agents are favorably incorporated into the toner.

The examples of such a useful surface releasing agent include polyolefin, metal salt of aliphatic acid, aliphatic ester, partially saponified aliphatic ester, higher alcohol, fluid or solid paraffin wax, amide wax, multivalent alcohol ester, silicone varnish, aliphatic fluoro carbon, and the like. Among these examples, those preferred have a softening point, measured by a ring and ball test specified in JIS K2531-1960, of 80 to 180°C, in particular 70 to 160°C. These surface releasing agents may be singly used, or more than two of them may be combinedly used.

The examples of above-mentioned useful polyolefin include resins such as polypropylene, polyethylene, polybutene and the like.

The examples of above-mentioned metal salt of aliphatic acid are as follows: salts of maleic acid and a metal such as zinc, magnesium, calcium and the like; salts of stearic acid and a metal such as zinc, cadmium, barium, lead, iron nickel, cobalt, copper aluminum, magnesium, and the like: lead salt of dibasic stearic acid; salts of oleinic acid and a metal such as zinc, magnetisum, iron, cobalt, copper, lead, calcium and the like; salts of palmitic acid and a metal such as aluminum, calcium and the like; lead caprate, lead capronate, metal salts of linoleic acid and a metal such as zinc, cobalt and the like; salts of ricinoleic acid and a metal such as zinc, cadmium and the like; and the mixture of these salts.

The examples of the above-mentioned useful aliphatic ester include ethyl maleate, butyl maleate, methyl stearate, butyl stearate, cetyl palmitate, ethylene glycol montanate and the like.

As the above partially saponified apliphatic ester, for example, a montanic ester whose calcium area is saponified may be used.

The examples of the above-mentioned useful higher aliphatic acid include dodecanic acid, lauric acid, myristic acid, palmitic acid, stearic acid, oleic acid, linolic acid, ricinoleic acid, arachic acid, behenic acid, lignoceric acid, ceracholeic acid and the like, and a mixture of these acids.

The examples of the above-mentioned useful higher alcohol include dodecyl alcohol, lauryl alcohol, myristyl alcohol, palmityl alcohol, stearyl alcohol, aralkyl alcohol, behenyl alcohol and the like.

The examples of the above-mentioned useful paraffin wax include natural paraffin, microcrylstalline wax, synthetic paraffin, chlorinated hydrocarbon and the like.

The examples of the above-mentioned useful amide wax include amide stearate, amide oleinate, amide palmitate, amide laurate, amide behenate, methylenebisstearoamide, ethylenebisstearoamide and the like.

The examples of the above-mentioned useful alcohol ester include glycerol stearate, glycerol ricinolate, glycerol monobehenate, sorbitan monostearate, propylene glycol monostearate, sorbitan triolate and the like.

The examples of the above-mentioned useful silicone var nish include methylsilicone varnish, phenyl-silicone varnish and the like.

The examples of the above-mentioned useful aliphatic fluoro carbon include lower polymers such as ethylene tetrafluoride and propylene hexafluoride, and a fluorine-containing surface active agent disclosed in Japanese Patent O.P.I. Publication No. 124428/1978, and other agents.

The proportion of these surface release agents to be used is favorably 1 to 10 part weight per 100 parts weight binder resin.

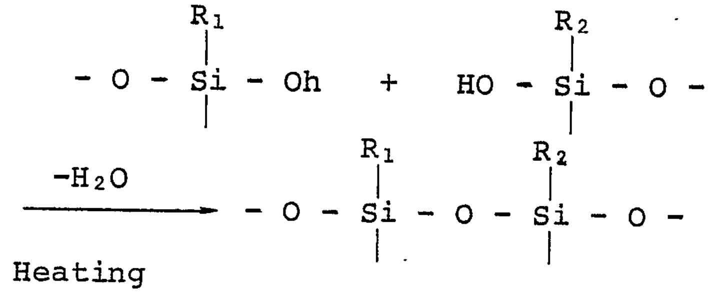
Other useful toner components are as follows: fluidizing agents such as fine silica powder, fine titania powder, fine alumina powder and the like; abrasive powder such as cerium oxide; lubricants such as zinc stearate and the like; charge controlling agents such as pigment or dye; and others.

The preferred toner used in the invention has a weight-average particle size of less than 20 µm, in particular, 1 to 15 µm. The use of a toner having such a preferred weight-average particle size enables an image having extremely good image quality to be formed. In contrast, the use of a toner having an excessively large weight-average particle size readily decreases the image resolution and may sometimes decrease the gradation reproducibility. At the same time, the use of a toner having an excessively small weight-average particle size may cause the toner to fly around in an image form ing apparatus, and this in turn may sometimes decrease the sharpness of resultant image.

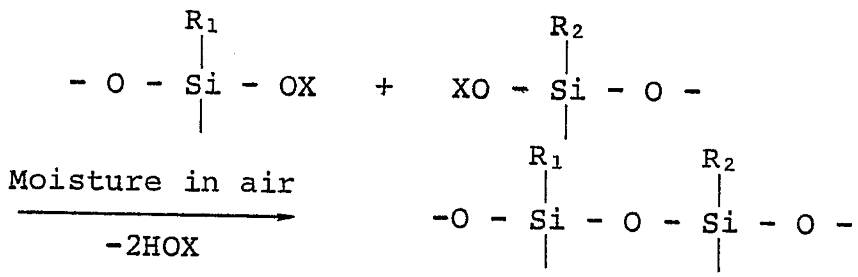
According to the invention a carrier composing a two-component developer together with a toner is, as mentioned previously, a resin-coated carrier whose individual particles comprise a magnetic particle coated with a resin containing silicone resin or fluororesin in an amount of at least 30 weights thereof.

The scope of resins used for this purpose in not specifically limited. However, the condensation reaction type silicone resins which harden by the following ractions (1) and (2) are favorably used.

(1) Heat-dehydration condensation-reaction



(2) Room-temperature moisture-hardening reaction



[wherein OX represents any of an alkoxy group, ketoxime group, acetoxy group, aminoxy group and the like.]

Among such condensation-reaction type silicone resins, the particularly favorable ones are those having a methyl substituent. Being tightly structured, the coating layer composed of a methyl-substituted condensation-reaction type silicone resin provides a carrier having a satisfactory water-repelling property and excellent moisture-resistance.

As a silicone resin used to form the coating layer of carrier particle, whichever a thermosetting silicone resin or normal-temperature setting silicone resin may be used. Since a high temperature not being necessary to set a resin, the used of normal-temperature setting silicone resin simplifys the carrier preparation.

The normal-temperature setting silicone resin is a silicone resin which hardens, under a normal atmosphere, at a temperature of 20 to 25°C, or a little higher, and accordingly, does not require a temperature exeeding 100°C.

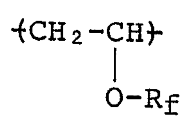
The silicone resin used as the coating layer of carrier is prepared by singly or combinedly using the above-described silicone resins, or a resin having not only the above silicone resin but another resin may be used for this purpose. Such another resin is favorably one having a high compartibility with a silicone resin. The exmaples of such a resin include an acryl resin, styrene resin, epoxy resin, urethane resin, polyamide resin, polyester resin, acetal resin, polycarbonate resin, phenol resin, vinyl chloride resin, vinyl acetate resin, cellulose resin, polyolefin resin, copolymers of these resins, blend resins of these resins, and others.

The scope of fluororesins used for forming the coating layer of carrier is not specifically limited, however, the preferred fluororesin is one capable of being dissolved in solvent, and being applied onto the surface of magnetic particle by a conventional coating method.

More specifically, the following are favorably used.

(1) Vinylidene fluoride-tetrafluoroethylene copolymer

(2) Polymer comprising a vinyl ether monomer represented by the following general formula and having a substituent in the position of a fluorine atom in the side chain



[wherein R_f represents an alkyl group or aralkyl group substituting mor than one fluorine atom.]

(3) Polymer comprising a vinyl ketone monomer represented by the following general formula

$$\left(CH_2-\underset{\underset{CO-R_f}{|}}{CH} \right)$$

[wherein R_f represents an alkyl group or aralkyl group substituting more than one fluorine atom.]

(4) Blend polymer comprising more than two of the resins correspondingly represented by the above formulas (1) through (3)

The fluororesin used to form the coating layer of carrier is prepared by singly or combinedly using the above-described fluororesin, or a resin having not only the above fluororesin but another resin may be used for this purpose. Such another resin is favorably one having a high compatibility with a fluororesin. The examples of such a resin include an acryl resin, styrene resin, epoxy resin, urethane resin, polyamide resin, polyester resin, acetal resin, polycarbonate resin, phenol resin, vinyl chloride resin, vinyl acetate resin, cellulose resin, polyolefin resin, copolymers of these resins, blend results of these resins, and others.

The conente of fluororesin in the coating resin is at least 30 weight%, or more favorably, 40 to 100 weight%, or most favorably 50 to 100 weight%. Less than 30 weight% of fluororesin content does not fully provide the favorable property of fluororesin, often resulting in unstable triboelectric charging characteristic.

With a resin-coated carrier used in the invention, the magnetic particle serving as a core being coated with a resin is a particle made of a substance which is strongly magnetized in the direction of magnetic field. The examples of such a substance are as follows: metals showing ferromagnetism such as ferrite, magnetite, as well as iron, nickel, cobalt and the like; alloys or compounds involving these metals; alloy not having ferromagnetic element but being endowed with ferromagnetism by an appropriate heat-treatment, and being typified by Heusler alloys such as manganese-copper-aluminum alloy, manganese-copper-tin, and the like; chromium dioxide and the like.

The term "ferrite" is a general term of a magnetic oxide involving iron and is not limited only to a Spinel structure ferrite represented by a formula $MO.Fe_2O_3$ (M represents a bivalent metal atom). Capable of being arbitrarily providing various magnetic characteristics by varying the composition of contained metal components, a ferrite is especially advantageous to prepare a carrier which best suits the object of the invention. Additionally, being made of oxidant, a ferrite powder has a specific gravity much smaller than metal powder such as iron powder or nickel powder. This feature allows easy mixing and blending with a toner, and advantageously contributes to the uniformity of toner concentration in the developer as well as to the optimization of triboelectrical potential formed in toner powder. A further advantage is that, since having a resistivity of 10^8 to $10^{12}\Omega$.cm, which is greater than that of iron powder, nickel powder or cobalt powder, the ferrite powder provides an insulative carrier satisfactorily used in a developing method in which a high bias voltage is applied to the developing gap, even when the layer thickness of resin forming the surface of carrier parti cle is extremely small, approximately 0.5 μm.

In relation to the 1000 Oe external magnetic field, the above-mentioned ferrite favorably has a saturated magnetization of 10 to 40 emu/g and a coercive force of 0.1 to 100 Oe. Furthermore, the ferrite favorably has a resistivity of 1×10^6 to $1 \times 10^{11}\Omega$.cm, a specific gravity of 4.0 to 5.5, and a porosity of 1.0 to 10%.

