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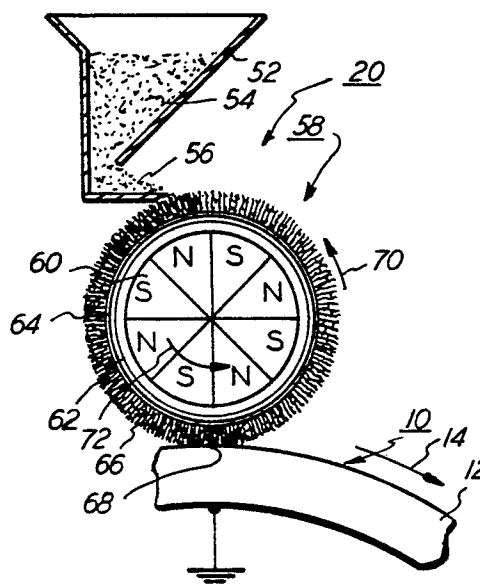
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⑤④ **Apparatus for developing a latent electrostatic image.**

⑤⑦ An apparatus (20) which develops a latent electrostatic image with magnetic particles (54). The apparatus (20) includes a member (62) having a multiplicity of magnetic fibres (66) extending outwardly therefrom. At least a portion of the fibres (66) have the free end regions thereof contacting the latent image. A magnet field attracts the particles (54) to the member (62). Relative movement between the member (62) and magnet field moves the particles (54) into contact with the latent image and moves the free ends of the fibres (68). As the particles (54) are deposited on the latent image, the end regions of the fibres (66) move forming a substantially uniform particle image.



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Apparatus for developing a latent electrostatic image

This invention relates generally to an apparatus for developing a latent electrostatic image with magnetic particles. An apparatus of this type is frequently employed in an electrophotographic printing machine.

Generally, an electrophotographic printing machine includes a photoconductive member which is charged to a substantially uniform potential to sensitize its surface. The charged portion of the photoconductive surface is exposed to a light image of an original document being reproduced. This records an electrostatic latent image on the photoconductive member corresponding to the informational areas contained within the original document. After the electrostatic latent image is recorded on the photoconductive member, the latent image is developed by bringing a developer mix into contact therewith. This forms a powder image on the photoconductive member which is subsequently transferred to a copy sheet. Finally, the copy sheet is heated to affix the powder image thereto.

Frequently, the developer mix comprises toner particles adhering triboelectrically to carrier granules. This two-component mixture is brought into contact with the latent image. The toner particles are attracted from the carrier granules to the latent image to form the powder image thereof.

With the advent of single component developer materials, carrier granules are no longer required. In general, the developer material particles have low resistivities, e.g. the resistivity ranges from about 10^4 to about 10^9 ohm-centimeters. During development, these particles are deposited on the latent image. Though development is optimized by employing particles having low resistivity or good conductivity, transfer is optimized by employing particles having high resistivities. Thus, the printing machine is faced with two contradictory requirements, i.e. the utilization of particles having low resistivity for optimum development, and having high resistivity for optimum transfer. It has been found that when more-resistive particles are employed, they frequently produce images having portions of the solid areas unreproduced. Various approaches have been devised to improve development.

The following prior art is relevant:

IBM Technical Disclosure Bulletin
Volume 8, Number 12, Page 1732
Author: Cross
Published: May, 1966

U.S. Patent No. 3 614 221
Patentee: Solarck
Issued: October 19 1971

U.S. Patent No. 3 664 857
Patentee: Miller
Issued: May 23 1972

Japanese Patent Laid Open No: 5367438
Laid Open Date: June 15 1978
Japanese Patent Application No: 51142260
Application Date: November 29 1976

The pertinent portions of the foregoing disclosures may be briefly summarized as follows:

Cross discloses a rotatable non-magnetic cylinder having iron helices thereon. The cylinder rotates in a container having magnets mounted externally thereof.

Solarck describes a woven pile brush having a mixture of non-conductive and conductive pile fibres. The conductive pile fibres are shorter than the non-conductive fibres, and can function as a development electrode while avoiding contact with the latent image.

Miller discloses a pair of metallised fur brushes having individual flexible filaments coated with a thin layer of an electrically conductive metal. One brush is of low electrical conductivity, while the other is

of high electrical conductivity.

