# United States Patent

[11] 3,592,167


[72] Inventor James H. Blow, Jr.
Rochester, N.Y.



[21] Appl. No. 812,797
[22] Filed Apr. 2, 1969
[45] Patented July 13, 1971



[73] Assignee Xerox Corporation
Rochester, N.Y.


[54] APPARATUS FOR LOADING TONER ON A DEVELOPING BRUSH

7 Claims, 2 Drawing Figs.


[52] U.S. Cl. ..... 118/637
[51] Int. Cl. ..... G03g 13/06
[50] Field of Search ..... 118/621, 637; 117/17.5



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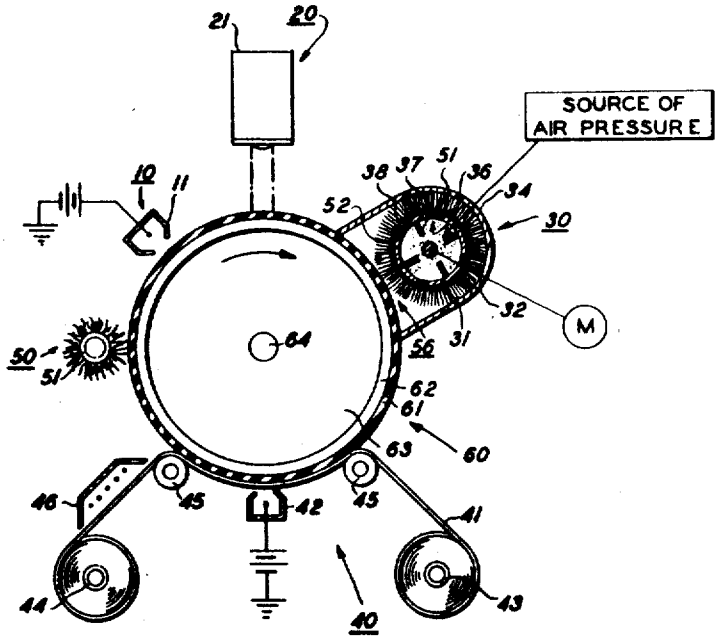
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*Primary Examiner*—Mervin Stein
*Attorneys*—Paul M. Enlow, Norman E. Schrader, James J. Ralabate, Ronald Zibelli, Donald F. Daley and Clarence A. Green



**ABSTRACT:** A brush for developing electrostatic latent images having apertures which enable toner particles within the core of the brush to pass through the brush onto its outer periphery. The toner is held on the outer periphery of the brush by electrical charges until attracted to the latent image by electrostatic charges.

