United States Patent

[11] **3,574,301**

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[21] Appl. No. **812,798**
[22] Filed **Apr. 2, 1969**
[45] Patented **Apr. 13, 1971**

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[54] **DEVELOPING APPARATUS**
6 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** **118/637**
[51] **Int. Cl.** **G03g 13/08**
[50] **Field of Search** 118/637; 117/17.5

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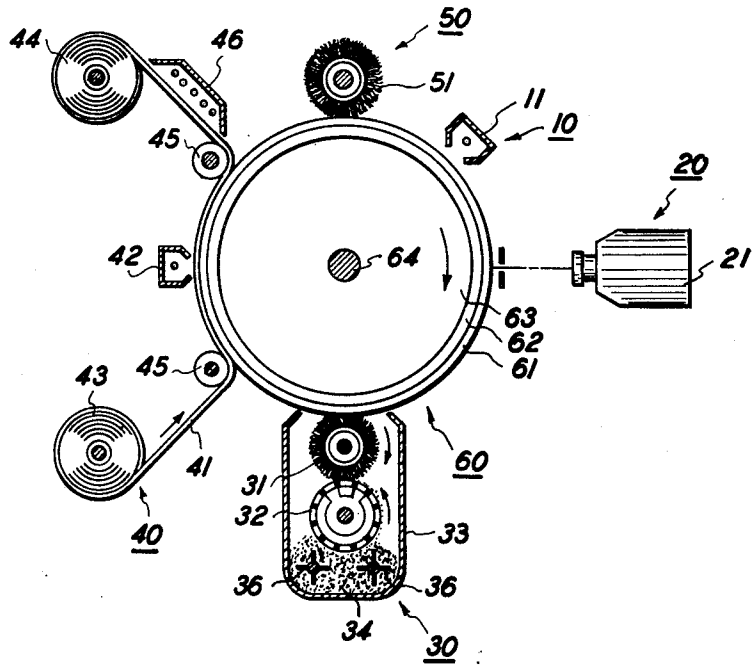
ABSTRACT: An apparatus for developing an electrostatic image on an insulating plate with toner particles including a brushlike developing member, means to generate a cloud of toner particles, a conductive donor member, and means to selectively place electrical biases on the donor member.