The Japanese patent application discloses a permanent magnet disposed inside a rotatable cylindrical non-magnetic sleeve. A fibre brush, whose volume electrical resistance ranges from about 10^6 to about 10^{14} ohm-centimeters, and whose height ranges from about 0.5 to about 10mm, is secured to the outer periphery of the non-magnetic sleeve.

In accordance with the present invention, there is provided an apparatus for developing a latent image. The apparatus includes a member having a multiplicity of magnetic fibres extending outwardly therefrom. At least a portion of the fibres has the free end region thereof contacting the latent image. Means are provided for generating a magnetic field to attract the particles to the member. Relative movement between the member and magnetic field is produced to move the particles into contact with the latent image. As the particles are being deposited on the latent image, the ends of the fibres move, forming a substantially uniform particle image.

The present invention will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a schematic elevational view of an electrophotographic printing machine incorporating the present invention therein;

Figure 2 is a schematic elevational view of one embodiment of the development system employed in the Figure 1 printing machine;

Figure 3 is a schematic elevational view of a developer roller utilized in the Figure 2 development system;

Figure 4 is a schematic elevational view of another embodiment of the development system employed in the Figure 1 printing machine;

Figure 5 is a schematic elevational view of a developer roller used in the Figure 4 development system;

Figure 6 is a fragmentary, exploded view depicting one embodiment of the fibre weave on the developer roller, and

Figure 7 is a fragmentary, exploded view depicting another embodiment of the fibre weave on the developer roller.

For a general understanding of the features of the present invention, reference is made to the drawings. In the drawings, like reference numerals have been used throughout to designate like elements. Figure 1 schematically depicts the various components of an illustrative electrophotographic printing machine incorporating the development apparatus of the present invention therein. It will become evident from the following discussion that the development apparatus is equally well suited for use in a wide variety of electrostatographic printing machines, and is not necessarily limited in its application to the particular embodiments shown herein.

Inasmuch as the art of electrophotographic printing is well known, the various processing stations employed in the Figure 1 printing machine will be shown hereinafter schematically and their operation described briefly with reference thereto.

As shown in Figure 1, the illustrative electrophotographic printing machine employs a drum 10 having a photoconductive surface 12. Preferably, photoconductive surface 12 comprises a transport layer containing small molecules dispersed in an organic resinous material, and a generation layer having selenium dispersed in a resinous material. Drum 10 moves in the direction of arrow 14 to advance successive portions of photoconductive surface 12 sequentially through the various processing stations disposed about the path of movement thereof.

Initially, a portion of photoconductive surface 12 passes through charging station A where a corona generating device, indicated generally by the reference numeral 16, charges photoconductive surface 12 to a

relatively high substantially uniform potential.

Next, the charged portion of photoconductive surface 12 is advanced through exposure station B including exposure system 18, wherein an original document is positioned face-down upon a transparent platen. The light rays reflected from the original document are transmitted through a lens to form a light image thereof. The light image is projected onto the charged portion of photoconductive surface 12 to dissipate the charge thereon selectively. This records an electrostatic latent image on photoconductive surface 12 corresponding with the indicia on the original document. Thereafter, drum 10 advances the electrostatic latent image on photoconductive surface 12 to development station C.

At development station C, a magnetic fibre brush development system, indicated generally by the reference numeral 20, advances magnetic particles into contact with the electrostatic latent image. The latent image attracts the particles, forming a particle image on photoconductive surface 12 of drum 10. The detailed structure of the development system will be described hereinafter with reference to Figures 2 through 7, inclusive.

Drum 10 then advances the particle image to transfer station D at which a sheet of support material is moved into contact with the particle image. The sheet of support material is advanced to transfer station D by a sheet feeding apparatus indicated generally by the reference numeral 22. Preferably, sheet feeding apparatus 22 includes a feed roll 24 contacting the uppermost sheet of a stack of sheets 26. Feed roll 24 rotates in the direction of arrow 28 so as to advance the uppermost sheet into the nip defined by forwarding rollers 30. Forwarding rollers 30 rotate in the direction of arrow 32 to advance the sheet into chute 34. Chute 34 directs the advancing sheet of support material into contact with the photoconductive surface of drum 10 so that the particle image developed thereon contacts the advancing sheet at transfer station D.

Transfer station D includes a corona generating device 36 which sprays ions onto the back of the sheet. This attracts the particle

image from photoconductive surface 12 to the sheet. After transfer, the sheet continues to move in the direction of arrow 38 onto a conveyor 40 which advances the sheet to fusing station E.