In preparing a resin coated carrier, the coating layer is formed in the following steps. A solution prepared by dissolving silicone resin or fluororesin, and, if necessary, another resin, in a solvent is applied on the surface of individual magnetic particles by a dipping method, spray method, fluidized bed method or the like, whereby usually by heating, the solvent is allowed to vaporize and the solution is allowed to dry, then during or after the drying, the coat layer is allowed to set.

Into the coating solution to form the coating layer may be added other additives in compliance with a requirement. A solvent being used for this purpose is not specifically limited, as far as a silicone resin, fluororesin, and another additional resin can be dissolved in such a solvent. However, the typical examples of such a solvent are as follows: aromatic hydrocarbons such as toluene, xylene and the like; ketones such as acetone, methylethyl ketone; tetrahydrofuran; dioxane; higher alcohol; and mixed solvents involving any of the above solvents.

In setting the coating layer, when a thermosetting silicone resin requires heating at 200 to 250°C. Though a normal-temperature setting silicone resin does not require heating with a high temperature, the heating with a temperature range of 150 to 250°C may be performed to accelerate the setting. Additionally, in the course of drying, a metal soap of octyl acid, nephthic acid or the like and lead, iron, cobalt, tin, manganese, zinc or the like may be used as a dryer. Also, an organic amine such as ethanol amine may be satisfactorily used as a dryer.

The preferred thickness of the formed resin coating-layer containing silicone resin is usually 0.1 to 20 µm.

The preferred heating temperature necessary for setting a coating layer comprising a resin containing fluororesin is usually 100 to 350°C. To accelerate the drying or setting, a dryer or setter composed of, for example, an organic metal salt such as zinc octylate, dibutyl zinc oxide or the like may be used.

The preferred thickness of the formed resin coating-layer containing fluororesin is, for example, 0.1 to 10 µm, and more specifically, 0.3 to 4 µm, and most specifically, 0.3 to 2 µm.

The individual particles of resin-coated carrier used in the invention are favorably spherical-shaped and have a weight-average particle size of less than 100 µm, and more favorably, 5 to 50 µm. The use of a resin-coated carrier having such a favorable weight-average particle size improves the image resolution as well as the gradation reproducibility. The use of a carrier having an excessively large weight-average particle size may sometimes make it difficult to form a thin developer layer on a developer bearing/carrying member, and possibly resulting in the deteriorated developability and decreased image quality. In contrast, the used of a carrier having an excessively small weight-average particle size may sometimes deteriorate the developability, triboelectrical charging property, fluidity and the like, and may cause the carrier to fly around in an image forming apparatus.

A resin-coated carrier used in the invention is an insulative carrier having a registivity of more than $10^8 \Omega$.cm, favorably, more than $10^{13} \Omega$.cm, and more favorably, more than $10^{14} \Omega$.cm. The use of such a highly insulative carrier satisfactorily prevents, in the course of developing, a potential from being injected by a bias voltage and resulting in a filming of carrier on the surface of a latent image carrying member, or a potential to form an electrostatic latent image from being eliminated.

Incidentally, the weight-average particle sizes of toner and carrier are values determined with a Coulter Counter manufactured by Coulter Ltd.

The resistivities of magnetic particles as well as resin-coated carrier particles are determined by the following procedure: sample particles are poured into a container having a cross-sectional area of 0.50 cm^2 and tamped down, then a load of 1 kg/cm^2 is applied onto the tamped sample particles so as to make the thickness of sample to be approximately 1 mm, whereby an electrical field of 10^2 to 10^5 V/cm is applied to between the load and a bottom electrode and the value of current flowing is measured.

In preparing a two-component developer used into the invention, the preferred blending ratio between toner and carrier is a ratio where the total surface area of toner is approximately same as the similar area of carrier. For example, if a weight-average particle size of toner is 10 µm and a weight-average particle size of carrier is 20 µm, the preferred toner concentration (weight ratio per total developer) is 5 to 40 weight%, in particular, 8 to 25 weight%. More specifically, unlike a conventional developer comprising large-sized carrier particles whose individual surface being covered with a multiplicity of toner particles, it is advantageous to prepare the two-component developer used in embodying the invention by blending a toner and a fine particle carrier whose particle size being approximately the same as the toner at a ratio whre the total surface areas of carrier and toner are approximately the same with each other.

[Typical Examples of the Invention]

The typical examples of the present invention are hereinafter described. However, the scope of the invention is not limited only to these examples.

First, the example where a resin-coated carrier comprising magnetic particles coated with silicone resin-containing resin is described below.

(Example 1)

Fig. 3 is an explanatory diagram schematically illustrating one example of image forming apparatus being used in embodying the developing method of the invention. The move of a draft table causes the optical draft image formed by an illuminating light source 21 to be focused on a latent image carrying member 20 via a mirror 22 and a lens 23, and an electrostatic latent image corresponding to an original draft is formed on the latent image carrying member 20. A developing unit A has a constitution, for exmaple, shown in Fig. 1. The electrostatic latent image formed on the latent image carrying member is developed by the developing unit A to form a toner image.

A toner image obtained in such a manner is transferred onto a recording paper P with a transfer electrode 29 after being electrically neutralized for easy transfer by an exposure lamp 28. The recording paper P is separated by a separation electrode from the latent image carrying member 20 and is fixed with a fixer 31 to form a fixed image. At the same time, the latent image carrying member 20 is electrically neutralized by a neutralization electrode 32 and its surface is cleaned by a cleaning mechanism 33.

The cleaning mechanism 35 in this example has a cleaning blade 34 for scraping off toner. Toner particles scraped off by the blade 34 are collected by a roller 36.

Using such an image forming apparatus and applying the developing method of the invention, the following test procedure was exercised by actually conducting image forming operation.

Preparation of resin-coated carrier

(1) Carrier A

With a fluidized-bed equipment, 100 parts spherical copper-zinc ferrite particles having a weight-average particle size of 35 μm (manufactured by TDK Corporation) were coated with 25 parts condensation-reaction type silicone resin solution SR-2411 (manufactured by Toray Silicone Co., Ltd.) at a temperature of 80°C, and were further heat-treated at a temperature of 200°C for one hour to obtain a carrier having individual particles being coated with a silicone resin layer. The coating layer has a thickness of approximately 1 μm. The carrier was designated carrier A.

The properties of the carrier A were as follows:

Weight average particle size 42 μm
Magnetization 20 emu/g
(Measured magnetic field: 1000 Oe)
Resistivity more than $10^{14}\Omega$.cm
Specific gravity 4.9 g/cm^3

(2) Carrier B

A carrier having particles individually being coated with a 1 μm thick silicone resin layer was prepared in a manner identical to that of carrier A except that silicone resin solution SR-2410 was used in the place of silicone resin solution SR-2411. This carrier was designated carrier B.

The properties of the carrier B were as follows:

Weight-average particle size 35 μm
Magnetization 16 emu/g
(Measured magnetic feild: 1000 Oe)
Resistivity $10^{14}\Omega$.cm
Specific gravity 4.8 g/cm^3

(3) Carrier C

A carrier having aprticles individually being coated with a 1 μm thick silicone resin layer was prepared in a manner identical to that of carrier A except that thermosetting silicone resin solution (manufactured by The Sin-Etsu Chemical Co., Ltd.) was used in the place of silicone resin solution SR-2411. This carrier was designated carrier C.

The properties of the carrier C were as follows:
Weight average particle size 42 µm
Magnetization 14 emu/g
(Measured magnetic field: 1000 Oe)
Resistivity more than 10^{14}Ω.cm
Specific gravity 4.8 g/cm^3

(4) Comparison carrier a

A carrier comprising copper-zinc ferrite particles identical to those of carrier A was designated comparison carrier a.
The properties of the comparison carrier a were as follows:
Weight-average particle size 40 µm
Magnetization 18 emu/g
(Measured magnetic field: 1000 Oe)
Resistivity 4 × 10^{10}Ω.cm Specific gravity 5.2 g/cm^3

(5) Comparison carrier b

A carrier having particles individually have a coating layer of 1 µn thick styrene was prepared in a manner identical to that of carrier A except that toluene solution (solid content, 10 weight%) containing styrene resin (weight-average molecular weight Mw, 71,000; number-average molecular weight Mn, 32,000; glass transition point Tg, 125°C) was used in the place of silicone resin solution SR-2411. This carrier was designated comparison carrier b.
The properties of the comparison carrier b were as fol lows:
Magnetism 20 emu/g
(Measured magnetic field: 1000 Oe)
Resistivity more than 10^{14}Ω.cm
Specific gravity 4.9 g/cm^3

(6) Comparison carrier c

A carrier having particles individually being coated with a 1.5 µm thick methyl methacrylate resin layer was prepared in a manner identical to that of carrier A except that toluene solution (solid content, 10 weight%) containing methyl methacrylate resin (weight average molecular Mw, 73,000; number average molecular Mn, 33,000; glass transition point Tg:-121°C) was used in the place of silicone resin solution SR-2411. This carrier was designated comparison carrier c.
The properties of the comparison carrier c were as follows:
Weight-average particle size 40 µm Magnetization 20 emu/g
(Measured magnetic field: 1000 Oe)
Resistivity more than 10^{14}Ω.cm
2 Specific gravity 4.8 g/cm^3

Preparation of toners

(1) Black toner A

With a Henschel mixer, 100 parts weight polyester resin (UXK-120 P, manufactured by Kao Soap Co., Ltd.) and 3 parts weight polypropylene (Viscol 660 P, manufactured by Sanyo Kasei Kogyo Co., Ltd.) and 10 aprts Carbon Black (Mogal L, manufactured by Cabot) and 2 parts weight charge controlling agent (Bontron E-82, manufactured by Orient Chemicals Co., Ltd.) were mixed, then thoroughly kneaded with a triple-roller at a temperature of 140°C. Further, the mixture, after cooled and crushed, was pulverized with a jet mill and classified to prepare black tonre powder having a particle size distribution of 5 to 25 µm and a weight-average particle size of 11 µm.

To 100 aprts weight of the black toner powder, 0.5 parts weight hydrophobic fine silica particles (R-812, manufactured by Nippon Aerozyl Co., Ltd.) was added, then thoroughly blended by a Henschel mixer to prepare black toner. This toner was designated black toner A. The static bulk density of the black toner A was 0.44 g/cm^3.

(2) Yellow toner B

A yellow toner was prepared in a manner identical to that of black tonre A except that yellow pigment, Pigment Yellow, was used in the place of Carbon Black. This toner was designated yellow toner B. The static bulk density of the yellow toner B was 0.44 g/cm^3.

(3) Magenta toner C

A magenta tonre was prepared in a manner identical to that of black tonr A except that magenta pigment, Permanent Carmine F-5B, was used in the place of Carbon Black. This toner was designated magenta toner C. The static bulk density of the magenta toner C was 0.45 g/cm^3.

(4) Cyan toner D

A cyan toner was prepared in a manner identical to that of black tonre A except that cyan pigment, Copper Phthalocyanine, was used in the place of Carbon Black. This toner was designated cyan toner D. The static bulk density of the cyan toner D was 0.44 g/cm^3.

<u>Preparation of developers</u>

The above-mentioned carriers A through C were independently combined with the black tonre A to prepaer developers 1 through 3 individually having a toner concentration of 10 weight%. At the same time, the above-mentioned comparison carriers a through c were also combined with the black toner A to correspondingly prepare comparison developer 1 through 3 individually having a toner concentration of 10 weight%.