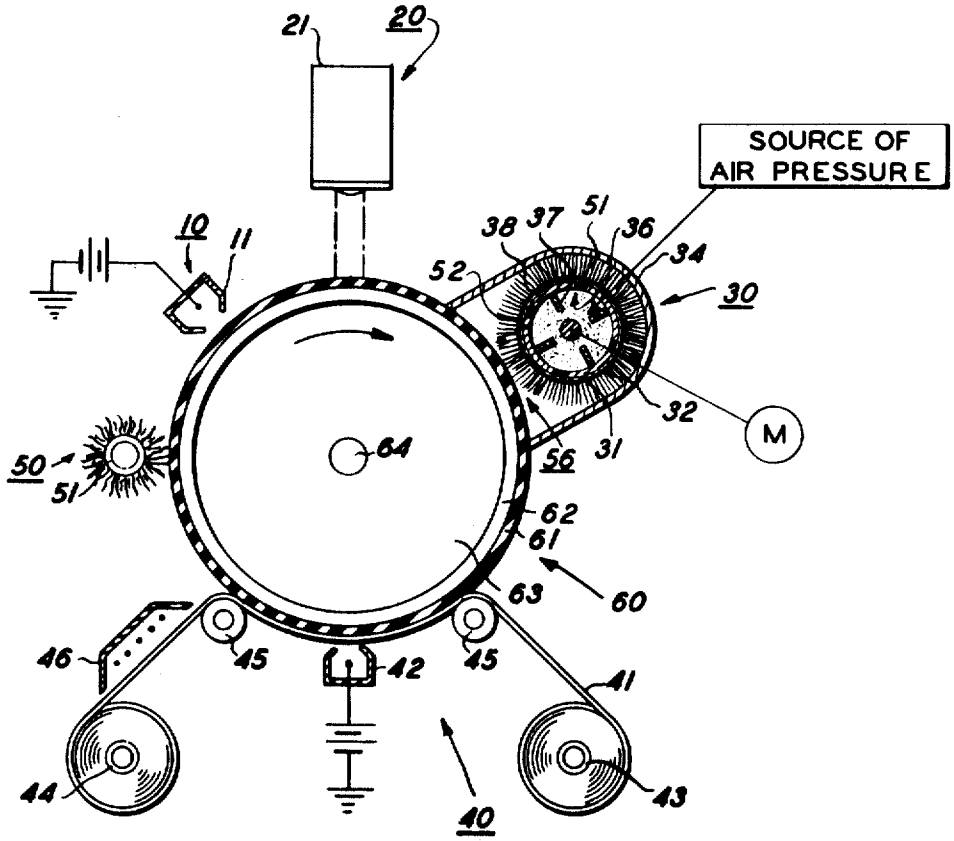



FIG. 1

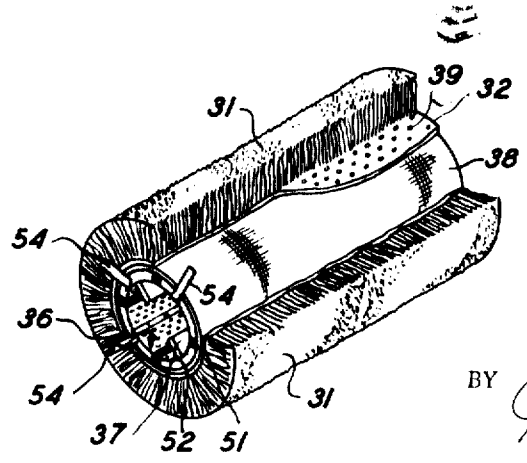



FIG. 2

INVENTOR.
JAMES H. BLOW JR.
BY
ATTORNEY

# APPARATUS FOR LOADING TONER ON A DEVELOPING BRUSH

This invention relates to developing latent electrostatic images on an insulating plate, and, in particular, to placing toner on the brushlike periphery of a cylindrical developing brush used to develop the plate by rotating in interference therewith.

In reproduction apparatus such as xerographic copiers a latent image conforming to the information to be reproduced is first formed on an insulating plate and then the latent image is made visible, or developed, by the application of marking material such as a pigmented, resinous powder called toner. One method of developing the latent image is by applying toner to it with a toner-laden developing brush.

There are various known methods and apparatus for placing toner on the developing brush. One method of accomplishing this is to pass the brush through a toner reservoir. In this technique the toner particles are picked up and held by the brush as it passes through the reservoir by mechanical forces and/or forces of electrostatic attraction. Although relatively simple in operation, this method has an inherent difficulty in that a cavity develops in the toner as the brush rotates making it difficult to continue to load the brush. The toner particles in the reservoir tend to become packed and stick together, especially at higher humidities. As a result, once those particles adjacent the brush are removed from the reservoir, the fibers on the brush no longer contact the remaining toner particles in the reservoir since they remain packed and do not readily fall around the brush replacing the toner particles previously removed. An auger or some other type of mixing apparatus can be placed in the reservoir to keep the toner from packing, but it has been found such cavities still occur resulting in inefficient loading of the brush over a period of continuous operation.

A second loading technique is to distribute toner particles to a developing brush through a screened hopper. The hopper is usually vibrated and placed over the brush so that the toner held inside the hopper falls through the screen, usually of fine mesh, and onto the surface of the brush. This type of loading device has a metering problem resulting in nonuniform quantities of toner being placed on the brush which impairs the subsequent developing step. 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.