Fusing station E includes a fuser assembly, indicated generally by the reference numeral 42, which permanently affixes the transferred particle image to the sheet. Preferably, fuser assembly 42 includes a heated fuser roller 44 and a back-up roller 46. The sheet passes between fuser roller 44 and back-up roller 46 with the particle image contacting fuser roller 44. In this manner, the particle image is permanently affixed to the sheet. After fusing, the forwarding rollers 48 advance the sheet to catch tray 50 for subsequent removal from the printing machine by the operator.

Invariably, after the sheet of support material is separated from photoconductive surface 12 of drum 10, some residual particles remain adhering thereto. These residual particles are removed from photoconductive surface 12 at cleaning station F. Cleaning station F includes a rotatably mounted fibrous brush in contact with photoconductive surface 12. The particles are cleaned from photoconductive surface 12 by the rotation of the brush in contact therewith. Subsequent to cleaning, a discharge lamp (not shown) floods photoconductive surface 12 with light to dissipate any residual electrostatic charge remaining thereon prior to the charging thereof for the next successive image cycle.

It is believed that the foregoing description is sufficient for purposes of the present application to illustrate the general operation of an electrophotographic printing machine incorporating the features of the present invention therein.

Referring now to the specific subject matter of the present invention, one embodiment of development system 20 is depicted in Figure 2. As shown in Figure 2, development system 20 includes a hopper 52 storing a supply of magnetic particles 54 therein. Particles 54 descend through aperture 56 in hopper 52 onto the surface of developer roller

58. Developer roller 58 includes an elongated cylindrical magnet 60 mounted interiorly of a relatively-movable tubular member 62. A tubular sleeve 64 fits over tubular member 62. Preferably, tubular sleeve 64 is made from a fabric and has a multiplicity of stainless steel tufts 66 extending outwardly therefrom. Sleeve 64 is preferably cemented to tubular member 62. A voltage source (not shown) electrically biases sleeve 64 to a suitable magnitude and polarity to effect development of the latent image with the magnetic particles. Each tuft 66 on sleeve 64 includes a multiplicity of stainless steel fibres. Tufts 66 contact photoconductive surface 12 of drum 10 in development zone 68. Thus, as the particles 54 are being deposited on the latent image recorded on photoconductive surface 12, tufts 66 are in contact therewith. Tufts 66 extend about the entire circumferential surface of tubular member 62. Tubular member 62 is made from a non-magnetic material, such as aluminum. Preferably, magnet 60 is made from barium ferrite having a permanent magnetic field.

Tubular member 62 rotates in the direction of arrow 70. The angular velocity of tubular member 70 is such that the tangential velocity thereof is equal to the tangential velocity of drum 10. Magnetic member 60 rotates, in the direction of arrow 72, at an angular velocity greater than the angular velocity of tubular member 62. Alternatively, magnetic member 60 may rotate in a direction opposed to arrow 72. As magnet 60 moves relatively to sleeve 64 particles 54 are transported over and around tufts 66. This is because magnetic dipoles are set up in each fibre of tufts 66, which causes movement of the free end of each fibre. It is desirable to move the free end of each fibre of tufts 66 both circumferentially and laterally. This may be achieved by employing fibres having differing magnetic properties, in which case magnetic fields of varying strength are established between the fibre ends. Fibre motion is dependent upon the magnetic field gradient at any point on the fibre. This results in the fibres moving in all directions. Alternatively, both circumferential and lateral movement of each tuft fibre may be achieved by forming magnet 60 with a helical magnetic pattern. The foregoing is shown more clearly in Figure 3.

Figure 3 shows developer roller 58 in greater detail. Magnet 60 is mounted rotatably within tube 62 and has a helical magnetic pole pattern 74 formed thereon. Preferably, the helix angle is about 74° , e.g., one turn per 2.5 cm axial length for a 2.8 cm diameter magnet. Tube 62 and magnet 60 are rotated by a constant speed drive motor 61. The gears coupling motor 61 with magnet 60 and tube 62 are selected such that magnet 60 rotates at a greater angular velocity than tube 62. Preferably, tube 62 is rotated at an angular velocity such that the tangential velocity thereof is substantially equal to the tangential velocity of drum 10.