Additionally, yellow toner B, magenta toner C and cyan toner D were independently combined with carrier A to correspondingly prepare color developers 1 through 3 individually having a toner concentration of 12 weight%.

<u>Test 1 by actual copying operation</u>

Using each of these developers, a test was performed by executing copying operation, in accordance with the developing process based on the below specified developing conditions, for 30,000 sheets, whereby the triboelectricity on toner, fog, adhesion of carrier on a latent image carrying member, imaging failure, and uneven imaging were evaluated at the first and 30000th formed images. The results are listed in Table 1 shown later.

[Developing conditions (normal developing)]

-Latent image carrying member: 100 mm dia. drum type photosensitive member made of selenium
-Linear velocity: 100 mm/sec
-Surface potential: +800 V (image area) to +50 V (non-image area)
- Diameter of developing sleeve: 25 mm
-Linear velocity of developing sleeve: 250 mm/s (forward direction)
-Total number of poles on magnetic roll: 8 poles
-Rotational speed of magnetic roll: 1200 rpm
-Thin layer forming member: 3 mm thick resilient plate made of urethane rubber, being pressed on the

surface of developing sleeve
-Development gap: 500 μm
-Thickness of developer layer: 400 μm (maximum value)
-Toner content in developer: 10 weight%
-Toner content in developer layer formed on developing sleeve: 0.3 mg/cm^2
-DC bias voltage: 50 to 200 V
-AC bias voltage: 1.0 to 2 kV (frequency, 3 kHz; peakpeak value)

Table 1

Developer	Carrier	Tribo-electricity (°C/g)		Fog		Carrier adhesion		Imaging failure		Uneven imaging		Toner spent
		Initial	After 30000 sheets	Initial	After 30000 sheets	Initial	After 30000 sheets	Initial	After 30000 sheets	Initial	After 30000 sheets	After 30000 sheets
Developer 1	Carrier A	-22	-20	No	No	No	No	No	No	No	No	No
Developer 2	Carrier B	-19	-16	No	No	No	No	No	No	No	No	No
Developer 3	Carrier C	-23	-18	No	No	No	No	No	No	No	No	No
Comparison developer 1	Comaprison carrier a	-9	-5	Great	Great	Yes	Great	Yes	Yes	Yes	Yes	Yes
Comparison developer 2	Comparison carrier b	-12	-3	Minor	Great	No	Great	Yes	Yes	Yes	Yes	Yes
Comparison developer 3	Comparison carrier c	-40	-10	No	Minor	Yes	Great	Minor	Yes	Minor	Yes	Yes

The methods of evaluation were as follows:

Triboelectricity

Measured by a known blow-off method.

Fog

A fixed image was inspected with human eye.

Carrier adhesion on latent image carrying/transporting member

The surface of latent image carrying/transporting member was inspected with human eye.

Imaging failure

A fixed image was inspected with human eye.

Adhesion of toner material to the surface of carrier (toner spent)

Judged by inspecting carrier particles with a scanning electron microscope.

As cna be understood from the results listed in Table 1, when executing the developing method of the invention with any of the developers 1 through 3, the toner demonstrated a proper triboelectricity, and a sharp image featuring high-resolution as well as excellent gradation reproducibility is formed without accompanying any of fog, carrier adhesion of the image carrying member, imaging failure, and uneven imaging.

With a fluctuation in toner triboelectricity being small, the developing method of the invention using any of the developers 1 through 3 provides a sharp image, whose quality is comparable to that of the first copied image, even after 30000 sheet-copying operation. Additionally, inspection of the contamination in an image forming apparatus confirmed only an extremely limited contamination with toner and carrier. This is because the silicone resin to form the coating layer of the carrier used in embodying the invention has a smaller critical surface tension when compared to a resin used to prepare a comparison carrier, and accordingly, the toner substance does not easily adhere to the surface of individual carrier particles. Furthermore, the developing effects of bias voltage was satisfactorily demonstrated.

In contrast, the sue of comparison developer 1 incurred a smaller triboelectricity even in the initial stage of continuous 30000 sheet copying operation, and an obtained image was not sharp, showing considerable fog, imaging failure and uneven imaging. Also, the carrier adhesion on the latent image carrying member was found. In addition, the above problems further deteriorated after the completion of 30000-sheet copying operation, because of furthre decreased toner triboelectricity. Also, considerable adhesion of toner material on the surface of individual carrier particles also occurred.

Furthermore, the use of comparison developer 2 incurred a smaller triboelectricity even in the initial stage of continuous 30000-sheet copying operation, and an obtained image was not sharp, showing minor fog, imaging failure and uneven imaging. In addition, the above problems further deteriorated after the completion of 30000-sheet copying operation, because of further decreased toner triboelectricity. Also, considerable adhesion of toner material on the surface of individual carrier particles also occurred.

The use of comparison developer 3 incurred imaging failure and uneven imaging on an obtained image during the initial stage of continuous 30000-sheet copying operation, and the carrier adhesion on the latent image carrying member was also found. After the completion of 30000-sheet copying operation, the toner triboelectricity further decreased, and accordingly, the obtained image is not sharp, showing minor fog, as well as imaging failure and uneven imageing. Also, considerable carrier adhesion on the latent image carrying member as well as considerable adhesion of tonre substance on the surface of individual carrier particles also occurred.

Test 2 by actual copying operation

A test was performed in a manner identical to the above test 1 by actual copying operation except that the modified developing conditions below were used. The results similar to those of test 1 were obtained.

[Developing conditions (reverse developing)]

-Latent image carrying member: 140 mm dia. drum type photosensitive member having organic photoconductive photosensitive layer
-Linear velocity: 60 mm/sec
-Surface potential: -700 V (image area) to -50 V (non-image area)
-Diameter of developing sleeve: 20 mm
-Linear velocity of developing sleeve: 250 mm/s (forward direction)
-Total number of poles on magnetic roll: 8 poles
-Rotational speed of magnetic roll: 1000 rpm
-Thin layer forming member: 3 mm thick resilient plate made or urethane rubber, being pressed on the surface of developing sleeve
-Development gap: 500 µm
-Thickness of developer layer: 400 µm (maximum value)
-Toner content in developer: 10 weight%
-Toner content in developer layer formed on developing sleeve: 0.4 mg/cm^2
-DC bias voltage: -500 to -600 V
-AC bias voltage: 1.0 to 2.5 kV (frequency, 3 kHz; peak-peak value)

(Example 2)

Fig. 5 schematically illustrates the constitution of another example of an image forming apparatus used in embodying the developing method of the invention, wherein an image input unit IN is unit-built and comprises an illuminating light source 1, a mirror 22, a lens 23 and one-dimensional color CCD image sensor 24. The image input unit IN is shifted in the direction shown by an arrox x with an unshown driving mechanism, and the CCD image sensor 24 reads an original draft. Instead, with the image input unit IN being stationary, a draft table may be shifted to shift the original draft 25.

The image information read by the image input unit IN is converted into data suitable for recording at an image processing unit TR. A laser optical system 26 forms a latent image on the image carrying member 20 in the following manner and based on the above-mentioned image data. The surface of image carrying member 20 is uniformly electrified with a Scorotron electrification electrode 27. Then, image exposure light L with the recorded data incorporate is illuminated from the laser optical system 26 via a lens upon the image forming member 20. In this way, an electrostatic latent image corresponding to the original draft is formed on the latent image carrying member 20.

The electrostatic latent image is developed by a developing unit A containing yellow toner B. The latent image carrying member 20 on which a toner image has been formed in again uniformly electrified by the Scorotron electrification electrode 27 and receives image exposure light L into which recorded data of anothre color element has been incorporated. The formed electrostatic latent image is developed by a developing unit B containing magenta toner C.

As a result, a two-color toner image of yellow toner B and magenta toner C is formed on the image carrying member 20. Similarly, a cyan toner D image as well as a black toner A image are consecutively superposed on the two-color toner image to form a four-color toner image on the latent image carrying member 20. Additionally, the developing units A, B, C, and D respectively containing each color toner commonly have the constitution similar to that of the developing unit in Fig. 1.

A multicolor toner image obtained in such a manner is transferred on a recording paper P with a transfer electrode 29 after being electrically neutralized for eash transfer by an exposure lamp 28. The recording paper P is separated by a separation electrode 30 from the latent image carrying member 20 and is fixed with a fixer 31, thus forming a fixed image. At the same time, the triboelectricity on the image carrying member 20 is neutralized by a neutralization electrode 32, and the surface of which is cleaned by a cleaning mechanism 33.

The cleaning mechanism 33 in this example has a cleaning blade 34 and a fur brush 35 which are kept out of contact with the latent image carrying member 20 during formation of an image. Once a multicolor image is finally formed on the latent image carrying member 20, the cleaning blade 34 and the fur brush 35 come in contact with the latent image carrying member 20 and scrape off toner left untransferred on the member 20. Then, the cleaning blade 34 leaves the latent image carrying member 20, and, a little later, the fur brush also leaves the latent image carrying member. The fur brush 35 functions to remove toner left on the latente image carrying member 20 after the cleaning blade 34 leaves the member 20. Numeral 36 denotes a roller which collects toner scraped off by the blade 34.

A typical example of laser optical system 26 is shown in Fig. 9. In this figure, numeral 37 denotes a semiconductor laser generator, numeral 38 a rotatable polygon mirror, and numeral 39 a $f\theta$ lens.

In such an image forming apparatus, it is advantageous to carry out with a timing for starting imagewise exposure by providing an optical reference mark for positioning of each image on the latent image carrying member 20 and by reading the mark by an optical sensor or the like.

Test 3 by actual copying operation

Using the image forming apparatus, and by actually applying the developing method of the invention, a test operation to form 30000 sheets of copied image was performed so as to examine the triboelectricity on toner, fog, adhesion of carrier on a latent image carrying member, imaging failure, and uneven imaging. The results are listed in Table 2 shown later.

In this test by actual copying operation, a reverse developing method schematically shown in Fig. 6 was performed, whereby the image forming process was performed based on the operation timings (in this figure a higher level corresponds to an ON status) listed in Fig. 7.

Fig. 6 schematically illustrates the change in the surface potential of latent image carrying member having a positive triboelectrically polarity. PH represents an exposure area in the latent image carrying member, DA a non-exposure area in the similar member, and DUP an increase in potential due to the adhesion of positive-charged toner T′ on the exposure area PH caused by the first development.

The latent image carrying member is uniformly electrified with a Scorotron electrode, so as to have a specific positive surface potential E as shown in Fig. 6-(1). Next, the first imagewise exposure is effected by an exposure light source such as a laser, cathode ray tune, LED or the like, whereby the potential of exposure are PH drops in proportion to the light amount as shown in Fig. 6-(2). An electrostatic latent image formed in this way is developed by a developing unit to which a positive bias voltage approximately equal to the surface potential E on the non-exposure area is applied. As a result, a positive-charged toner T: adheres to the exposure area PH having a relatively low potential as shown Fig. 6-(3), thus the first toner image is formed. The potential in this areas wher the toner image having been formed increases by DUP, since the positive-charged toner T_1 has adhered there. However, the potential still differs from that of the non-exposed area DA. Next, the surface of latent image carrying member where the first toner image has been formed is subjected to the second electrification by the electrifier, as a result, whichever the toner T_1 is present or not, uniform surface potential E is attained, as shown in Fig. 6-(4). The surface of latent image carrying member is further subjected to the second imagewise exposure, which forms an electrostatic latent image, as shown in Fig. 6-(5). The electrostatic latent image is, similarly to the above description, developed with a positive-charged toner T_2whose color different from that of the tonre T_1. This step forms the second toner image shown in Fig. 6-(6).