Both of these loading techniques require large and cumbersome apparatus in addition to the developing brush itself to contain the toner and load it onto the brush. Consequently, the combination of the loading apparatus and developing brush heretofore required a large amount of the space available within the reproduction machine and contributed to the overall bulkiness of it. Another disadvantage of these loading techniques is that the developing brush must be placed within well-defined locations relative to the plate bearing the latent image. For instance, if the plate were in the shape of a drum which rotates through various process stations in the reproduction process, and the hopper-type loading techniques were used, the developing brush could not be placed in the vicinity of the lowest point of the drum since the toner is loaded on the brush by gravitational forces necessitating that the brush be placed underneath the hopper. Similarly, if the reservoir loading technique were used, the developing brush could not be placed in the vicinity of the highest point of the drum since the brush scoops into the toner reservoir during loading thereby necessitating that the brush be placed above the reservoir.

The invention described herein overcomes the problems of loading a developing brush which existed in the prior art methods and apparatus. The loading technique is such that the developing brush can be placed in any location relative to the plate bearing the latent image; e.g., at any point about the periphery of the drum-type plate. In addition, the problems of a cavity being formed by packed toner, metering the toner flow onto the brush and adequate triboelectrification of the toner particles are all avoided by the present invention.



The present invention is a developing brush having a supply of toner which flows from the core of the brush to its periphery. The brush is a self-contained unit which does not require a separate loading apparatus and which takes up very little space in a copier relative to the prior art devices.

Accordingly, it is an object of this invention to improve apparatus and method for developing latent electrostatic images by the application of toner with a developing brush.

It is a further object to improve apparatus and method for developing latent electrostatic images by making the overall size of the developing apparatus smaller than that of the prior art devices.

A still further object is to improve apparatus and method for developing latent electrostatic images by loading a developing brush with toner particles contained within the brush.

A still further object is to improve apparatus and method for developing latent electrostatic images by accurately metering the rate at which toner is placed on a developing brush.

The present invention is a developing brush having a self-contained means to load the periphery of the brush with toner as the brush rotates adjacent the latent image being developed by it. Toner which is contained within the core of the brush flows through apertures in the brush material to the periphery of the developing brush as the brush rotates. The brush can be made of a material which generates a triboelectric charge on the toner particles as they flow through the apertures and is partially surrounded by a housing to maintain toner on its periphery in areas other than in the vicinity where the latent images are being developed.

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 read in conjunction with the accompanying drawings wherein:

FIG. 1 is a schematic illustration of a xerographic machine having a developing brush incorporating the present invention.

FIG. 2 is a perspective view of a developing brush incorporating the present invention and having portions broken away to show internal construction.

The present invention can be used for the developing step in any system where toner particles are applied with a developing brush to a latent electrostatic image on an insulating plate. The invention is disclosed herein principally within the environment of a xerographic system, but it is not intended that its application be limited to this type of reproduction system.

Referring to FIG. 1, there is shown an automatic xerographic machine. The principal element of the machine is photosensitive plate **60**. The plate has five distinct stations arranged about its periphery which carry out the operational steps of the xerographic process. These stations include charging station **10**, exposing station **20**, developing station **30**, transfer station **40** and cleaning station **50**. The plate is in the shape of a rotatable drum **63** which is driven about shaft **64** by a motor (not shown). The peripheral surface of the drum is covered with layer **62**, an electrically conductive material, which, in turn, is covered on its outer surface with layer **61**, a photosensitive insulating material such as vitreous selenium.

An electrostatic latent image is formed on the drum by passing it through charging station **10** and exposing station **20**. The charging station consists of any suitable means for placing a uniform charge on layer **61** such as corona charging device **11** shown in the Figure. Exposing station **20** comprises projector **21** which projects and focuses on the drum a light pattern conforming to the image to be reproduced by the xerographic machine. The image projected onto the photosensitive layer of the drum is synchronized with the movement of the photosensitive layer of the drum. The projected light pattern causes selective charge dissipation on elemental areas of layer **61**, thus forming an electrostatic latent image. Other means for

forming electrostatic images including means for forming images on ordinary insulating surfaces are known in the art and may be used instead of the one shown.