When magnet 60 has a helical pole pattern 74 formed thereon, the magnetic particles will advance in a lateral direction substantially parallel to the longitudinal axis of tubular member 62 as well as circumferentially. Thus, the unused magnetic particles will progress toward one end of tubular member 62. In order to prevent these particles from cascading over photoconductive surface 12, they must be collected and returned to hopper 52 for subsequent re-use. To achieve the foregoing, a housing (not shown) is located at one end of tubular member 62 for receiving the unused particles. A particle transport (not shown), e.g. a helical auger or bead chain, returns the particles to hopper 52.

Referring now to Figure 4, another embodiment of development system 20 is depicted. Once again, hopper 52 houses a supply of magnetic particles 54 which descend through aperture 56 onto tubular member 54. An elongated cylindrical magnet 76 is disposed interiorly of tubular member 74. Tubular member 74 remains substantially stationary while magnetic member 76 rotates in the direction of arrow 78. An arcuate fabric member 80 is secured to tubular member 74. Preferably, fabric member 80 is cemented to tubular member 74 in development zone 82. The position of fabric member 80 is optimized with reference to development zone 82. A multiplicity of tufts 84 extend in an outwardly direction from fabric 80. Each tuft is woven through fabric 80 and comprises a multiplicity of fibres. Each tuft 84 is in contact with photoconductive surface 12

of drum 10 in development zone 82. A voltage source electrically biases fabric 80 to a suitable magnitude and polarity to facilitate development. Magnet 76 rotates in the direction of arrow 78 while tubular member 74 remains stationary. As magnetic member 76 rotates, particles 54 advance around tubular member 74 into development zone 82. Once particles 54 enter the development zone, they move around and over tufts 84 and are deposited on the latent image recorded on photoconductive surface 12 of drum 10. The free end of each tuft fibre moves as magnet 76 rotates in the direction of arrow 78. As magnet 76 rotates, magnetic dipoles are set up in each tuft fibre producing movement thereof. Once again, it is desirable to have both circumferential and lateral motion of the free end portions of the tuft fibres. The foregoing may be achieved by employing fibres having different magnetic properties or, alternatively, by imposing a helical pole pattern on magnet 76. If magnet 76 has a helical magnetic pole pattern, rotation thereof will produce both circumferential and lateral movement of the end of each tuft fibre. This will occur even if the magnetic properties of the fibres are substantially similar. Preferably, tubular member 74 is made from a non-magnetic material such as aluminum. Magnet 76 is preferably made from barium ferrite.

As previously indicated, the utilization of a magnet having a helical pole pattern formed thereon moves the particles both circumferentially and laterally. This results in the unused magnetic particles moving toward one end of tubular member 62 where they are collected in a housing (not shown). A particle transport (not shown) returns the unused particles to hopper 52 for subsequent re-use.

Referring now to Figure 5, there is shown tubular member 74 having fabric 80 secured thereto in development zone 82. Hence, fabric 80 extends over a small arcuate region, the length thereof being defined by development zone 82. Tufts 84 are of sufficient length to have the free end portions thereof contacting photoconductive surface 12. As drive motor 75 rotates magnet 76, particles 54 move around tubular member

74 and into development zone 82. In development zone 82, particles 54 contact the moving tuft fibres. Motor 75 is preferably a constant speed motor. This ensures that the particle image deposited on photoconductive surface 12 of drum 10 is substantially uniform.

Referring now to Figure 6, there is shown one manner in which tufts 66 may be secured to fabric 64. One skilled in the art will appreciate that the foregoing technique may be employed for the embodiment shown in Figures 2 and 3 as well as for the embodiment depicted in Figures 4 and 5. Each tuft 66 includes a multiplicity of stainless steel fibres 86. Each group of fibres 86 in tuft 66 pass through fabric 64 in a W-shaped configuration. The tufts 66 are spaced uniformly apart by distance $\underline{d}$.

An alternate method of weaving tuft 66 in fabric 64 is shown in Figure 7. As depicted thereat, each fibre 86 of each tuft 66 passes through fabric 64 in a U-shaped configuration. Once again, the inter-tuft distance $\underline{d}$ is maintained.