With the above tonre image forming process being repeaded, a multicolor toner image is formed on the latent image carrying member. Then, the multicolor toner image is transferred onto a recording paper, which is heated or pressed to fix the image. Thus, the multicolor recorded image is finally formed. Toner and triboelectrical potential on the surface of latent image carrying member are removed, and the next sequence of multicolor image forming is prepared. Additionally, it is also possible to use a method to fix a multicolor toner image directly onto the latent image carrying member. In the developing method illustrated in Fig. 6, it is favorable that the processing step in Fig. 6-(6) be performed without allowing the developer layer to come in contact with the surface of latent image carrying member.

[Developing conditions (reverse developing) and others]

-Latent image carrying member: 140 mm dia. drum type photosensitive member having organic photoconductive photosensitive layer

-Linear velocity: 60 mm/sec

-Surface potential: -700 V (non-image area) to -50 V (image area) - Exposure light source: Semiconductor laser (wavelength, 780 nm; recording density, 16 dots/mm)

-Constitution of developing units A through D

Diameter of developing sleeve: 20 mm

Linear velocity of developing sleeve: 250 mm/s (forward direction)

Total number of poles on magnetic roll: 8 poles

Rotational speed of magnetic roll: 800 rpm

Thin layer forming member: 3 mm thick resilient plate made of urethane rubber, being pressed on the surface of developing sleeve

Development gap: 0.4 mm

Maximum magnetic flux density on surface of developing sleeve: 700 gauss

Thickness of developer layer: 250 µm (maximum value)

Toner content in developer layer formed on sloping sleeve: 0.8 mg/cm^2

DC bias voltage during developing: -500 V

AC bias voltage during developing: 1.2 kV

(Frequency, 2 kHz; peak-peak value)

DC bias voltage during non-developing: 0 V

AC bias voltage during non-developing: Higher than 0.3 kV

(Frequency, 2 kHz; peak-peak value)

(During non-developing, magnetic roll and developing sleeve are stationary. Developing sleeve may be electrically floated.)

-Developing sequence: (Yellow) → (Magenta) → (Cyan) → (Black)

-Transfer process: Corona discharge method

-Fixing process: Heat roll method

- Cleaning process: Blade and fur brush

Table 2 (Part 1)

Developer		Average particle size (μm)	Specific gravity (g/cm³)	Resistivity (Ω·cm)	Magnetization	Toner concentration (weight%)
Carrier A		35	4.9	More than 10^{14}	17 emu/g	
Toner	Yellow toner B	12	1.2	More than 10^{14}		12
	Magenta toner C	12	1.2	More than 10^{14}		12
	Cyan toner D	12	1.2	More than 10^{14}		12
	Black toner A	10	1.2	More than 10^{14}		12

Table 2 (Part 2)

Toner	Carrier	Initial tribo-electricity (μC/g)	Fog	Carrier adhesion	Imaging failure	Uneven imaging	Toner spent
			After 30000 sheets	After 30000 sheets	After 30000 sheets	After 30000 sheets	After 30000 sheets
Yellow toner B	Carrier A	-16	No	No	No	No	No
Magenta toner C	Carrier A	-16	NO	NO	NO	NO	NO
Cyan toner D	Carrier A	-16	No	No	No	No	No
Black toner A	Carrier A	-16	No	No	No	No	No

As can be understood from the results listed in Table 2, when executing the developing method of the invention, the toner demonstrated a proper triboelectricity, and a sharp color image featuring high-resolution as well as excellent gradation reproducibility is formed without accompanying any of fog, carrier adhesion of the image carrying member, imaging failure, and uneven imaging.

The developing method of the invention is capable of providing a sharp image, whose quality is comparable to that of the first copied image, even after 30000 sheet-copying operation. Additionally, inspection of the contamination in an image forming apparatus confirmed only an extremely limited contamination with toner and carrier.

(Example 3)

Fig. 8 schematically illustrate the outline of another example of image forming apparatus used for embodying the developing method of the invention. This image forming apparatus has a constitution, wherein a multicolor toner image is formed at once, while a latent image carrying members completes one rotation. The image forming apparatus in Fig. 8 differs from the apparatus in Fig. 5 in that:

(1) Developing units A through D individually have electrification electrodes respectively 27A, 27B, 27C and 27D, and laser optical systems respectively 26A, 26B, 26C and 26D, in order to enable the developing processes with all the color toners to be sequentially performed, and;

(2) A cleaning mechanism 33 comprises a cleaning blade 34 and a roller 36 for collecting toner, and, the cleaning blade 34 is always being pressed upon the latent image carrying member 20, and;

(3) The appratus has a transporting path, for a recording paper P, which is different from that of the apparatus in Fig. 5.

When forming, for example, a four-color image with this image forming apparatus, and even if the linear velocity of the latent image carrying member is set equal to that of the apparatus in Fig. 5, the image may be formed approximately four times swiftly than the latter apparatus.

Test 4 by actual copying operation

Using the image forming apparatus in Fig. 8, and by actually applying the developing method of the invention, a test operation to form 30000 sheets of copied image was performed so as to examine, respectively in the initial stage of image forming operation and after the completion of 30000-sheet copying operation, the triboelectricity on toner, fog, adhesion of carrier on a latent image carrying member, imaging failure, and uneven imaging. The results were as satisfactory as those of the previously mentioned test 3 by actual copying operation.

In this test by actual copying operation, an image form ing process in compliance with the following developing conditions was exercised.

[Developing conditions (reverse developing) and others]

-Latent image carrying member: 140 mm dia. drum type photosensitive member having organic photoconductive photosensitive layer
-Linear velocity: 200 mm/sec
-Surface potential: -700 V (non-image area) to -50 V (image area)
-Exposure light source: Semiconductor laser (wavelength, 780 nm; recording density, 16 dots/mm)
-Constitution of developing units A through D
Diameter of developing sleeve: 20 mm
Linear velocity of developing sleeve: 500 mm/s (forward direction)
Total number of poles on magnetic roll: 8 poles
Rotational speed of magnetic roll: 1500 rpm
Thin layer forming member: 3 mm thick resilient plate made of urethane rubber, being pressed on the surface of developing sleeve
Development gap: 0.3 μm
Maximum magnetic flux density on surface of developing sleeve: 700 gauss
Thickness of developer layer: 250 μm (maximum value)
Toner content in developer layer formed on developing sleeve: 0.6 mg/cm^2
DC bias voltage during developing: -500 V
AC bias voltage during developing: 2.0 kV
(Frequency, 3 kHz; peak-peak value)
DC bias voltage during non-developing: 0 V
AC bias voltage during non-developing: More than 0.3 kV
(Frequency, 2 kHz; peak-peak value)
(During non-developing, magnetic roll and developing sleeve are stationary. Developing sleeve may be electrically floated.)
-Developing sequence: (Yellow) → (Magenta) → (Cyan) → (Black)

-Transfer process: Corona discharge method
-Fixing process: Heat roll method
- Cleaning process: Blade system

Additionally, int his test 4 by actual operation, the color development sequence may be modified; for example, (black) → (yellow) → (magenta) → (cyan).

Next, one example using a resin-coated carrier comprising magnetic particles individually coated with resin containing more than 30 weight% fluororesin is described below.

Using the image forming apparatus in Fig. 3, a test was performed in a manner identical to that of Example 1.

Preparation of resin-coated carrier

(1) Carrier X

26 g vinylidene fluoride-tetrafluoro ethylene copolymer (copolymerization molar ratio, 80:20; intrinsic viscosity, 0.95 dℓ/g; manufactured by Daikin Kogyo Co., Ltd.) was dissolved in 800 mℓ acetone-methyethyl ketone (weight ratio, 1:1) mix solution to prepare a coating solution.

Using a Spiller Coater manufactured by Okada Seiko-sha Co., Ltd., the coating solution was applied to copper-zinc ferrite particles (particle size distribution, 15 to 60 µm; weight-average particle size, 35 µm), whereby heating with 100°C temperature was performed to prepared carrier having individual particles being coated with resin containing fluororesin. The thickness of coating layer was 1.0 µm. This carrier was designated carrier X.

The properties of the carrier X were as follows:

Weight-average particle size 35 µm
Magnetization 20 emu/g
(Measured magnetic field: 1000 Oe)
Resistivity More than $10^{14}\Omega$.cm

(2) Carrier Y

A carrier having particles individually being coated with a 1.0 µm thick fluororesin layer was prepared in a manner identical to that of carrier X except that a polymer comprising monomer represented by the following general formula was used instead of the vinylidene fluoride-tetrafluoro ethylene copolymer. This carrier was designated carrier Y.

$$-\!\!\left(CH_2-\underset{\displaystyle COCH_2CH_2OCF_2CF_2H}{\underset{|}{CH}}\right)\!\!-$$

(Intrinsic viscosity of polymer = 0.59 dℓ/g)

The properties of the carrier Y were as follows:

Weight-average particle size 40 µm
Magnetization 20 emu/g
(Measured magnetic field: 1000 Oe)
Resistivity More than $10^{14}\Omega$.cm

(3) Carrier Z

A carrier having particles individually being coated with a 1.0 µm thick fluororesin layer was prepared in a manner identical to that of carrier X except that blend polymer of the polymers (1) and (2) (weight ratio = 7:3) specified below was used instead of the vinylidene fluoride-tetrafluoro ethylene copolymer. This carrier was designated carrier Z.

Polymer (1): Vinylidene fluoride-tetrafluoro ethylene copolymer (copolymeric molar ratio, 80:200; intrinsic viscosity, 0.95 dℓ/g)

Polymer (2): Methyl methacrylate copolymer, Acrypet MF, manufactured by Mitsubishi Rayon Co., Ltd.

The properties of the carrier Z are as follows:

Weight-average particle size 40 µm

Magnetization 20 emu/g

(Measured magnetic field: 1000 Oe)

Resistivity More than $10^{14}\Omega$.cm

(4) Comparison carrier x

A carrier comprising copper-zinc ferrite particles identical to those of carrier X was prepared. This was designated comparison carrier x.

The properties of the comparison carrier x were as follows:

Weight-average particle size 38 µm

Magnetization 22 emu/g

(Measured magnetic field: 1000 Oe)

Resistivity More than $10^{10}\Omega$.cm

(5) Comparison carrier y

A carrier having particles individually have a coating layer of 1.0 µm thick styrene resin was prepared in a manner identical to that of carrier X except that styrene (weight-average molecular weight Mw, 71,000; number-average molecular weight Mn, 32,000; glass transition point Tg, 125°C) was used instead of vinylidene fluoride-tetarfluoro ethylene copolymer. This carrier was designated comparison carrier y.