After the formation of the electrostatic latent image by passing the drum through stations **10** and **20**, the drum carries the image to developing station **30** where toner particles are applied to the surface of the drum by a developing brush. As toner particles are applied to the surface of the drum, they adhere to it according to the configuration of the electrostatic latent image formed beforehand. The structure and operation of the developing apparatus shown at station **30** will be described in more detail below.

Following the developing step the drum carries the developed image through transfer station **40** where the image is transferred from the drum surface to support material **41**. Transfer of the developed 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 triboelectric charge on the toner particles. Transfer takes place between guide rollers **45** which act to position the support material against the photosensitive drum at the transfer station.

Support material **41** is fed from reel **43** before transfer and is rewound on reel **44** after transfer takes place. If support material **41** is the permanent substrate upon which the developed image is to be fixed, as shown in the Figure, fusing device **46** can be placed along the path of the support material between the point where the support material is rewound on reel **44**. The fusing device is positioned to heat the toner particles thereby permanently bonding them to the support material.

The final station shown in FIG. **1** is cleaning station **50** which comprises a cylindrical brush **51** which contacts the photosensitive surface of the drum. The cleaning station is utilized to remove any residue toner particles from the photosensitive surface after transfer occurs and before the surface begins a new cycle.

The above-described process and apparatus are commercially known in the art, and any of the many known equivalents of process or apparatus elements may be employed in connection with the present invention. It is intended that appropriate drive mechanisms and control circuits be a part of the general disclosure herein which would enable the continuous xerographic process to operate, however, such apparatus is not shown since the elements can be of any suitable design to accomplish the operational movement of the system described above.

It is within the confines of the development station, station **30**, that the present invention is utilized. The development station includes a developing brush which applies toner particles to the surface of the plate bearing the latent image by bringing the toner particles in contact with the latent image and depositing them in conformance with the latent image. The brush can be made of any suitable material which has the capability of carrying toner particles to the latent image and depositing them on the plate. For instance, a fur brush having a multitude of fibers to carry and deposit toner particles can be satisfactorily used for this purpose and is shown in the Figures. The brush shown consists of a backing material or pad **32** having elongated fibers **31** protruding therefrom. Synthetic materials such as nylon, velvet, and Dynel can also be used as a brush material.

The backing material is supported by frame **36** which is mounted so that it can be rotated adjacent the drum. Any suitable means can be used to fix the backing material onto the frame such as glue, fasteners, etc., and the frame is rotated by any suitable drive means which is symbolically depicted in FIG. **1**.

The core of frame **36** is hollow so that toner particles can be placed within it. The brush also contains small holes or perforations **39** which allow toner particles within the core to pass through the brush. The toner passes from the core to the periphery of the brush as the brush rotates due to centrifugal forces imposed on the toner particles. Since the toner supply is self-contained in the brush and loading of the brush occurs through the brush due to its rotation, the development system is a very compact system where compared to the apparatus and amount of space required by other known systems. In addition, the self-contained nature of the brush allows it to be placed at any position relative to the plate bearing the latent image. For instance, in a reproduction system using a rotatable drum, such as drum **63** in FIG. **1**, the brush can be placed anywhere about the periphery of the drum to develop the image. Unlike other development systems, the brush is not dependent on gravity loading or collateral apparatus which limits its position in a reproduction system.

The toner particles used to develop latent images are customarily finely divided, electroscopic particles of thermoplastic resins having colored pigments dispersed throughout. The size of the toner particles is generally in the range of 3 to 30 microns. In order that the toner particles are able to pass onto the periphery of the brush they must flow from the core of the brush through the perforations or apertures. To assure that the toner does flow onto the brush periphery, the size of the apertures must be larger than the size of the toner particles, and preferably large enough to have a continuous, uniform flow of toner particles to the periphery. The size of the holes also plays a role in the amount of toner reaching the periphery of the brush over a given amount of time. Consequently, the rate of toner passage can be metered by preselecting the size of the holes in the brush; the larger the size, the greater amount of toner passage. The number of holes also play a role in metering. If only one hole were placed in the brush, only a small amount of toner would flow out of the brush over a given time, but if a great many holes are placed in the brush, the rate of toner passage would be increased manyfold. The amount of holes desirable ultimately depends on the amount of toner necessary to properly develop an image.