By way of example, the fabric is preferably made from cotton having a conductive coating of black latex heavily loaded with carbon thereon. Preferably, each tuft has from about 500 to about 1500 fibres therein. Each fibre ranges from about 0.005 to about 0.015 mm in thickness. It has been found that the density of tufts is important, and that too great a density prevents independent movement of each fibre and results in particle blockages, causing image streaking. Thus, it is preferred that there be from about 8 to about 16 tufts per square cm of fabric. The distance $\underline{d}$ between each adjacent tuft preferably ranges from 2.0 to 2.5 mm. It is desirable that the tufts be of sufficient length to form a fairly soft brush. However, it has been found that the length is but one parameter in defining the softness of the brush, another parameter being the manner of weave. Hence, a W-shaped weave, as shown in Figure 6, has been found to be stiffer than a U-shaped weave, as depicted in Figure 7.

Claims:

1. Apparatus (20) for developing a latent electrostatic image with magnetic particles (54), characterized by a member (62) having a multiplicity of magnetic fibres (86) extending outwardly therefrom with the free ends of at least a portion of said fibres (86) being intended to contact the surface bearing the latent image; means (60) for generating a magnetic field to attract the particles (54) to said member (62), and means (68, 75) for producing relative movement between said member (62) and the magnetic field to move the particles (54) attracted to said member (62) into contact with the latent image, and to move the free end region of each of said fibres (86) so that the particles (54) being deposited on the latent image form a substantially uniform particle image.
2. An apparatus (20) as recited in Claim 1, wherein said member (62) includes an elongated tubular member.
3. An apparatus (20) as recited in Claim 2, wherein said generating means includes an elongated magnetic member (60) disposed interiorly of said tubular member (62).
4. An apparatus (20) as recited in Claims 2 or 3, wherein said fibres (86) are grouped together to form a multiplicity of spaced tufts (66) with each of said tufts (66) having a multiplicity of fibres (86).
5. An apparatus (20) as recited in Claim 4, wherein the spacing between adjacent tufts (66) is substantially equal.
6. An apparatus (20) as recited in Claim 5, further including a fabric (64) secured to said tubular member (62) and having said tufts (66) woven therethrough.
7. An apparatus (20) as recited in Claim 6, wherein said fabric

(64) includes a conductive coating.

8. An apparatus (20) as recited in Claim 4, wherein said tufts (66) are disposed on the circumferential portion of said tubular member (62) positioned adjacent the latent image.

9. An apparatus (20) as recited in Claim 4, wherein said tufts (66) are disposed on the circumferential surface of said tubular member (62).

10. An apparatus (20) as recited in Claim 4, wherein said fibres (86) are made preferably from a magnetic stainless steel.