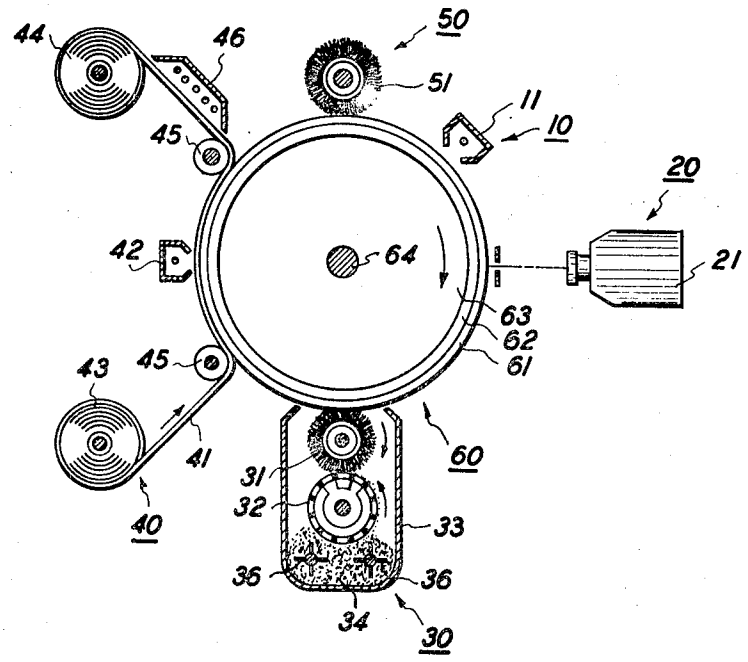


FIG. 1

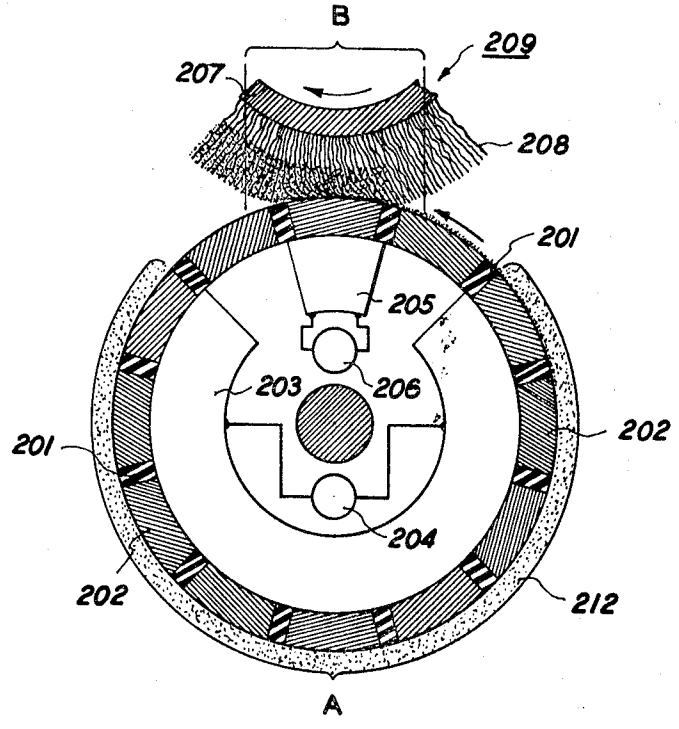


FIG. 2

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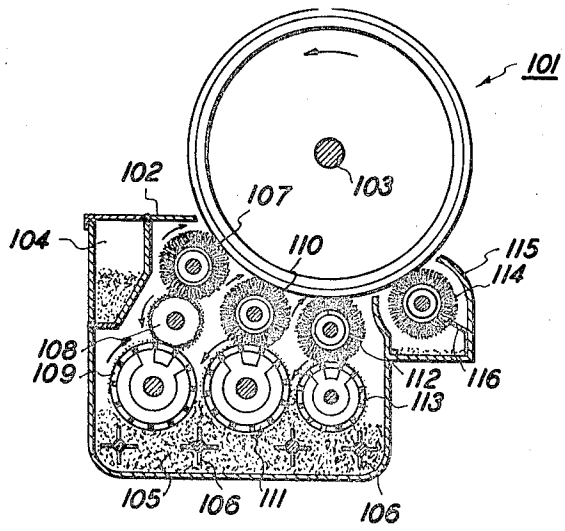
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FIG. 3

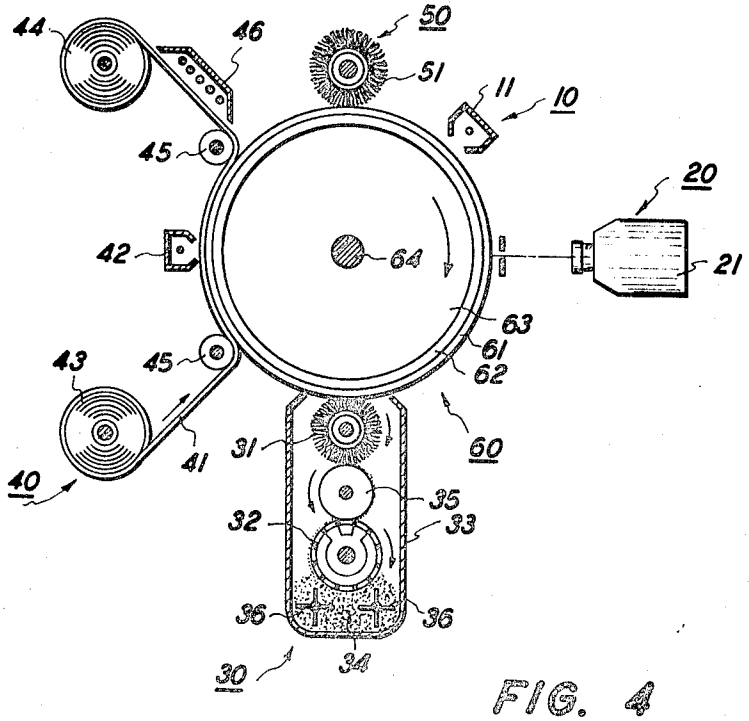
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FIG. 4

DEVELOPING APPARATUS

This invention relates to apparatus for developing electrostatic images, and, in particular, to an apparatus for placing toner particles on a brushlike developing member used to develop an electrostatic image on an insulating surface.