The developing brush can contain either toner particles alone or a of toner particles and carrier beads. The carrier heads can be any suitable granular material which has a triboelectric property which in turn will properly charge the toner when mixed therewith. If toner particles alone are placed in the core of the brush, a triboelectric charge of the correct polarity should be acquired by the particles before they reach the latent image. This charge is desirable since it aids in the deposition of toner on the plate bearing the latent image.

The toner particles can be charged in any suitable manner prior to their being placed in the core of the brush or, in the alternative, can acquire a triboelectric charge as the brush is rotated after being placed in the brush. The latter method is accomplished through the use of mixing vanes **37** and/or charging material **38**. Both the mixing vanes and charging material are made of or coated with any suitable material which has a triboelectric property different than that of the toner particles and which will generate a triboelectric charge of desired polarity on the toner when the toner rubs against it. In the case of the mixing vanes, a triboelectric charge is placed on the toner as the brush rotates since the vanes pass through and move relative to the toner. The vanes also tend to keep the toner in a loose consistency which avoids packing and aids its passage through the brush. Charging material **38** can be used to generate a charge of the toner as the toner passes through the brush and onto its periphery. This material, which also has apertures to allow toner passage, is placed adjacent the frame either between the backing material and frame or inside the frame. As toner passes from the core of the brush to its periphery, it must pass through the charging material where a triboelectric charge is placed on it. The charging material in FIG. **2** is shown as a mesh material to allow the easy flow of toner. If the toner particles are charged prior to their being placed in the core of the brush, the vanes and charging material would not be necessary. However, it may be desirable to keep the vanes and charging material in the brush even though

the toner particles have been charged to make certain that all the toner particles have a uniform charge prior to being applied to the latent image.

When the toner particles are placed in the core of the brush as part of a developer mixture which includes carrier beads as well as toner particles, a triboelectric charge is generated on the toner particles as a result of their mixing with and rubbing against the carrier beads. For this reason the carrier bead material is chosen for its triboelectric property relative to the toner particles and is generally grossly larger than the toner particles.

If a developer mixture is placed in the core of the brush, the apertures in the brush should be smaller than the carrier beads so that the carrier beads are always kept within its core. In this case, both impact and centrifugal forces are used to get the toner from the core to the periphery of the brush. The impact forces are used to separate toner from the carrier beads and, concurrently, centrifugal forces coerce the toner particles through the brush to its periphery. The impact forces on the developer are generated generally from collisions of the carrier beads with the frame, vanes and each other. During the operation of the brush the toner particles flow through the apertures in the backing material of the brush and onto the fibers due to centrifugal and impact forces as the brush rotates, these forces causing the toner particles to move in the direction substantially perpendicular to the backing material. Since the quantity of centrifugal force varies directly with the speed of rotation of the developing brush and since it might be desirable to rotate the brush at relatively slow speeds under some development circumstances, it may be necessary to place an additional force on the toner particles to achieve a free flow of toner onto the fibers. A way of accomplishing such additional force is to introduce into the interior of the developing brush a positive air pressure which would cause the particles to seek the lower pressure external to the brush and, therefore, pass through the apertures. This air pressure can be introduced to the core of the brush by any suitable means and is depicted in FIG. 1 symbolically. The combination of air pressure with centrifugal and impact forces on the particles cause a uniform, continuous flow of toner through the apertures. Provision can also be made to replenish the supply of toner particles within the brush as they are used to develop the latent image. Any suitable means can be utilized for this purpose such as introducing additional toner particles with the flow of air brought into the core of the brush.

Because the brush develops the latent image on the drum only at the position where the developing brush interferes with the drum surface, i.e., in the development zone **56**, provision is made for maintaining all toner particles on the fibers of the brush until they reach the development zone. For this purpose housing **34** is used to partially surround the brush. It is the function of the housing to contain any toner particles which fall off the periphery of the brush in areas which are not in the development zone. The housing is preferably located just adjacent the path through which the ends of the fibers travel and because of its proximity to the brush, any particles that fall off the brush are prevented from leaving the vicinity of the brush. Eventually, toner particles which fall off the brush are reloaded onto the brush due to this proximity.