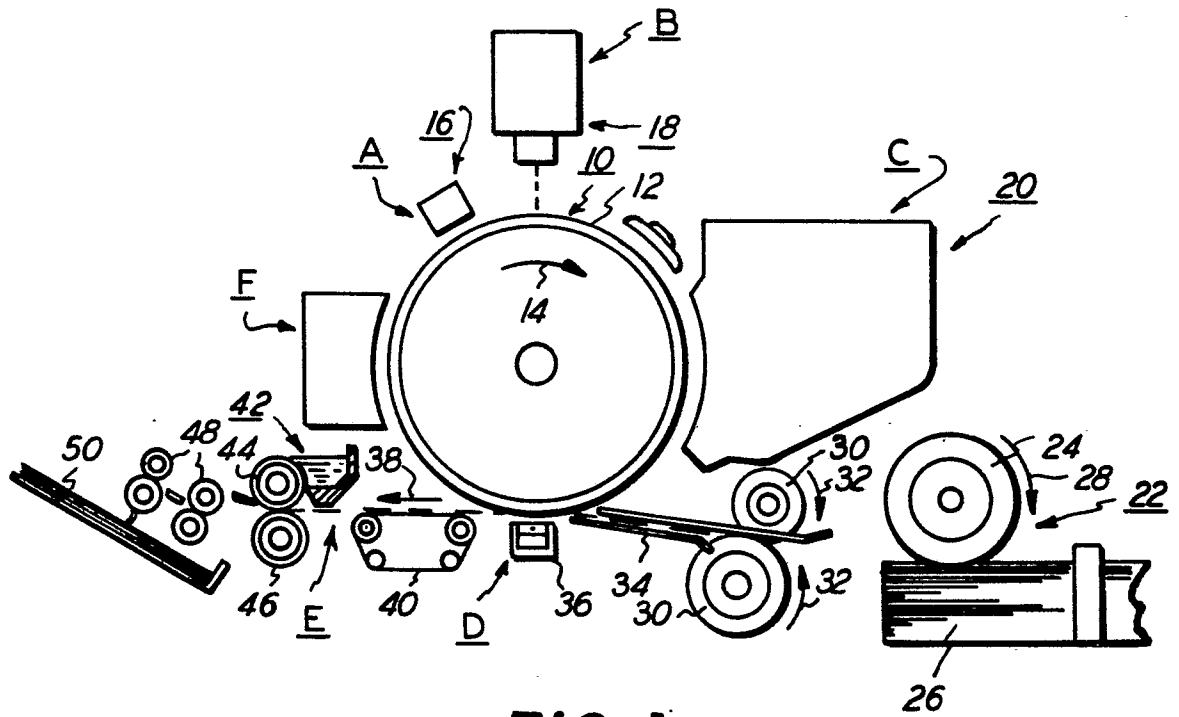


FIG. 1

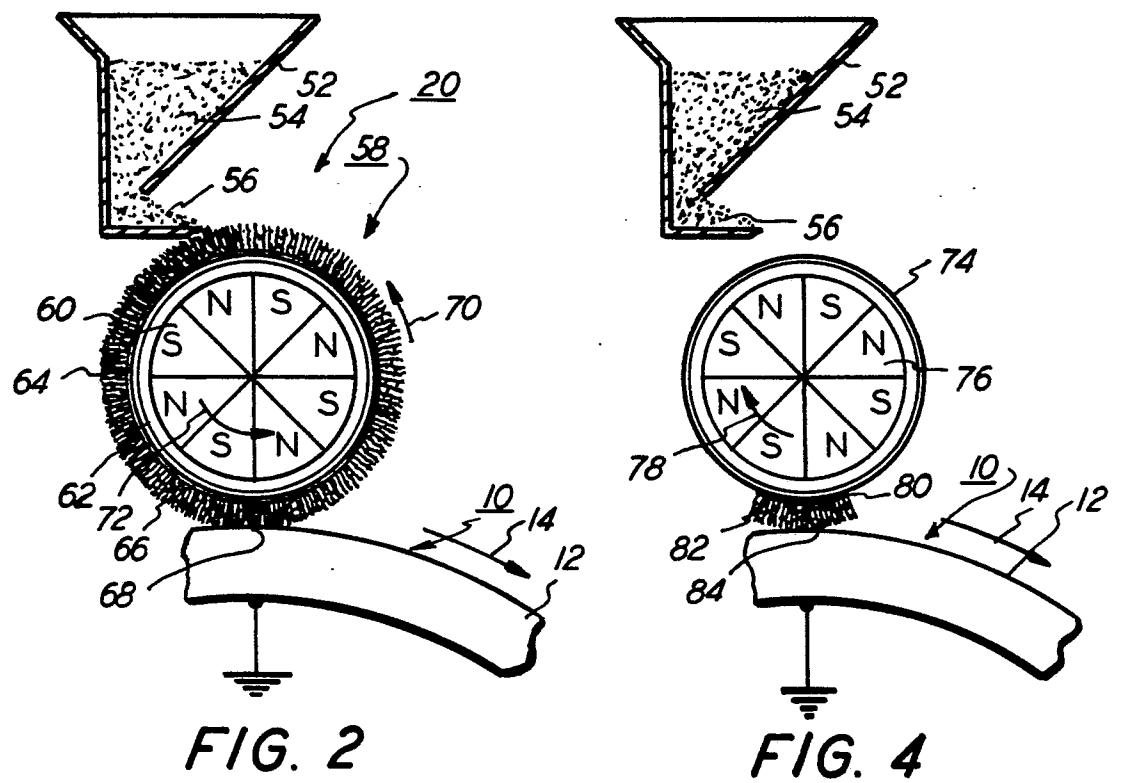


FIG. 2

FIG. 4

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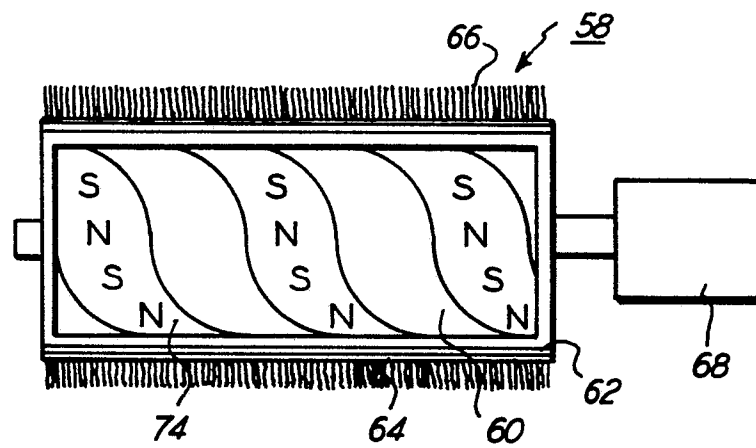