In xerography, as well as other reproduction processes, a latent electrostatic image is formed on an insulating plate and made visible by developing the image with marking particles such as finely divided pigmented resinous powders called toner. One method of developing electrostatic images is by depositing toner particles on the plate in a pattern conforming to the latent image by a developing member carrying toner particles. In this developing technique, a brushlike material is loaded with toner particles and brought into contact with the insulating plate bearing the electrostatic image. As the toner-laden brush fibers contact the plate, the electrostatic fields on the plate attract the particles to the plate in imagewise configuration. A problem with brush development is the difficulty encountered in attempting to load the brush with toner particles and in replenishing toner particles depleted from the brush during development. This problem is especially acute in a continuous reproduction system where the brush must be constantly reloaded with toner as development takes place.

There are two known loading techniques which exhibit particular difficulties. One method of loading a developing brush is to pass the brush through a toner container in such a manner that the toner particles adjacent the brush fibers are triboelectrically attracted to the fibers. Although a relatively simple technique, this method does not continuously load the brush satisfactorily since a cavity of packed toner is formed in the toner container which eliminates the necessary contact between the brush and toner. Mechanical agitators of various types have been placed in the toner container to keep the toner in a loose consistency, but it has been found that cavities still occur especially at high humidities resulting in inefficient loading of the brush.

A second method of loading is to cause toner to fall from a vibrating hopper onto the brush. The hopper is usually placed over the brush so that toner particles in it fall through a fine-mesh screen to the periphery of the brush. This loading technique has a metering problem resulting in nonuniform quantities of toner being placed on the brush which impairs the quality of development. In addition, it is important that a charge of desirable polarity and uniform intensity be placed on the toner particles before they reach the plate and this is difficult to achieve in a hopper-loading system.

The invention described herein overcomes the problems encountered in loading a developing brush which existed in presently known systems. The present system avoids the problem of packed toner in the toner container and can be adapted to load a developing brush at a high rate of speed. In addition, the rate of toner loading can be accurately metered and the toner polarity can be selected as desired.

The invention includes a selectively biased donor member which feeds toner to a developing brush as it rotates adjacent the brush. The donor member is located within a toner container having agitators which create a toner cloud. The donor member has alternate sections of conductive and relatively nonconductive material and means to selectively bias the conductive portions so that toner in the cloud adjacent the donor member adheres to the periphery of the donor member until it is adjacent the developing brush. When the toner on the donor member reaches the developing brush it is transferred from the donor member onto the brush due to a repulsive bias placed on the donor member and the sweeping action of the brush. The brush then deposits the toner on the insulating plate to develop the electrostatic image thereon.

Accordingly, it is an object of the present invention to improve the development of an electrostatic image with a brushlike developing member.

It is another object of the invention to improve apparatus for loading a developing brush by feeding toner to the brush from a toner-laden, selectively biased, donor member.

It is a further object of the invention to improve development of latent images by increasing the rate at which toner particles are loaded onto a developing brush.

It is a further object of the invention to improve development of latent images by loading a developing brush with positively or negatively charged toner particles as desired.

It is a further object of the invention to improve development of latent images by accurately metering the rate at which toner is placed on the developing brush.

The present invention is an apparatus for developing a latent electrostatic image on an insulating plate. A cylindrical donor member having alternate sections of conductive and relatively nonconductive material is placed in a cloud of toner particles adjacent to and in contact with the developing brush. The donor member is selectively biased in such a manner that a first electrical bias is applied to the conductive sections which are immediately adjacent the developing brush and a second electrical bias is applied to the other conductive sections in the member. The first bias repels toner particles from the donor member and the second bias attracts toner particles to the donor member. As the donor member rotates, toner particles in the cloud are attracted to the donor member by the second bias and brought adjacent the developing brush as the member rotates. When these toner particles are positioned in the vicinity of the brush, the first bias urges them from the donor member into the developing brush. The developing brush then deposits the toner particles on the insulating plate as it rotates in interference therewith to develop the latent electrostatic image on it.

For a better understanding of the invention as well as other objects and further features thereof, reference is had to the following detailed description of the invention to be used in conjunction with the accompanying drawings wherein:

FIG. 1 is a schematic illustration of a xerographic machine incorporating the invention.

FIG. 2 is a detailed view of the donor member with a portion removed to show the internal structure.

