

[54] **MAGNETIC BRUSH FOR USE IN
DEVELOPING ELECTROPHOTOGRAPHIC
IMAGES**

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[22] Filed: **Dec. 20, 1973**

[21] Appl. No.: **426,578**

[30] **Foreign Application Priority Data**

Dec. 28, 1972 Switzerland..... 18946/72

[52] **U.S. Cl.**..... **118/637; 117/17.5**

[51] **Int. Cl.**..... **G03g 13/06**

[58] **Field of Search** **118/623, 637; 117/17.5**

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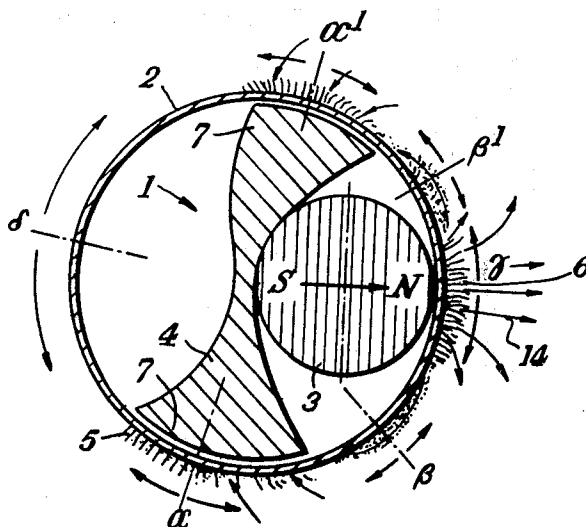
Primary Examiner—Ronald Feldbaum

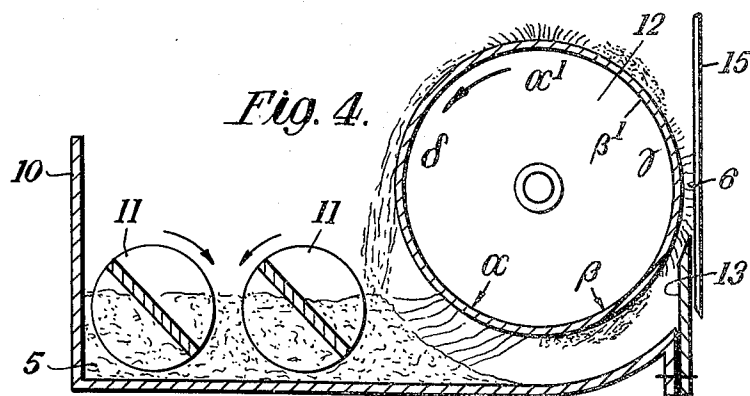
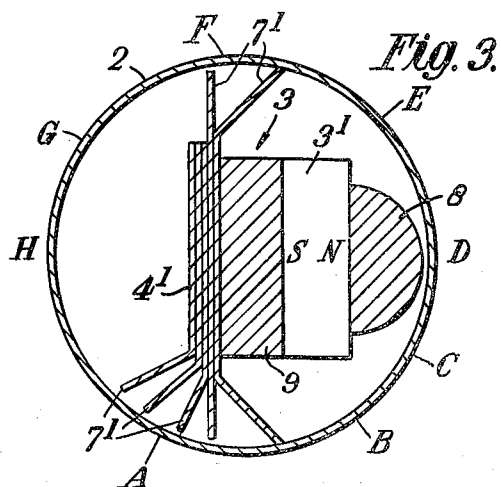
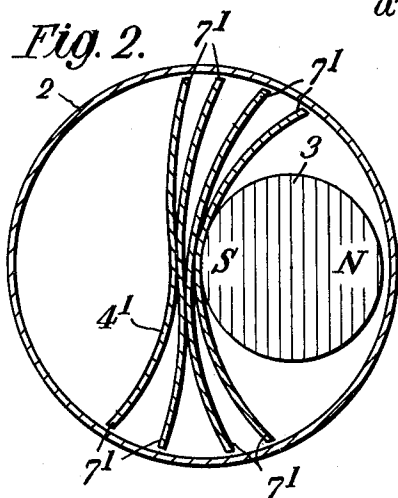
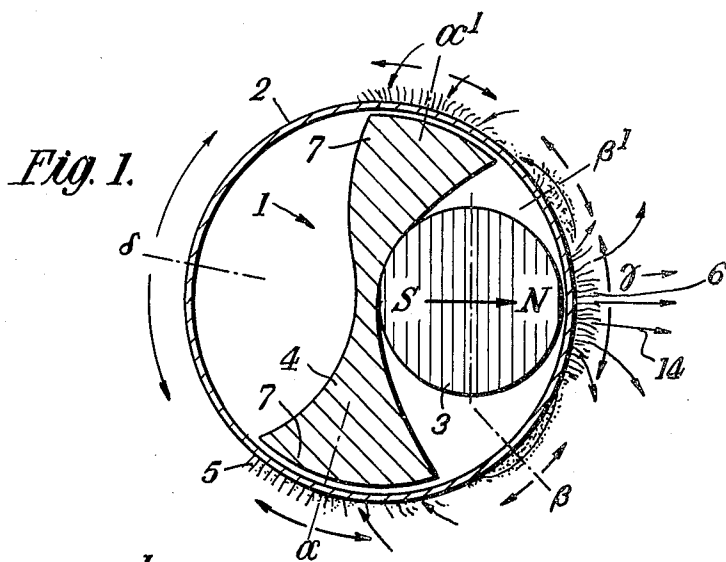
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[57] **ABSTRACT**

