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ROTARY BRUSH DEVELOPMENT

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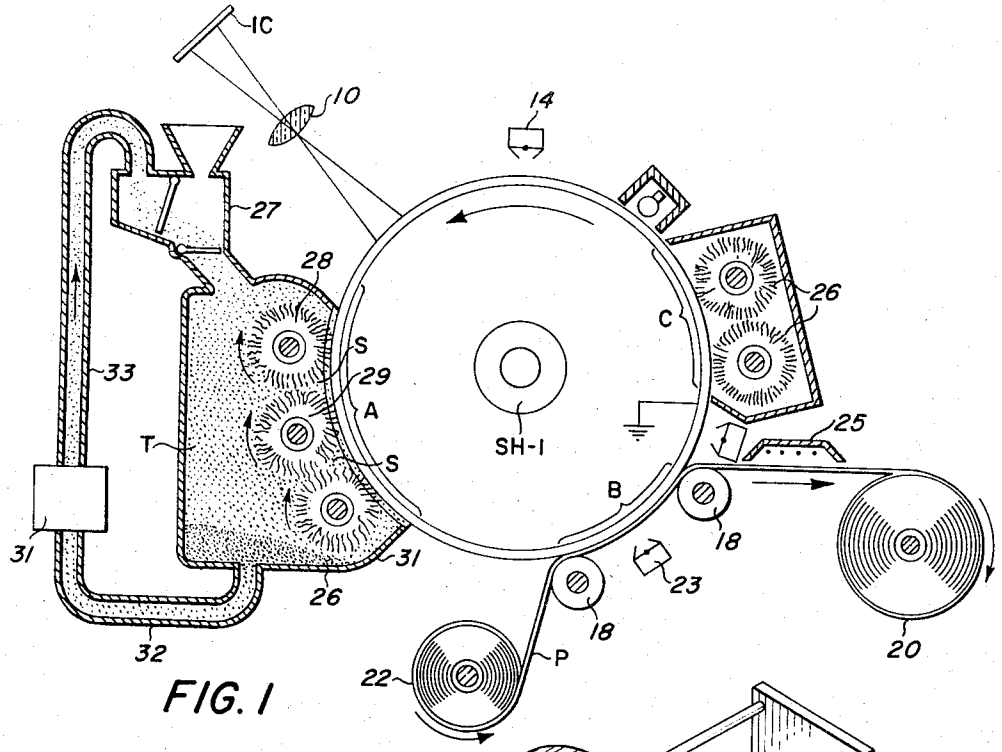