The properties of the comparison carrier y were as follows:

Weight-average particle size 30 µm

Magnetization 20 emu/g

(Measured magnetic field: 1000 Oe)

Resistivity More than $10^{14}\Omega$.cm

(6) Comparison carrier z

A carrier having particles individually have a coating layer of 1.0 µm thick styrene resin was prepared in a manner identical to that of carrier X except that methyl methacrylate resin (weight-average molecular weight Mw, 73,000; number-average molecular weight Mn, 33,000; glass transition point Tg, 121°C) was used instead of vinylidene fluoride-tetrafluoro ethylene copolymer. This carrier was designated comparison carrier z.

The properties of the comparison carrier z were as follows:

Weight-average particle size 40 µm

Magnetization 18 emu/g

(Measured magnetic field: 1000 Oe)

Resistivity More than $10^{14}\Omega$.cm

Preparation of toners

(1) Black toner O

With a Henschel mixer, 100 parts weight styrene-acryl resin (R-5, manufactured by Sekisui Chemical Co., Ltd.) and 3 parts weight polypropylene (Viscol 660 P, manufactured by Sanyo Kasei Kogyo Co., Ltd.) and 10 parts Carbon Black (Mogal L, manufactured by Cabot) and 2 parts weight positive-type charge controlling agent (P-51, manufactured by Orient Chemicals Co., Ltd.) were mixed, then thoroughly kneaded with a triple-roller at a temperature of 140°C. Further, the mixture, after cooled and crushed, was pulverized with a jet mill and classified to prepare black toner powder having a particle size distribution of 6 to 30 µm and a weight-average particle size of 11 µm.

To 100 parts weight of the black toner powder, 0.6 parts weight hydrophobic fine titania particles (T-805, manufactured by Nippon Aerozyl Co., Ltd.) was added, then thoroughly blended by a Henschel mixer to prepare black toner. This toner was designated black toner O. The static bulk density of the black toner O was 0.38 g/cm^3.

(2) Yellow toner P

A yellow tonre having a weight-average particle size of 11 µm was prepared in a manner identical to that of black toner O except that yellow pigment, Pigment Yellow, was used in the place of Carbon Black. This toner was designated yellow toner P. The static bulk density of the yellow toner P was 0.28 g/cm^3.

(3) Magenta toner Q

A magenta toner having a weight-average particle size of 11 µm was prepared in a manner identical to that of black toner O except that magenta pigment, Permanent Carmine F-5B, was used in the place of Carbon Black. This toner was designated magenta toner Q. The static bulk density of the magenta toner Q was 0.29 g/cm^3.

(4) Cyan toner R

A cyan toner having a weight-average particle size of 11 µm was prepared in a manner identical to that of black toner O except that cyan pigment, Pigment Blue 1, was used in the place of Carbon Black. This toner was designated cyan toner R. The static bulk density of the cyan toner was 0.27 g/cm^3.

<u>Preparation of developers</u>

The above-mentioned carriers X through Z were indepdendently combined with the black toner O to prepare developers 4 through 6 individually having a toner concentration of 12 weight%. At the same time, the above-mentioned comparison carriers x through z were also combined with the black toner O to correspondingly prepare comparison developer 4 through 6 individually having a toner concentration of 12 weight%.

Additionally, yellow toner P, magenta toner Q and cyan toner R were independently combined with carrier X to correspondingly prepare color developers 4 through 6 individually having a toner concentration of 12 weight%.

<u>Test 5 by actual copying operation</u>

Using each of these developers, a test was performed by executing copying operation, in accordance with the developing process based on the below specified developing conditions, for 30,000 sheets, whereby the triboelectricity on toner, fog, adhesion of carrier on a latent image carrying member, imaging failure, and uneven imaging were evaluated on the first and 30000th formed images. The results are listed in Table 3 shown later.

[Developing conditions (reverse developing)]

-Latent image carrying member: 100 mm dia. drum type photosensitive member made of selenium
-Linear velocity: 100 mm/sec
-Surface potential: +800 V (non-iamge area) to 0 V (image area)
-Diameter of developing sleeve: 25 mm
-Linear velocity of developing sleeve: 25 mm/s (forward direction)
-Total number of poles on magnetic roll: 8 poles
-Rotational speed of magnetic roll: 1200 rpm

-Thin layer forming member: 3 mm thick resilient plate made of urethane rubber, being pressed on the surface of developing sleeve
-Development gap: 500 µm
-Thickness of developer layer: 400 µm (maximum value)
-Toner content in developer: 12 weight%
-Toner content in developer layer formed on developing sleeve: 0.3 mg/cm^2
-DC bias voltage: 600 to 700 V
-AC bias voltage: 0.5 to 2 kV (frequency, 2 kHz; peak-peak value)

Table 3

Developer	Carrier	Tribo-electricity (µC/g)		Fog		Carrier adhesion		Imaging failure		Uneven imaging		Toner spent
		Initial	After 30000 sheets	Initial	After 30000 sheets	Initial	After 30000 sheets	Initial	After 30000 sheets	Initial	After 30000 sheets	After 30000 sheets
Developer 4	Carrier X	+18	+17	No	No	No	No	No	No	No	No	No
Developer 5	Carrier Y	+15	+14	No	No	No	No	No	No	No	No	No
Developer 6	Carrier Z	+13	+13	No	No	No	No	No	No	No	No	No
Comparison developer 4	Comparison carrier x	+5	+2	Yes	Great	No	Yes	No	Yes	No	Yes	Yes
Comparison developer 5	Comparison carrier y	+10	-5	No	Great	No	Minor	Yes	Yes	Yes	Yes	Yes
Comparison developer 6	Comparison carrier z	+22	-4	No	Great	Yes	Minor	Yes	Yes	Yes	Yes	Yes

The methods of evaluation were identical to those of Example 1.

As can be understood from the results listed in Table 3, when executing the developing method of the invention with any of the developers 4 through 6, the toner demonstrated a proper triboelectricity, and a sharp image featuring high-resolution as well as excellent gradation reproducibility is formed without incurring any of fog, carrier adhesion of the image carrying member, imaging failure, and uneven imaging.

With a fluctuation in toner triboelectricity being small, the developing method of the invention using any of the developers 4 through 6 provides a sharp image, whose quality is comparable to that of the first copied image, even after 30000 sheet-copying operation. Additionally, inspection of the contamination in an image forming apparatus confirmed only an extremely limited contamination with toner and carrier. This is because the fluororesin to form the coating layer of the carrier used in embodying the invention has a smaller critical surface tension when compared to a resin used to prepare a comparison carrier, and accordingly, the toner substance does not easily adhere to the surface of individual carrier particles. Furthermore, the developing effects of bias voltage was satisfactorily demonstrated.

In contrast, the use of comparison developer 4 incurred a smaller triboelectricity even in the initial stage of continu ous 30000-sheet copying operation, and an obtained image was not sharp, showing fog, and uneven imaging. In addition, the above problems further deteriorated after the completion of 30000-sheet copying operation, because of further decreased toner triboelectricity. Also, considerable carrier adhesion on the latent image carrying member, as well as imaging failure were also found.

Furthermore, the use of comparison developer 5 provided a relatively smaller triboelectricity even in the initial stage of continuous 30000-sheet copying operation, and an obtained image was not sharp, showing imaging failure and uneven imaging. In addition, the above problems further deteriorated after the completion of 30000-sheet copying operation, because of further decreased toner triboelectricity. Also, large fog ocurred, and minor carrier adhesion on the latent image carrying member was also found.

The use of comparison developer 6 incurred imaging failure and uneven imaging on an obtained image during the initial stage of continuous 30000-sheet copying operation, and the carrier adhesion on the latent image carrying member was also found. After the completion of 30000-sheet copying operation, the toner triboelectricity significantly decreased, and accordingly, the obtained image is not sharp, showing great fog, as well as imaging failure and uneven imaging. Also, minor carrier adhesion on the latent image carrying member also occurred.

Test 6 by actual copying operation

A test was performed in a manner identical to the above test 5 by actual copying operation except that the modified developing conditions below were used. The results similar to those of test 5 were attained.

[Developing conditions (normal developing)]

- -Latent image carrying member: 140 mm dia. drum type photosensitive member having organic photoconductive photosensitive layer
- -Linear velocity: 60 mm/sec
- -Surface potential: -700 V (image area) to -50 V (non-image area)
- -Diameter of developing sleeve: 20 mm
- -Linear velocity of developing sleeve: 250 mm/s (forward direction)
- -Total number of poles on magnetic roll: 8 poles
- -Rotational speed of magnetic roll: 1000 rpm
- -Thin layer forming member: 0.1 mm thick resilient plate made of phosphor bronze plate being pressed on the surface of developing sleeve
- -Development gap: 500 μm
- -Thickness of developer layer: 400 μm (maximum value)
- -Toner content in developer: 12 weight%
- -Toner content in developer layer formed on developing sleeve: 0.4 mg/cm^2
- -DC bias voltage: -100 to -200 V
- -AC bias voltage: 0.5 to 2.5 kV (frequency, 2 kHz; peak-peak value)

(Example 5)

Test 7 by actual copying operation

Using the image forming apparatus illustrated in Fig. 5 and already described in Example 2, a test operation to form 30000 sheets of copied image was performed, in a manner identical to that of test 3 by actual copying operation, so as to examine, respectively in the initial stage of image forming operation and after the completion of 30000-sheet copying operation, the triboelectricity on toner, fog, adhesion of carrier on a latent image carrying member, imaging failure, and uneven imaging. The results are listed in Table 4 shown later.

In this test by actual copying operation, a reverse developing method schematically shown in Fig. 6 was performed, similarly to the test 3 by actual copying operation, whereby the image forming process was performed based on the operation timings (in Fig. 7 a higher level corresponds to an ON status) listed in Fig. 7.