FIG. 3

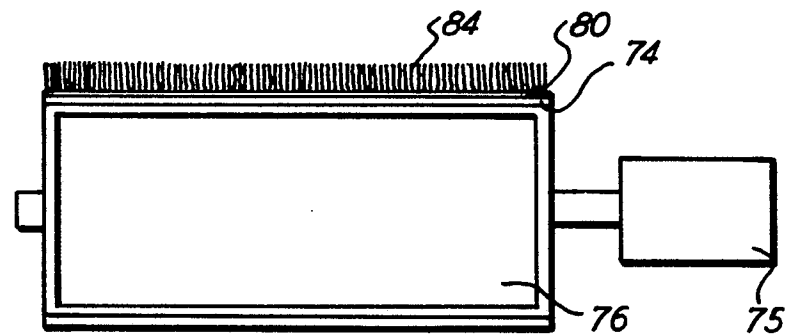


FIG. 5

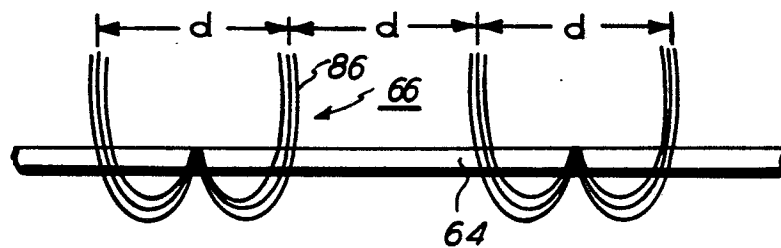


FIG. 6

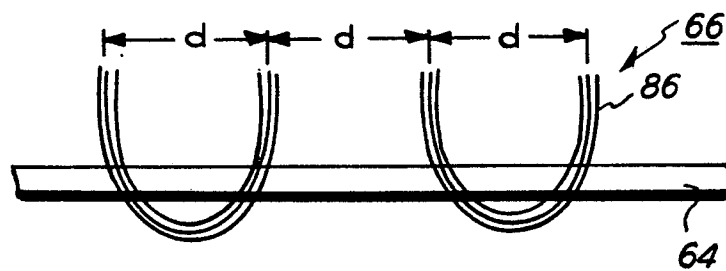


FIG. 7



European Patent
Office

EUROPEAN SEARCH REPORT

0018078
Application number

EP 80 30 0765.7

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.3)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
	<u>US - A - 3 246 629</u> (L.E. SHELFFO et al.) * claims; fig. 1 to 4 *	1	G 03 G 15/09

	<u>DE - B2 - 1 943 392</u> (RANK XEROX) * claims 1, 2; fig. 1 *	1	

	<u>GB - A - 871 041</u> (MASON & SONS) * claims; fig. 1 to 3 *	1	

D	IBM TECHNICAL DISCLOSURE BULLETIN, Vol. 8, No. 12, May 1966 New York R.G. CROSS "Magnetic Brush Developer" pages 1730 to 1732 * whole document *	1	TECHNICAL FIELDS SEARCHED (Int. Cl.3) G 03 G 15/00 G 03 G 21/00
D	<u>JP - A - 53 67438</u> * fig. 1, 2 *		

D	<u>US - A - 3 614 221</u> (TH. W. SOLAREK) * claims 1, 6; fig. 1 to 4 *		CATEGORY OF CITED DOCUMENTS
	---		X: particularly relevant A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: conflicting application D: document cited in the application L: citation for other reasons
D	<u>US - A - 3 664 857</u> (H.A. MILLER) * fig. 1 *		&: member of the same patent family, corresponding document

X	The present search report has been drawn up for all claims		
Place of search Berlin		Date of completion of the search 07-08-1980	Examiner HOPPE