FIG. 1

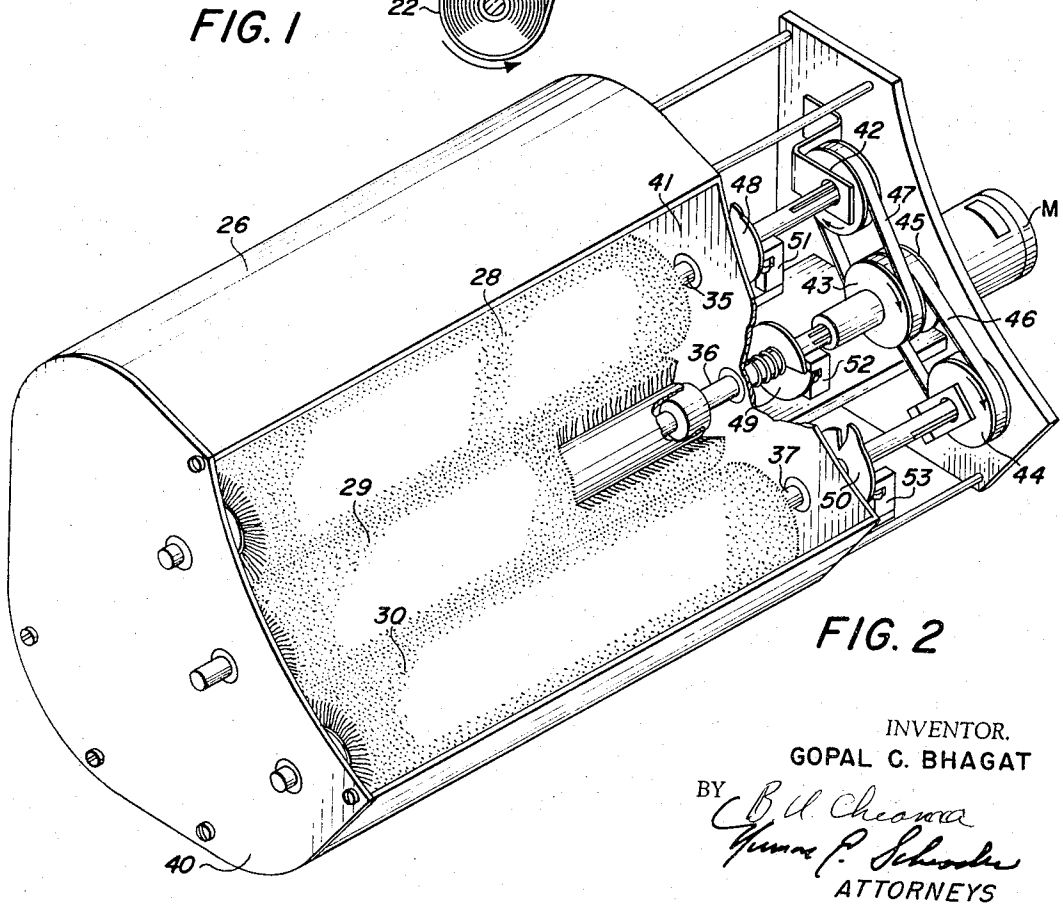

FIG. 2

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ROTARY BRUSH DEVELOPMENT

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ABSTRACT OF THE DISCLOSURE

A developing apparatus for applying toner particles to a photoconductive surface carrying a latent electrostatic image having a plurality of cylindrical rotary brushes adapted to contact lightly both the surface and each other and arranged for rotation such that the bristles of one brush move in a direction opposite the movement of the contacted bristles of adjacent brushes. This produces powder clouds between the rollers and within spaces adjacent the surface. A device is provided for loading carrier-free toner on the bristles of the brushes.

This invention relates to improvements in electrostatographic development devices and, particularly, to improvements wherein these devices are arranged to produce high quality, solid area coverage and line copy development, especially for very high-speed xerographic reproduction processing.

In conventional xerography, solid area electrostatic images can be reproduced on a xerographic selenium plate only after great care has been practiced and for high-speed development, say on the order of 25–50 inches per second of xerographic plate travel. This goal is almost impossible to reach using conventional methods. Using cascade development at these speeds places undue frictional stress upon the photoconductor surface and the developing materials as well as the equipment necessary to produce cascade movement of developing material. At high speeds, the use of two component developer material requires low impact of developing materials on photoreceptors and tightly sealed developer housings in order to prevent scattering and loss of toner particles and the usual carrier beads. In systems which utilize toner particles without carrier beads, there is the problem of conveying toner into the presence of an electrostatic latent image and at high photoreceptor speeds, the use of toner particles has been completely unsuccessful for either good line copy or solid area coverage. The results have always been a line copy with no fringe development and heavy background.

Therefore, the principal object of the invention is to effect solid area development using only toner particles and to maintain high image quality at very high development speeds. A further object of the invention is to effect optimum solid image quality with minimum background conditions during electrostatic development processing. Another object of the invention is to produce solid area images while at the same time effecting line copy images at very high speeds using a minimum of developing materials and mechanical parts and equipment and thus extensively reducing the impact and frictional wear on the photoreceptor and the developing materials.

These and other objects of the invention are attained by means of the application of multiple rotary brushes to an electrostatic image bearing plate at the development station of an electrostatic reproduction machine. Means are provided for imparting counter-rotational movement to the brushes which are arranged to form small powder cloud spaces therebetween. Means are also provided for imparting axial reciprocatory movement to each of the rotary brushes in order to enhance the application of toner particles to the electrostatic latent image areas for longer periods of time.

A preferred form of the invention is shown in the accompanying drawings, wherein:

FIG. 1 is a schematic sectional view of a typical xerographic reproduction machine embodying the principles of the invention; and

FIG. 2 is an isometric view partly broken away of the rotary brush assembly utilized in the invention.