FIG. 3 is a schematic illustration of a high-speed developing system incorporating the invention.

FIG. 4 is a schematic illustration of an alternative embodiment of the invention.

FIG. 1 illustrates a continuous xerographic machine incorporating the present invention. The principal element of the machine is photosensitive plate **60** which is shown as a rotatable drum. The drum has five stations arranged about its periphery which carry out the various steps of the xerographic process. These stations include charging station **10**, exposing station **20**, developing station **30**, transfer station **40**, and cleaning station **50**. Drum **63**, which is driven about shaft **64** by a suitable drive means (not shown), includes layer **62**, an electrically conductive material, and layer **61**, a photoconductive insulating material such as vitreous selenium.

A latent electrostatic image is formed on the surface of the drum by passing it through charging station **10** and exposing station **20**. The charging station includes any suitable means for placing a uniform charge on layer **61** such as corona charging device **11**. Exposure station **20** includes projector **21** which projects and focuses a light pattern conforming to the image to be reproduced on the drum in synchronism with the surface movement of the drum. The projected light pattern causes selective charge dissipation on elemental areas of layer **61** thus forming a latent electrostatic image. Other means for forming an electrostatic latent image including means for forming images or ordinary insulating surfaces can be used and these are known in the art and may be used instead of the one shown.

After the information of the latent electrostatic image the drum passes through developing station **30**. The developing station includes developing brush **31**, donor member **32**, and

means for producing a toner cloud 36, all contained within housing 33 along with a quantity of toner particles 34. The operation of developing station 30 will be described in greater detail below.

Following the developing step, the drum passes through transfer station 40 where the developed image can be transferred to support material 41. Transfer of the image onto the support material is aided by corona charging device 42 which applies an electrostatic charge to the support material having a polarity opposite that of the toner particles. Transfer of the developed image from the photosensitive surface to the support material takes place between guide rollers 45 which act to position the support material adjacent the photosensitive drum while it is within the transfer station.

Support material 41 is fed from reel 43 before transfer and is rewound on reel 44 after transfer takes place. If the support material is the permanent substrate upon which the image is to be fixed, as shown in FIG. 1, fusing device 46 is desirable and should be placed along the path of the support material between the point where the developed image is transferred to the support material and the point where the support material is wound on reel 44. The fusing device is positioned to heat the toner particles and permanently bond them to the support material. The final station in the system shown in FIG. 1 is cleaning station 50. This station includes fibrous brush 51 which contacts the photosensitive surface of the drum and removes any toner particles remaining on the drum after transfer is completed and before a new cycle is begun.

The above-described process and apparatus, with the exception of the developing station, are commercially known in the art, as evidenced in U.S. Pat. No. 3,117,891, and any of the many known equivalents of process or apparatus may be employed in connection with the invention. It is intended that appropriate drive mechanisms and control circuits be part of the general disclosure herein which would enable the continuous xerographic process to operate, however, such apparatus is not shown or described in detail since the elements can be of any suitable design to accomplish the operational movement of the system as described above.

Referring to the developing station 30 shown in FIG. 1, toner is loaded onto brush 31 by donor member 32, and development of the image is carried out thereafter by the brush as it rotates in interference with drum 60. A quantity of toner 34 is placed at the bottom of the housing 33 and agitated by agitators 36 to form a cloud of toner particles within the lower portion of the housing. Donor member 32 is selectively biased so that the portions of its surface adjacent the brush; that is, in the release zone, are electrically repulsive to the toner while the other portions of its surface; that is, the collection zone, are electrically attractive to the toner. As a result, the toner particles in the cloud surrounding the donor member are attracted to and adhere to the surface of donor member in the collection zone and are then carried into the transfer zone as the donor member rotates. When the toner is carried through the transfer zone it is urged from the surface of the donor member to the developing brush due to the presence of the repulsive bias on the donor member and a sweeping action by the brush. After toner is transferred from the donor member to the brush, the surface of the donor member is reloaded with new toner particles as it again passes through the collection zone. In this manner toner is constantly attracted to the donor member in the collection zone and transferred to the brush in the transfer zone.

The rate at which toner is loaded onto the brush can be varied by varying the speed of rotation of the donor member, the faster the speed of rotation of the donor member, the greater the amount of toner that can be transferred to the brush during a given period of time. This aspect of the loading system becomes significant when the toner requirements change in a continuous developing process. In a situation where an occasional image being developed requires a greater amount of toner to be fully developed than others in the same reproduction run, the speed of the donor member can be increased to supply additional amounts of toner when needed. The speed of the donor member can also be decreased to accommodate development cycles where little toner is used.