[Developing conditions (reverse developing) and others]

- -Latent image carrying member: 140 mm dia. drum type photosnsitive member having selenium-tellurium photosensitive layer
- -Linear velocity: 60 mm/sec
- -Surface potential: +700 V (non-image area) to + 50 V (image area)
- -Exposure light source: Semiconductor laser (wavelength, 780 nm; recording density, 16 dots/mm)
- -Constitution of developing units A through D

  Diameter of developing sleeve: 20 mm

  Linear velocity of developing sleeve: 250 mm/s (forward direction)

  Total number of poles on magnetic roll: 8 poles

  Rotational speed of magnetic roll: 800 rpm

  Thin layer forming member: 3 mm thick resilient plate made of urethane rubber, being pressed on the surface of developing sleeve

  Development gap: 0.3 mm

  Maximum magnetic flux density on surface of developing sleeve: 700 gauss

  Thickness of developer layer: 250 µm (maximum value)

  Toner content in developer layer formed on developing sleeve: 0.3 mg/cm^2

  DC bias voltage during developing: +500 V

  AC bias voltage during developing: 1.2 kV

  (Frequency, 2 kHz; peak-peak value)

  DC bias voltage during non-developing: 0 V

  AC bias voltage during non-developing: More than 0.3 kV

  (Frequency, 2 kHz; peak-peak value)

  (During non-developing, magnetic roll and developing sleeve are stationary. Developing sleeve may be electrically floated.)
- -Developing sequence: (Yellow) → (Magenta) → (Cyan) → (Black)
- -Transfer process: Corona discharge method
- -Fixing process: Heat roll method
- - Cleaning process: Blade system and fur brush

Table 4 (Part 1)

Developer		Average particle size (µm)	Specific gravity (g/cm²)	Resistivity (Ω·cm)	Magnetization	Toner concentration (weight%)
Carrire X		35	5.2	More than 10^{14}	20 emu/g	
Toner	Yellow toner P	11	1.2	More than 10^{14}		12
	Magenta toner Q	11	1.2	More than 10^{14}		12
	Cyan tonre R	11	1.2	More than 10^{14}		12
	Black tonre O	11	1.2	More than 10^{14}		12

Table 4 (Part 2)

Toner	Carrier	Initial tribo-electricity (µC/g)	Fog	Carrier adhesion	Imaging failure	Uneven imaging	Toner spent
			After 30000 sheets	After 30000 sheets	After 30000 sheets	After 30000 sheets	After 30000 sheets
Yellow toner P	Carrier X	+16	No	No	No	No	No
Magenta tonre Q	Carrier X	+16	No	No	No	No	No
Cyan toner R	Carrier X	+16	No	No	No	No	No
Black toner O	Carrier X	+18	No	No	No	No	No

As can be understood from the results listed in Table 4, when executing the developing method of the invention, the toner demonstrated a proper triboelectricity, and a sharp color image featuring high-resolution as well as excellent gradation reproducibility is formed without accompanying any of fog, carrier adhesion of the image carrying member, imaging failure, and uneven imaging.

The developing method of the invention is capable of providing a sharp image, whose quality is comparable to that of the first copied image, even after 30000 sheet-copying operation. Additionally, inspection of the contamination in an image forming apparatus confirmed only an extremely limited contamination with toner and carrier.

(Example 6)

Test 8 by actual copying operation

Using the image forming apparatus illustrated in Fig. 8 and already described in Exmaple 3, a test operation to form 30000 sheets of copied image was performed, in a manner identical to that of test 3 by actual copying operation, so as to examine, respectively in the initial stage of image forming operation and after the completion of 30000-sheet copying operation, the triboelectricity on toner, fog, adhesion of carrier on a latent image carrying member, imaging failure, and uneven imaging. The results were as satisfactory as those of the previously mentioned test 7 by actual copying operation.

In this test by actual copying operation, the image forming process was performed in accordance with the following conditions.

[Developing conditions (erverse developing) and others]

-Latent image carrying member: 140 mm dia. drum type photosensitive member having As_2Se_2 photosensitive layer
-Linear velocity: 200 mm/sec
-Surface potential: +700 V (non-image area) to +50 V (image area)
-Exposure light source: Helium-neon laser (wavelength, 632.8 mm; recording density, 16 dots/mm)
-Constitution of developing units A through D
Diameter of developing sleeve: 20 mm
Linear velocity of developing sleeve: 50 mm/s (forward direction)
Total number of poles on magnetic roll: 8 poles
Rotational speed of magnetic roll: 1500 rp
m Thin layer forming member: 3 mm thick resilient plate made of urethane rubber, being pressed on the surface of developing sleeve
Development gap: 500 µm Maximum magnetic flux density on surface of development sleeve: 700 gauss
Thickness of developer layer: 400 µm (maximum value)
Toner content in developer layer formed on development sleeve: 0.4 mg/cm^2
DC bias voltage during developing: 600 to 700 V
AC bias voltage during developing: 0.5 to 2 kV
(Frequency, 2 kHz; peak-peak value)
DC bias voltage during non-developing: 0 V
AC bias voltage during non-developing: More than 0.3 kV
(Frequency, 2 kHz; peak-peak value)
(During non-developing, magnetic rolla nd developing sleeve are stationary. Developing sleeve may be electrically floated.)
-Developing sequence: (Yellow) → (Magenta) → (Cyan) → (Black)
-Transfer process: Corona discharge method
-Fixing process: Heat roll method
-Cleaning process: Blade system

Additionally, in this test 8 by actual operation, the color development sequence may be modified; for example, (black) → (yellow) → (magenta) → (cyan).

The typical examples embodying the present invention have been described above. However, the developing method of the invention may be advantageously applied also to an apparatus being capable of forming a multicolor toner image with one imagewise exposure on a latent image carrying member.

With one example of such an apparatus having a latent image carrying member favorably comprising an electroconductive member, photoconductive layer, and insulative layer comprising a plurality of different filters, a multicolor toner image is formed, for example, in the following manner.

By forming an electrical charge on the surface of latent image carrying member, which is then subjected to imagewise exposing, an image patterned on the degrees of interface potential density between an insulative layer and a photoconductive layer, whereby the image is uniformly exposed with a specific color light. This procedure forms a pattern representing different potentials on the filter layer on the latent image carrying member, whereby the potential pattern is developed by a developing unit containing a specific color toner in order to form a mono-color toner image.

Next, the latent image carrying member is triboelectrically cahrged to smooth its potential pattern, and subjected to a specific color light different from the above-mentioned specific color light, so as to form a potential pattern on the filter layer of the latent image carrying member, whereby the potential pattern is developed by a developing unit containing a specific color toner different from the above-mentioned specific color. This procedure forms the second color toner iamge as superposed on the first color toner image already formed on the latent image carrying member. Additionally, in performing this type of developing process, at least the second developing onwards should be effected in compliance with non-contact developing method.

Accordingly, the above developing process is repeated for a required number of times to allowing a toner of independent color to adhere onto a corresponding filter layer on the latent image carrying member, and this arrangement can resultingly provide a multicolor image. (Refer to Japanese Patent Applications Nos. 83096/1984, 187044/1984, 185440/1984 and 229524/1984.)

Such a type of multicolor image corming apparatus completes a multicolor image forming with only one sequence of the imagewise exposure, and this in turn precludes the possibility of an image whose independent toner images are not misaligned to each other.

The latent image carrying member may either have a constitution (refer to Japanese Patent Application No. 199547/1984), wherein a filter is incorporated into the electroconductive substrate side, so as to perform the imagewise exposure as well as uniform exposing on the filter side, or another constitution (refer to Japanese Patent Application No. 201084/1984).

Additionally, a photosensitive may either be made of a single layer or have a function-separating constitution comprising both a charge generating layer and a charge transporting layer (refer to Japanese Patent Application No. 245178/1985).

Furthermore, a latent image carrying member may have a constitution, wherein the photosensitive layer has color separation function (refer to Japanese Patent Applications Nos. 201085/1984 and 245177/1985).

Claims

1. In a method of developing a electrostatic latent image on a latent image-carrying member by forming a developer layer of a two component type developer on a developer transport member, said two component type developer comprising toner and carrier, and by providing said developer layer to a developing area formed between said latent image-carrying member and said developer transport member, said developing area effected an oscillatory electric field, the improvement characterised in that said method comprises a step of making said developer layer formed on said developer transport member to be a thin layer, and that said carrier is a resin coated carrier comprising a particle of magnetic substance cated with a resin selected from the group consisting of a resin containing silicone resin and a resin containing fluororesin in an amount more than 30 % by weight.

2. The method of claim 1, wherein the thickness of said developer layer is not more than 2000 μ m.

3. The method of claim 2, wherein the thickness of said developer layer is not more than 1000 μ m.

4. The method of claim 3, wherein the thickness of said developer layer is 10 to 500 μ m.

5. The method of claim 1, wherein in said developing area a minimum gap between said latent image-carrying member and said developer transport member is 100-1000 μ m.

6. The method of claim 1, wherein said silicon resin is condensation reaction type silicon resin.

7. The method of claim 1, wherein said resin containing fluororesin contains the fluororesin 40 to 100 % by weight.

8. The method of claim 1, wherein said resin containing fluororesin contains the fluororesin 50 to 100 % by weight.

9. The method of claim 1, wherein a thickness of the resin coating layer is 0.1 - 20 μ m.

10. The method of claim 1, wherein a thickness of the resin coating layer is 0.1 - 10 μ m.

11. The method of claim 1, wherein a thickness of the resin coating layer is 0.3 - 4 μ m.

12. The method of claim 1, wherein a thickness of the resin coating layer is 0.3 - 2 μ m.

13. The method of claim 1, said resin coated carrier is a insulative carrier having a registivity more than 10^8 Ω • cm.

14. The method of claim 1, said resin coated carrier is a insulative carrier having a registivity more than 10^{13} Ω • cm.

15. The method of claim 1, said resin coated carrier is a insulative carrier having a registivity more than 10^{14} Ω • cm.