For a general understanding of a typical xerographic processing system in which the invention may be incorporated, reference is made to FIG. 1 in which various components of a typical system are schematically illustrated. As in all xerographic systems, a light image of an original to be reproduced is projected onto the sensitized surface of a xerographic plate to form an electrostatic latent image thereon. Thereafter, the latent image is developed with the same or an oppositely charged developing toner material, depending upon negative-to-positive or positive-to-positive mode of reproduction, to form a xerographic powder image corresponding to the latent image on the plate surface. The powder image is then electrostatically transferred to a support surface such as a sheet of paper or the like to which it may be fused by a fusing device whereby the powder image is caused permanently to adhere to the support surface.

For purposes of the present disclosure, the xerographic reproduction machine includes an exposure station at which a light or radiation pattern of a document D to be reproduced is projected by a lens 10 onto an electrostatographic surface, such as a xerographic drum 12.

The xerographic drum 12 is detachably secured to a shaft SH–1 mounted in suitable bearings in the frame of the machine and is driven in a counterclockwise direction by a motor at a constant rate that is proportional to the scan rate for the document being reproduced whereby the peripheral rate of the drum surface is identical to the rate of movement of the projected light image of the document. The drum surface comprises a layer of photoconductive material on a conductive backing that is sensitized prior to exposure by means of a corona generating device 14.

The exposure of the drum to the document light image discharges the photoconductive layer in the areas struck by light, whereby there remains on the drum an electrostatic latent image in configuration corresponding to the light image projected from the document. As the drum surface continues its movement, the electrostatic latent image passes through a developing station A in which there is positioned a developer apparatus in accordance with the present invention.

Positioned next and adjacent to the developing station is the image transfer station B which includes a pair of rollers 18 for holding a support material in the form of paper web P against the surface of the drum to receive the developed xerographic powder image therefrom. The web P is moved in synchronism with the rotation of the drum by means of a take-up roll 20 which drives the support material P from a supply roll 22. A suitable drive mechanism (not shown) is connected to the drum 12 for imparting rotation thereto at a continuous speed. This drive mechanism may be connected to the take-up roll 20 for imparting rotation thereto thereby producing movement of the web material P in the same peripheral direction and at the same speed as the peripheral surface of the drum. In order to insure identical movement of the two coating surfaces, a suitable programming device may be utilized to effect continuous synchronous movement of these surfaces.

The transfer of the xerographic powder image from the drum surface to the transfer material is effected by means of a corona transfer device 23 that is located at place of

contact between the transfer material and the rotating drum. The corona transfer device **23** is substantially similar to the corona discharge device **14** in that it includes an array of one or more corona discharge electrodes that are energized from a suitable high potential source and extend transversely across the drum surface and are substatntially enclosed within a shielding member.

In operation, the electrostatic field created by the corona discharge device **23** of appropriate polarity is effective to attract the toner particles comprising the xerographic powder image from the drum surface and cause them to adhere electrostatically to the surface of the transfer material.

Immediately subsequent to the image transfer station, the transfer material is carried to a fixing device in the form of a fuser assembly **25** whereby the developed and transferred xerographic powder image on the sheet material P is permanently fixed thereto. After fusing, the finished copy is preferably discharged from the apparatus at a suitable point for collection externally of the apparatus.

The next and final station in the device is a drum cleaning station C having positioned therein a corona precleaning device similar to the corona charging device **14** of appropriate polarity, negative for positive-to-positive mode of reproduction and positive for negative-to-positive mode of reproduction, to impose an electrostatic charge on the drum and residual powder adherent thereto to aid in effecting removal of the powder and a drum cleaning device under suction in the form of rotary brushes **26** adapted to remove any powder remaining on the xerographic drum.

In general, the electrostatic charging of the xerographic drum in preparation for the exposure step and the electrostatic charging of the support surface to effect toned image transfer are accomplished by means of corona generating devices whereby electrostatic charge on the order of from 700 to 1000 volts is measured on the respective surface in each instance. Although any one of a number of types of corona generating devices may be used, a corona charging device of the type disclosed in Vyverberg Patent No. 2,836,725 is used for both the corona charging device **14** and the corona transfer device **23**, each of which is secured to suitable frame elements of the apparatus and connected to a suitable electrical circuit.