FIG. 2 shows a more detailed view of the donor member used to load the developing brush. The donor member is shown as a hollow cylinder having conductive elements 202 and relatively nonconductive elements 201 oriented in alternate fashion. As the donor member is rotated adjacent the brush the conductive elements are selectively biased by electrical connectors 203 and 205. Electrical connector 203 applies an electrical bias to those conductive elements within the collection zone, depicted as zone A. The bias is generated by a suitable power source 204 which makes the donor member attractive to the toner particles in toner cloud 212. Electrical connector 205, on the other hand, applies an electrical bias to those conductive elements in the release zone, depicted as zone B. This bias is generated by any suitable power source 206 which makes the donor member repulsive to the toner particles on the donor member.

In the developing mode where negatively charged toner particles are used to develop the insulating plate, a bias which is positive relative to the toner particles is imposed on the conductive elements in zone A of the donor member. The toner is attracted to the periphery of the donor member and is conveyed to the vicinity of developing brush 209 as the donor member rotates in a clockwise direction as shown in FIG. 2. The donor member brings the toner within zone B as it rotates where a second bias is imposed on the toner through the donor member. The bias placed on the conductive elements of the zone B is negative relative to the negatively charged toner particles and has the effect of urging the particles from the donor member onto bristles 208 of the brush. As a result of the bias in zone B the toner particles are transferred to or swept onto the developing brush.

If on the other hand, positively charged toner particles were used to develop the insulating plate, the biases of the release and collective zones of the donor member can be modified to achieve the same results as described above in conjunction with loading negative toner onto the developing brush. It has been found, however, that when positively charged toner particles are used to develop the insulating plate, best results are realized when an intermediate roller is placed between the developing brush and the selectively biased donor member. This embodiment can be seen in FIG. 4 wherein the insulating plate shown as drum 60 is developed by brush 31. The toner 34 forms a toner cloud due to the action of agitators 36 and is attracted to donor member 32 as described above. The toner on the donor member is then transferred to intermediate roller 35 with the aid of the release zone bias placed on the donor member. The intermediate roller can be made of any suitable material such as rayon which will feed the toner to the developing brush. The advantages of using the intermediate roller with positively charged toner are that the roller tends to maintain the developing brush at its toner saturation level and the system consistently produces good developed image at low humidities.

The developing brush used to carry the toner from the donor member to the drum can be made of any suitable material such as brush material 207 having elongated fibers 208 used as toner carriers as shown in FIG. 2. It is desirable to use a material which has a triboelectric characteristic which enhances the carrying of toner to the insulating plate. Examples of such material are rayon, dynel, fox fur, rabbit fur and other suitable natural and synthetic materials. Similarly, the configuration of the developing member can be any suitable one adaptable to the developing system such as the cylindrical brush shown in FIG. 2. Examples of other various configurations are rotary brushes, endless belts, and oscillating brushes. The examples cited immediately above for brush materials and brush configurations are intended only as exemplary of the group that can be used for in the present invention and are not intended as an exhaustive list.

The donor member can be rotated at any convenient speed and in any desired direction depending upon the desired rate at which toner particles are to be placed on the brush. As mentioned above, the release zone, zone B, encompasses the vicinity of the interface between the developing brush and donor member. Zone A, on the other hand, can be any convenient portion of the periphery of the donor member as long as its bias in zone B. As shown in FIG. **2**, zone B occupies approximately the entire periphery of the donor member which is outside zone B.

FIG. **3** shows an apparatus which employs the donor member in combination with a number of development brushes which can be used in a high-speed reproducing system. Drum **101** which rotates in the counterclockwise direction about shaft **103** bears a latent electrostatic image. The developing station is contained within housing **102** which has a reserve supply of toner particles in compartment **104** which are allowed to pass into the housing as needed. In the lower part of the housing are several agitators **106** which maintain the toner particles in a cloud about donor members **109**, **111**, and **113**. Donor members **109**, **111** and **113** have an attraction zone in their lower regions and a release zone in the vicinity of roller **108**, and brushes **110**, and **112**, as described in conjunction with FIG. **2**.