In addition to housing **34**, a selective bias can be placed on the brush so that the toner particles remain on the brush's periphery until they enter the development zone. This is accomplished by using a frame with conductive and relatively nonconductive elements, alternately positioned. As can be best seen in FIG. **2**, the frame is made of conductive elements **52** and relatively nonconductive elements **51**. The conductive elements acquire a relatively small electrical bias in the areas outside the development zone by virtue of brushes **54** which are connected to a suitable power source (not shown). The nature of the electrical bias placed on the conductive elements will depend on the development mode used. For instance, if the positive-to-positive development mode is employed, the toner particles will be triboelectrically charged to a negative polarity and the bias placed on the conductive portions of the frame will be of a positive polarity. Conversely, if the negative-to-positive development mode is employed, the bias placed on the developing brush outside the development zone will be of a negative polarity.

Although three electrical brushes **54** are shown in FIG. **2**, it is intended that as many brushes be used to impose the bias on the frame of the developing brush as necessary to attract the toner particles to it outside the development zone. The number of electrical brushes actually required ultimately depends on the size and number of conductive elements used in the frame. After the toner particles pass through the apertures and onto the periphery of the brush, they tend to adhere to the brush by virtue of their triboelectric charge and the electrical bias placed on the brush in all portions of the brush except the portion within the development zone. As a portion of the brush passes through the development zone, the electrical bias on that portion is released and the periphery of the brush places the toner particles adjacent to and on the drum where they are deposited in imagewise configuration. As that portion of the brush continues to rotate and leaves the development zone, more toner particles flow from the core to the periphery of the brush to replace those particles which were deposited on the latent image.

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 herein.

What I claim is:

**1.** An apparatus for developing a latent electrostatic image on an insulating surface with finely divided toner particles comprising:

a hollow, cylindrical frame capable of containing a quantity of toner particles and having an outer surface of brushlike material fastened thereto with brush fibers extending outwardly from the outer surface,

apertures in the brushlike material and in the outer surface of the frame, said apertures being of a size sufficient to allow toner particles within the frame to pass through the outer surface to the fibers of the brushlike material,

means to support the frame in a position whereby the brush fibers extend into contact with the insulating surface containing an electrostatic image, and

means to rotate the frame whereby toner particles within the frame pass through the apertures in the outer surface to the fibers of the brushlike material and are brought into contact with the electrostatic image on the insulating surface.

**2.** The apparatus in claim **1** further including an intermediate layer of material between the frame and brushlike material and having apertures aligned with the apertures in the frame and brush material, said intermediate layer of material having triboelectric properties relative to the toner particles whereby the toner particles are triboelectrically charged by rubbing against the intermediate layer as they pass from the frame to the brushlike material.

**3.** The apparatus in claim **1** further including a plurality of mixing vanes attached to the frame and extending into the hollow portion of the frame, said vanes being of a material which has triboelectric properties, relative to the toner particles, whereby the toner particles are triboelectrically charged by contact with the vanes.

**4.** The apparatus in claim **1** further including means to generate air pressure within the frame to urge toner particles to pass through the apertures to the brushlike material.

**5.** The apparatus in claim **1** wherein the frame comprises alternate elements of conductive and relatively nonconductive material, and further including a means to impose an electric field on those conductive elements of the frame which are located other than immediately adjacent the insulating surface, the electric field having the characteristic of placing on those conductive elements a charge having the opposite

polarity as the polarity of the toner particles whereby the toner particles on the surface of the brush material at positions other than in the vicinity of the insulating surface are urged to remain on the brushlike material.

6. The apparatus of claim 1 wherein the brushlike material comprises fur brush material having a backing pad with elongated carrier fibers protruding therefrom, and further including a housing surrounding the brush except that portion of the brush immediately adjacent the insulating plate.

7. The apparatus in claim 1 further including a quantity of carrier particles within the frame which are of grossly larger size than the toner particles and the apertures and comprise a material which has triboelectric properties relative to the toner particles to thereby triboelectrically charge the toner particles as the frame rotates.