At the development station A there is positioned a developing apparatus mounted within a developer housing **26** into which is contained a supply of toner material T from a toner dispenser **27** and a plurality of rotary fur brushes. In the illustrated example, there are three brushes, indicated by the reference thereof **28**, **29**, and **30**. Also, the integral part of the developer housing **26** is a suction operated toner feedback system **31**, preferably in the form of a blower unit connected by an input conduit **32** for drawing toner out of the sump portion of the housing **26** and an output conduit **33** for conducting toner and air into the toner dispenser and the housing in aerated form. The unit **31** serves to feed back the toner particles cumulating in the sump of the developer housing **26** in continuous movement and to insure more efficient performance of the toner supply system during use of the developer apparatus. The toner in the housing will thereby remain in a continuous, highly agitated condition to produce a dense powder cloud, thus allowing some of the toner to become triboelectrically attracted to the bristles of the brushes, as will be described hereinafter.

As shown in FIG. 2, the rotary fur brushes **28**, **29** and **30** are arranged on parallel oriented mandrels **35**, **36** and **37**, respectively. Each of the brushes comprises a hollow conductive or insulative cylinder **38**, only one being shown, and bristle material, such as dynel or rabbit fur, which may be suitably cemented to the cylinder comprising the brush. The bristles for each of the brushes are of such a length and the brushes are spaced from one another so as to position the outer extremities of the bristles, for any two adjacent brushes, in very slight direct contact. Each of the cylinders is insulated relative to its respective mandrel and to this end, the hubs for the cylinders may be made from non-conductive material. Thus, an appropriate polarity bias may be applied to these brushes individually from a power source (not shown). This provision would aid in enhancing solid area development and background suppression.

The mandrels **35**, **36** and **37** for the brushes extend through the end walls **40**, **41** of the housing **26**. Suitable bearings (not shown) mounted interiorly of the housing on the wall **40** support one end of each of the mandrels while at their other ends, each of the mandrels extends beyond the wall **41** for a short distance before terminating by means of splined connections to pulleys **42**, **43** and **44**, respectively. The wall **41** is also provided with suitable bearings for supporting each of the brushes for rotation.

The mandrel **36** for the middle brush **29** is connected to the drive shaft of a suitable gear reduction drive (not shown) and powered by a motor M. Also secured to the shaft **36** is a pulley **45** which is connected by a belt **46** to the pulley **44** for the brush **30**. Another belt **47** connects the pulleys **42** and **43** for imparting rotation to the brush **28**. With this arrangement then, the motor M is adapted to drive each of the brushes and in a direction that is common to all. In FIG 1, this direction is illustrated as clockwise for a reason to be described hereinafter.

As previously stated, each of the shafts **35**, **36** and **37** is splined to its respective pulley **42**, **43** and **44**. This permits limited axial movement of the shafts relative to the pulleys thereby permitting rotational driving action to be imparted to each of the rollers while allowing them to be moved axially in either direction. In other to accomplish reciprocatory axial movement for each of the brushes, each shaft corresponding thereto has secured thereon a spring-loaded wobble plate **48**, **49** and **50**, which cooperate with stops **51**, **52** and **53**, respectively, suitably mounted on the frame of the housing **26**. As each of the wobble plates is rotated and maintained in contact with its respective stop, the shaft associated with that wobble plate will reciprocate the distance the wobble plate is out of vertical flat. Preferably, the wobble plates **48**, **49** and **50** are arranged so as to produce varied reciprocal movement to the brushes, for example, while the middle brush **29** is moved to the left as viewed in FIG. 2, the brushes **28** and **30** are moved to the right, and so on. In other words, the wobble plates can be run out or in phase with other brush shafts.