A collection zone bias on each donor member attracts toner particles to the periphery of the donor member. The donor member rotates carrying the tone particles to roller **108** and brushes **110** and **112** where an other bias urges the toner to transfer to the roller and brushes. Roller **108**, an intermediate roller, in turn, passes the toner particles from donor member **109** to brush **107**.

Brushes **107**, **110**, and **112** develop the latent image on drum **101**. The use of more than one brush is desirable in a high-speed system in order to assure that the amount of toner delivered to the drum is sufficient for good development when the drum surface is moving at relatively high speeds. It has been found that the bulk of the toner is laced on the latent image by brush **107**; that is, the first brush which the drum contacts in the development station. Brushes **110** and **112** deposit additional amounts of toner on the latent image as needed and also act to clean up the background areas of the image thereby improving copy quality.

In addition to brushes **110** and **112** acting as background removal brushes, fur brush **114** is intended for the specific purposes of cleaning the background areas of the developed image. The fibers of this fur brush actually contact the surface of drum **101** and sweep any toner particles in the background areas or off the drum. Those toner particles swept from the drum surface by the brush **114** are removed from the brush by flicker bar **116** and fall into housing **115** surrounding it.

Appropriate drive mechanisms for driving the various moving parts shown in FIG. **3** are to be understood as part of the system shown.

In addition to the apparatus outlined above, many other modifications and/or additions to this invention will be readily apparent to those skilled in the art upon reading this disclosure, and these are intended to be encompassed within the spirit of the invention.

I claim:

1. An apparatus for developing a surface bearing a latent electrostatic image with toner particles comprising:

means for containing a quantity of toner particles adjacent said surface;

a fibrous developing brush supported for rotation in the toner container means with the fibers of said brush extending into contact with said surface;

means to rotate said developing brush;

means to form a cloud of toner particles in said toner container means;

a conductive donor member supported for rotation in said toner container means, a portion of said donor member being in contact with said developing brush;

means to rotate said donor member to bring successive portions of said donor member in contact with said developing brush; and

means to bias said successive portions of said donor member before they are brought in contact with said developing brush to attract toner particles from the toner cloud to said successive portions of the donor member,

the the periphery of said donor member having a collection zone in which toner cloud are attracted to the periphery of the donor member and a release zone in which toner particles attracted to said donor member are transferred from said donor member to said developing brush;

said release zone encompassing said portion of said donor member which is in contact with said developing brush and said collection zone encompassing the remainder at said donor member.

2. The apparatus in claim **1** further including means to bias said portion of said donor member in contact with said developing brush to urge toner particles from said donor member to said developing brush.

3. The apparatus in claim **2** wherein the donor member is a hollow cylinder having individual elements of conducting and relatively nonconducting material placed adjacent one another in alternate fashion, and means to separately bias said portion of said donor member in contact with said developing brush and said successive portions of said donor member including a source of electrical power operatively connected to a conductive brush which contains electrical contact with the internal surface of said donor member as it rotates.

4. The apparatus in claim **1** wherein the developing brush is a fur brush having elongated fibers extending therefrom.

5. An apparatus for developing a surface bearing a lent latent electrostatic image with toner particles having a positive charge comprising:

means for containing a quantity of toner particles adjacent said surface;

a fibrous developing brush supported for rotation in the toner container means with the fibers of said brush extending into contact with said surface;

means to rotate said developing brush;

means to form a cloud of toner particles in said toner container means;

an intermediate roller supported for rotation in said toner container means, said intermediate roller being in contact with said developing brush and being made of a material adapted to carry toner particles having a positive charge;

means to rotate said intermediate roller;

a conductive donor member supported for rotation in said toner container means, a portion of said donor member being in contact with said intermediate roller;

means to rotate said donor member to bring successive portions of said donor member in contact wit said intermediate roller; and

means to bias said successive portions of said donor member before they are brought in contact with said intermediate roller to attract toner particles from the toner cloud to said successive portions of the donor member;

the periphery of said donor member having a collection zone in which toner particles in said cloud are attracted to the periphery of the donor member and a release zone in which toner particles attracted to said donor member are transferred from said donor member to said intermediate roller,

said release zone encompassing said portion of said donor member which is in contact with said intermediate roller and said collection zone encompassing the remainder of said donor member.

6. The apparatus in claim **5** wherein the intermediate roller material is rayon.