16. The method of claim 1, said resin coated carrier is a spherical-shaped particle.

17. The method of claim 1, said resin coated carrier is a weight-average particle size of less than 5 to 50 μm.

FIG. 1

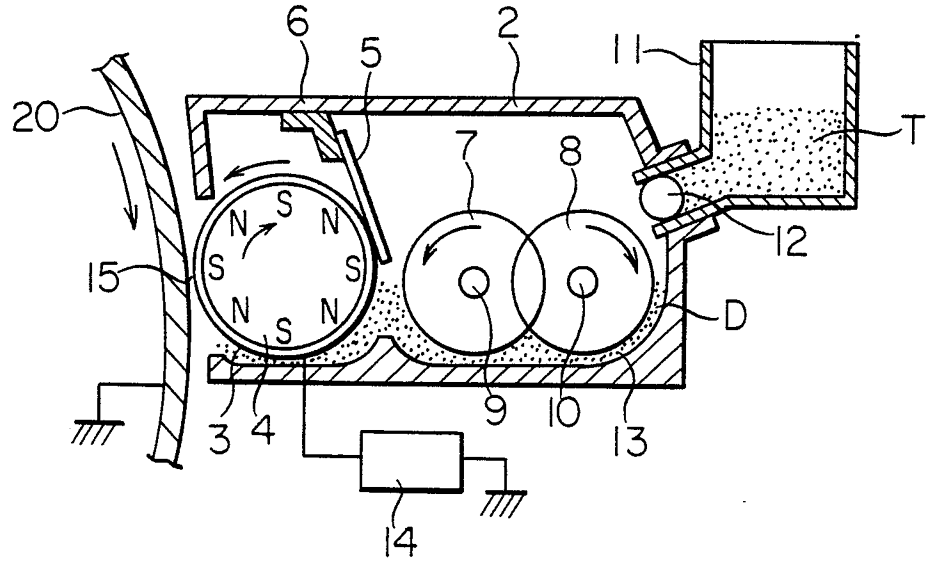

6
5
2
11
T
20
7
8
12
N
S
N
S
S
N
S
N
15
D
9
10
13
3
4
14

FIG. 3

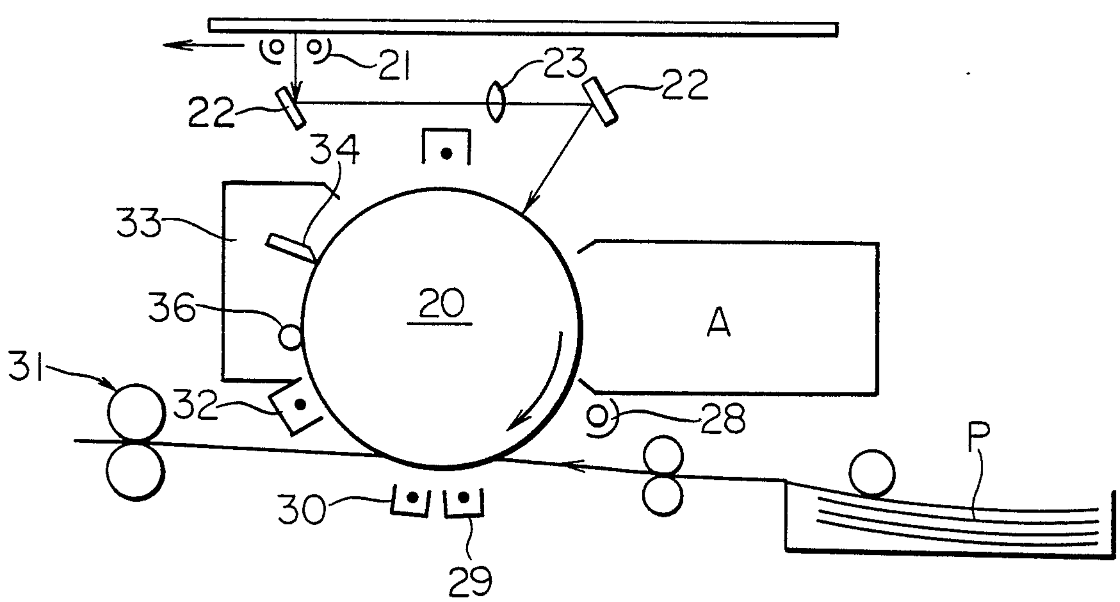

21
23
22
22
34
33
20
A
36
31
32
28
P
30
29

FIG. 2 (a)

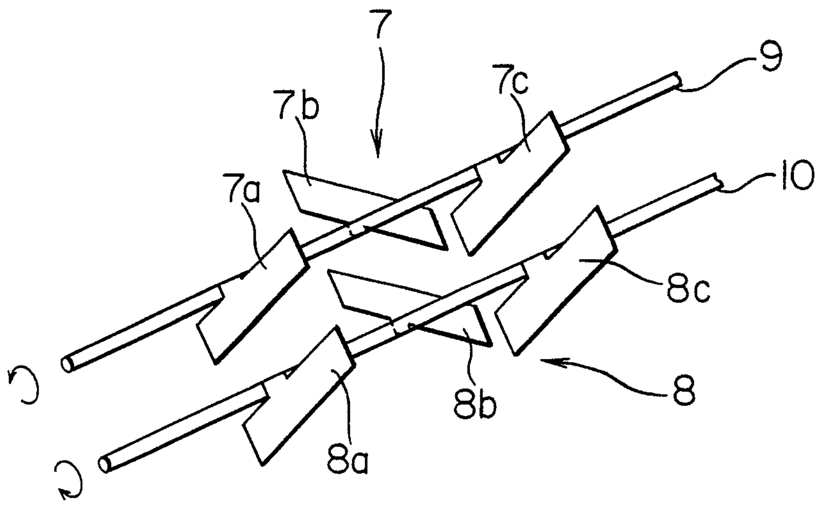


FIG. 2 (b)

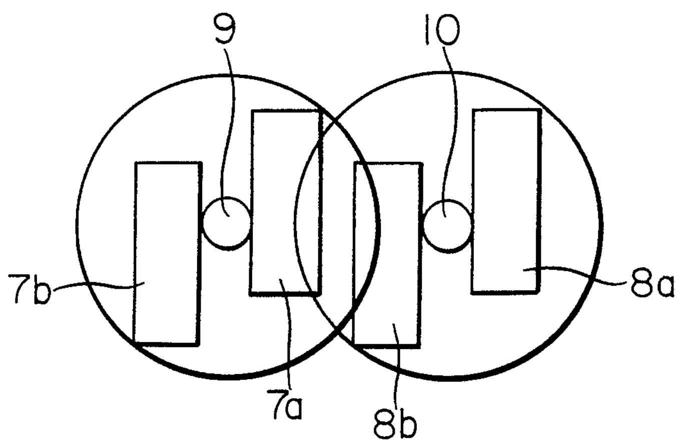


FIG. 4

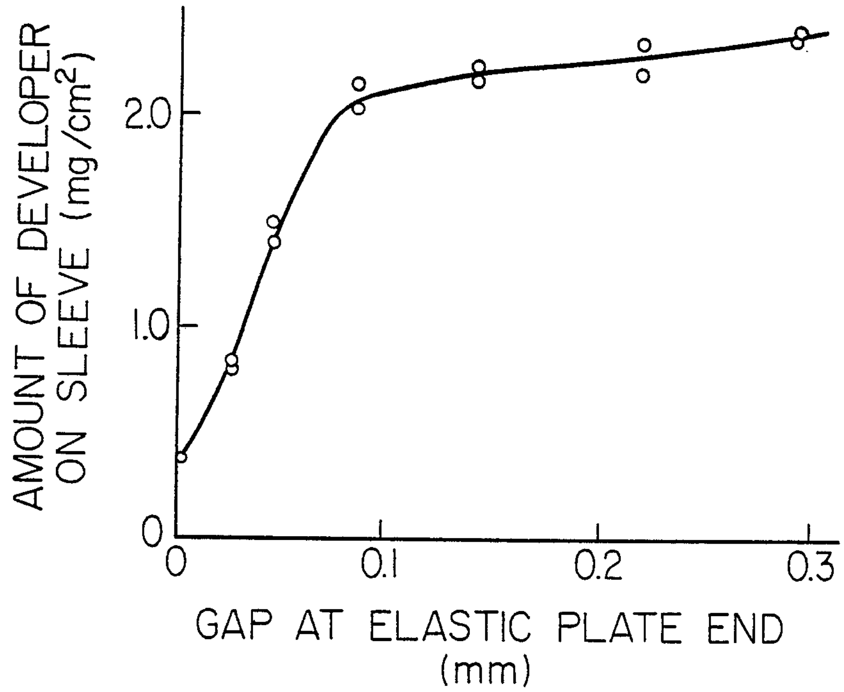

AMOUNT OF DEVELOPER
ON SLEEVE (mg/cm2)
2.0
1.0
0
0
0.1
0.2
0.3
GAP AT ELASTIC PLATE END
(mm)

FIG. 5

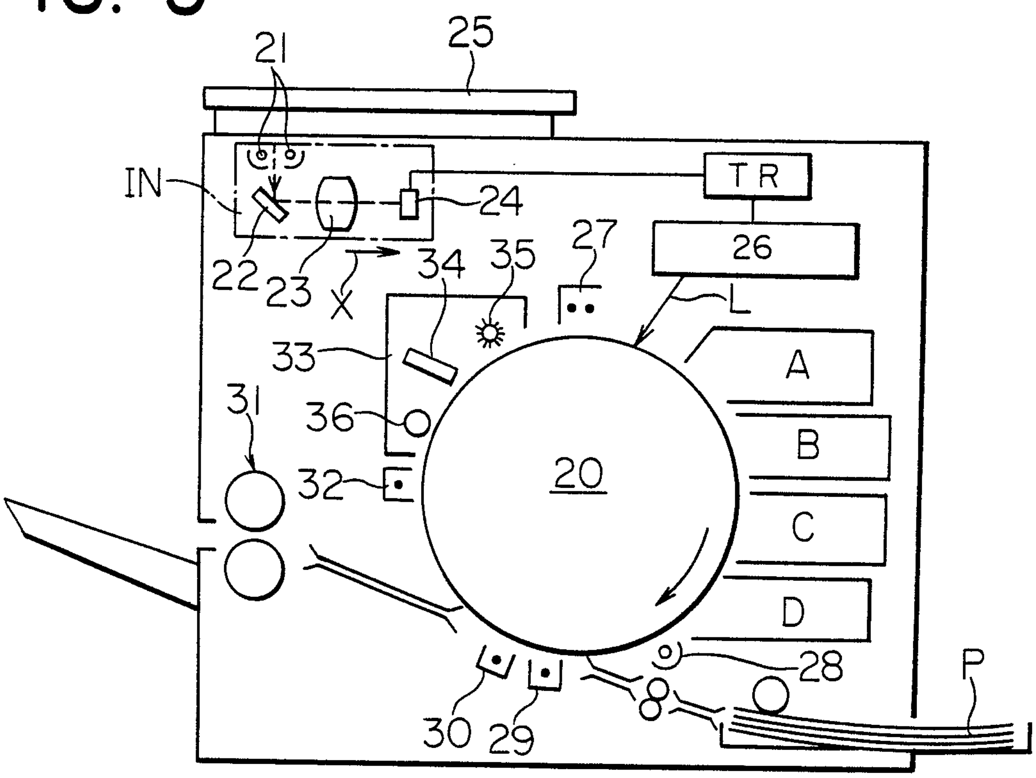
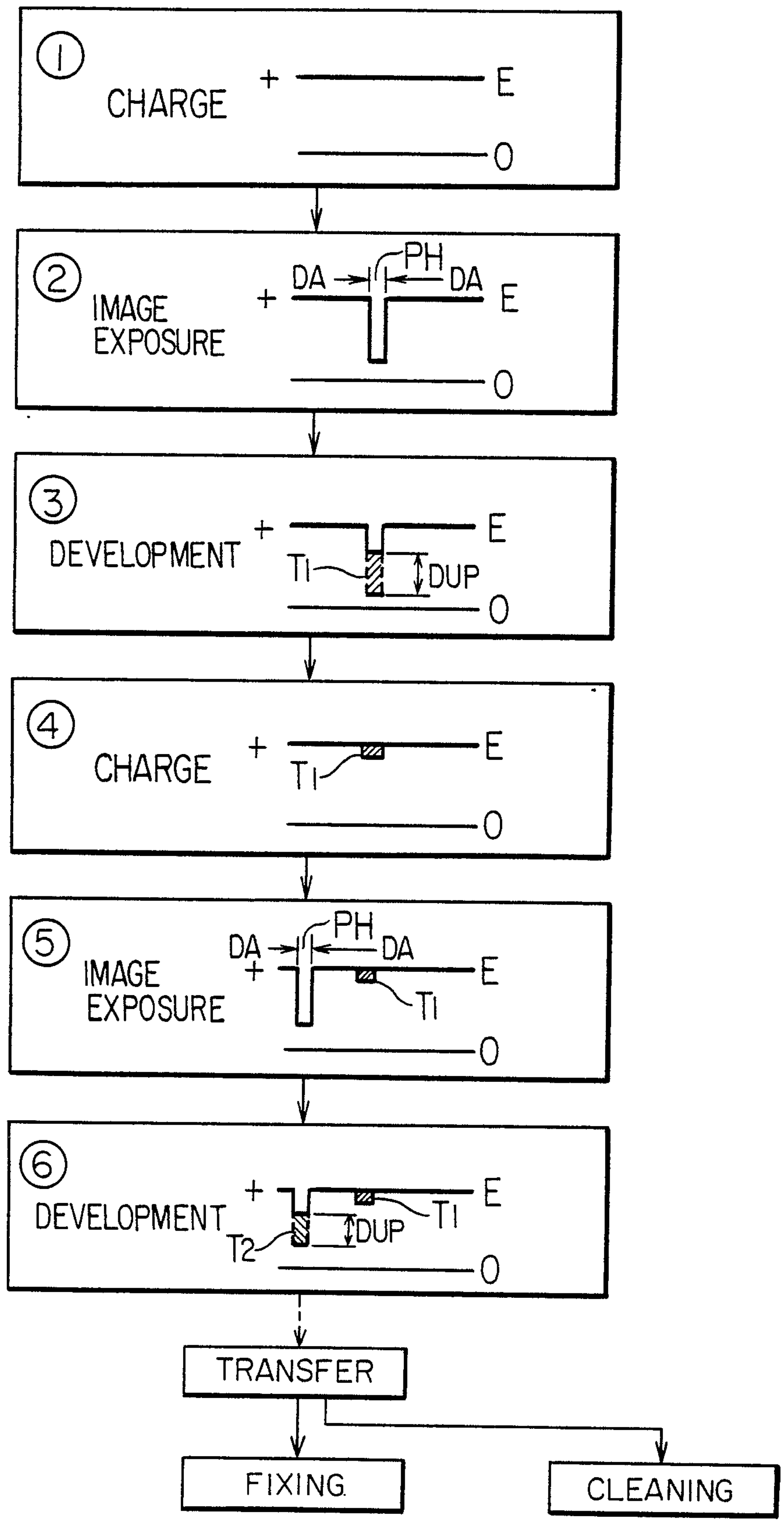