During the development stage of the xerographic processing with the rotary brushes **28**, **29** and **30** in a continuous rotary motion and, the toner feedback system **34** is effective to maintain a dense powder cloud in the housing **26**, the bristles for each of the brushes are adapted to come in contact with the toner in the powder cloud. With the triboelectric materials properly chosen, the toner particles will physically and triboelectrically adhere to the bristles of the brushes. These materials may be such that charges upon the toner particles are produced by contact-electrification during their highly agitated presence in the developing housing. By this arrangement, the brushes become loaded with toner and are adapted for developing. The bristles then are adapted to apply the toner particles to the electrostatic latent image that is moved into the development station A in order to develop the image. With an extremely light touching of the bristles of any two adjacent brushes, there is developed a powder cloud between any two brushes and, in the spaces indicated by the reference letters S, that is, between the brushes and the xerographic drum **12**. The uni-directional rotation of the brushes results in the movement of adjacent peripheries in the opposite direction thereby causing flicking of the ends of the opposing bristle and the enhancement of small spaces of powder clouds. The presence of these

clouds which are confined to the spaces S and to the narrow spaces between the brushes, aids in the development of electrostatic latent images on the drum **12**. The spaces S are confined by the action of the bristles of the brush **28** upon the xerographic drum and the contact of the bristles of the brush **30** with the drum surface at a lower point in the developer housing **26**. This minimizes or eliminates the spreading and loss of toner or leakage thereof out of the housing.

The reciprocatory movement of the brushes, as previously described, may prevent streaking and directional effects and will insure that toner particles are properly applied to all portions of the electrostatic latent image presented thereto. The effect of the reciprocatory movement is to produce many swirls in the brush bristles thereby greatly enhancing the opportunities for toner particles to come under the influence of charged latent images. The oscillatory motion of one brush relative to another also aids in the production of the powder cloud therebetween since as each adjacent set of bristles are loaded with the toner, the toner particles in or influenced by one brush may impinge upon the toner particles loaded upon the bristles of another brush thereby aiding in triboelectric generation and the generation of the powder clouds between the brushes as well as the spaces S.

The toner dispenser **27** may be placed in communication with the interior of the housing **26**, as shown in FIG. 5, in order to provide a continuous supply of toner particles to the developing apparatus. Since the developing devices in the form of rotary brushes are utilized, there is no need for toner carrier beads for aiding in the transporting and placing of an electrostatic charge on the toner particles. The bristles of the brush may be made of such material to effect the tribogeneration of electrostatic charges upon the toner particles in much the same fashion as the conventional carrier beads perform.

With the provision of rotary brushes in the development technique herein presented, and with the brush bristles in developing contact with the surface of the xerographic drum **12**, the cleaning requirement for the cleaning brushes is minimal. The developing brushes **28**, **29** and **30** are more or less self-cleaning, that is, upon emerging from the developing housing **26**, the drum surface is fairly free of toner, except for that which is adhering to the electrostatic latent image now in developed condition. The brushes also serve as background removal means and for the excess toner that may have been applied to the developed images. Also by appropriately biasing these brushes, the background can be suppressed.

While the invention has been described with reference to the structure disclosed herein, it is not confined to the details set forth, and this application is intended to cover such modifications or changes as may come within the purposes of the improvements or the scope of the following claims.

What is claimed is:

1. In an electrostatic image reproduction apparatus including a movable photoconductive surface for carrying an electrostatic latent image through a development apparatus containing electrostatically attractable toner particles to effect development of the latent image including:

a housing for containing the toner particles,

a plurality of cylindrical brushes having bristles attractable triboelectrically to the toner particles radially extending therefrom, said brushes being arranged in said housing and along the photoconductive surface such that the tips of the bristles of each brush touch the surface during rotation thereof,

support means for rotatably holding said brushes adjacent to the surface and adjacent to each other so that the bristle tips of one brush lightly touch the tips of an adjacent brush,

means for loading each of the brushes with toner particles,

and means for rotatably driving each of said brushes to effect a turbulence of air and toner particles between the brushes and also between the brushes and the surface.

2. The apparatus of claim **1** including means for moving reciprocally each of said brushes axially and in alternate directions thereof for producing a swirling effect upon the latent image caused by the counter movement of the adjacent brushes and the movement of the surface.

3. The apparatus of claim **1** wherein said brushes are rotatably driven in a direction whereby the bristles of one brush move in a direction opposite that of the bristles of an adjacent brush at the point of touching thereby effecting the said turbulence of air and toner particles.

4. The apparatus of claim **1** wherein said means for loading the brushes comprises means for producing aerial movement of toner particles within the developing housing and into contact with bristles of said brushes to become attracted thereto.

5. The apparatus of claim **1** wherein said means for loading the brushes comprises means for producing a powder cloud within the developing housing in contact with bristles of said brushes to become attracted thereto.

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