21
25
IN
24
TR
26
22
23
X
34
35
27
L
33
A
31
36
B
32
20
C
D
28
P
30
29

FIG. 6



①
CHARGE
+
E
0
②
IMAGE EXPOSURE
+
DA
PH
DA
E
0
③
DEVELOPMENT
+
T1
DUP
E
0
④
CHARGE
+
T1
E
0
⑤
IMAGE EXPOSURE
DA
PH
DA
+
E
T1
0
⑥
DEVELOPMENT
+
DUP
T1
T2
E
0
TRANSFER
FIXING
CLEANING

FIG. 7

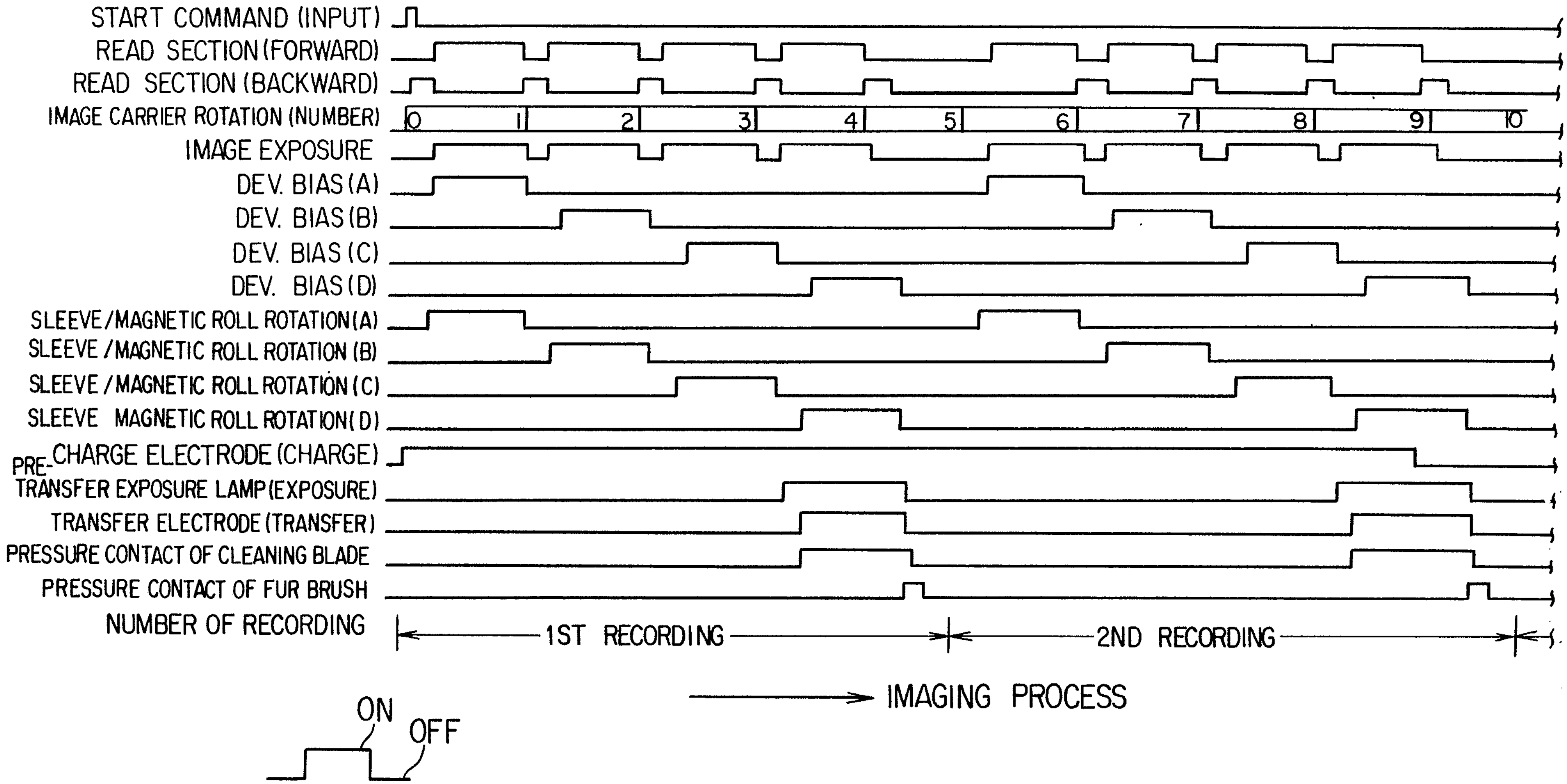

START COMMAND (INPUT)
READ SECTION (FORWARD)
READ SECTION (BACKWARD)
IMAGE CARRIER ROTATION (NUMBER)
0
1
2
3
4
5
6
7
8
9
10
IMAGE EXPOSURE
DEV. BIAS (A)
DEV. BIAS (B)
DEV. BIAS (C)
DEV. BIAS (D)
SLEEVE/MAGNETIC ROLL ROTATION (A)
SLEEVE/MAGNETIC ROLL ROTATION (B)
SLEEVE/MAGNETIC ROLL ROTATION (C)
SLEEVE MAGNETIC ROLL ROTATION (D)
PRE-CHARGE ELECTRODE (CHARGE)
TRANSFER EXPOSURE LAMP (EXPOSURE)
TRANSFER ELECTRODE (TRANSFER)
PRESSURE CONTACT OF CLEANING BLADE
PRESSURE CONTACT OF FUR BRUSH
NUMBER OF RECORDING
1ST RECORDING
2ND RECORDING
IMAGING PROCESS
ON
OFF

FIG. 8

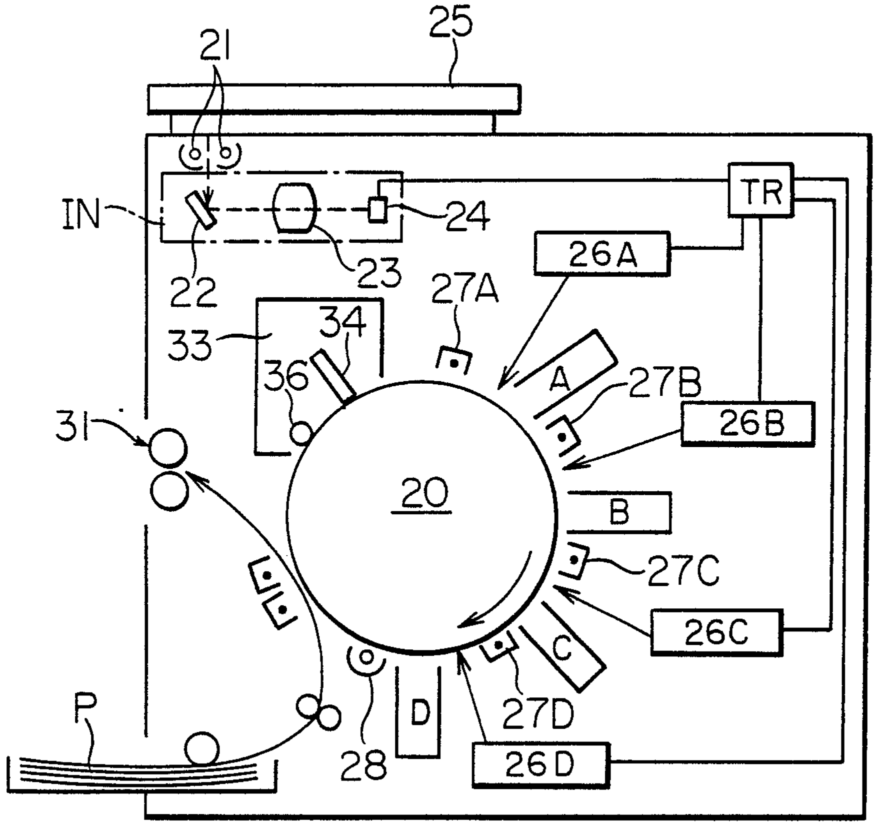
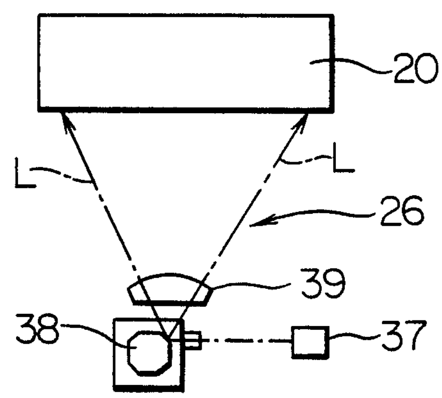

25
21
IN
24
TR
22
23
26A
27A
33
34
36
A
27B
31
26B
20
B
27C
26C
C
P
28
D
27D
26D

FIG. 9


20
L
L
26
39
38
37

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 87111197.7

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	EP - A1 - 0 161 128 (EASTMAN KODAK) * Claims 1,4,6 * --	1	G 03 G 13/08 G 03 G 9/10 G 03 G 15/00
A	DE - A1 - 3 511 171 (AICOH) * Claims 1,6,7; page 5, line 27 - page 6, line 20 * --	1,9-12, 17	
A	EP - A1 - 0 188 171 (KANTO) * Claims 1,5; page 5, lines 22-25 * --	1,16,17	
A	DE - A1 - 3 004 152 (MITA) * Claims 1,2 * ----	1,13,17	TECHNICAL FIELDS SEARCHED (Int. Cl.4) G 03 G 13/00 G 03 G 9/00 G 03 G 15/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	14-11-1987	SCHMIDT

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document