A magnetic brush for use in applying to a latent electrophotographic image on a carrier sheet a developer powder constituted by a mixture of particles of magnetizable material and a powdered toner and comprising a rotatable hollow cylinder of non-magnetic material and a stationary permanent magnet disposed within the cylinder, in which the cylinder also contains a screen of magnetizable material, the magnet and the screen being so disposed in relation to the cylinder as to produce at the surface thereof successive magnetic field zones of medium intensity sufficient to take up developer powder, of higher intensity for causing filaments to project radially from the cylinder for application of toner powder to the image and of intensity low enough to shed developer powder from the cylinder.

6 Claims, 4 Drawing Figures





MAGNETIC BRUSH FOR USE IN DEVELOPING ELECTROPHOTOGRAPHIC IMAGES

It is known in electrophotography to develop a latent electrophotographic image on a carrier sheet by application to the image, by means of a so-called magnetic brush, of a developer powder consisting of a mixture of particles of iron or other magnetisable material and a powdered toner. The developer powder is disposed in a container, in which it is subjected to agitation to cause the particles of toner to adhere to the iron particles due to the triboelectric effect. The magnetic brush is constituted by a rotating hollow cylinder containing an internal magnetic excitation system and the cylinder operates to transfer toner from the container to the image. It is termed a magnetic brush because the particles of magnetisable material project as filaments from the surface of the cylinder, like the bristles of a brush, to assist in transfer of the toner to the image. As the cylinder continues to revolve it returns to the container developer powder which is depleted in toner.

In one of the simplest and most effective of the magnetic brushes hitherto available the cylinder is of non-magnetic material and the magnetic excitation system consists of a stationary bar magnet which is axially magnetised and so disposed in the rotating cylinder as to produce at its surface two diametrically opposed zones of maximum magnetic field intensity, one of which is used to pick up the developer powder from the container and the other to apply it to the image to be developed. While such a magnetic brush is of simple construction it has the disadvantage that a large amount of developer powder is picked up by the cylinder, a laveller must be provided to produce projecting magnetized filaments of equal length and a wiper is required to scrape used developer powder from the cylinder and return it to the container. The wiper tends to crush the particles of toner, thereby adversely modifying its effectiveness in developing the image and tending to smear toner on to the surface of the cylinder.

It is the object of the invention to provide an improved magnetic brush, which is also of simple and inexpensive construction and which requires no wiper to remove used developer powder from its surface.

The invention accordingly provides a magnetic brush for use in applying to a latent electrophotographic image on a carrier sheet a developer powder constituted by a mixture of particles of magnetizable material and a powdered toner and comprising a rotatable hollow cylinder of non-magnetic material and a stationary permanent magnet disposed within the cylinder, in which the cylinder also contains a screen of magnetizable material, the magnet and the screen being so disposed in relation to the cylinder as to produce at the surface thereof successive magnetic field zones of medium intensity sufficient to make up developer powder, of higher intensity for causing filaments to project radially from the cylinder for application of toner powder to the image and of intensity low enough to shed developer powder from the cylinder.

In use the magnetic brush according to the invention is disposed horizontally in a container containing agitated developer powder. As the brush rotates the external surface of the cylinder picks up developer powder at the zone of medium magnetic field intensity, transfers toner powder to image-bearing sheets, or to a web bearing successive latent electrophotographic images,

fed past the brush at the zone of high magnetic field intensity and sheds developer powder, as the result of gravity and centrifugal force, at the zone of low magnetic field intensity which is disposed at the side of the screen remote from the magnet.

The positions of the zones of different magnetic field intensity with respect to the horizontal median plane of the cylinder and their extent depend on the positions of the image carriers to be developed and the reserve of developer powder in the particular developing apparatus and can be adjusted by change of position of the magnet and the screen to suit the particular conditions in such a way that, for taking up developer powder the zone of medium field intensity is directed towards the reserve of developer powder and the zone of highest field intensity, which causes the formation of brush filaments, faces the images to be developed, while the zone of lowest field intensity extends from the top of the cylinder to the area where the powder is taken up, so that the developer powder can fall off the cylinder surface and back into the container and in the remaining zones the field intensity is sufficient for transportation of the developer powder from the reception area to the top of the cylinder.

Preferably the magnet extends axially of the cylinder and is offset with respect to the axis of the cylinder, the axis of magnetization of the magnet extends radially with respect to the cylinder, one pole of the magnet is in close proximity to the inner wall of the cylinder to define the zone of high field intensity and the screen extends transversely to the magnet and is disposed adjacent its other pole. The pole of the magnet adjacent the wall of the cylinder then determines the zone of greatest field activity. The screen is preferably fixed to the magnet in tight contact with the pole remote from the wall of the cylinder and may have fanlike ends, extending nearly to the wall of the cylinder, which produces the zone of sufficient field intensity for picking up the developer powder. Between the ends of the screen and the pole of the magnet adjoining the wall of the cylinder are zones of sufficient field intensity for holding the developer. The zone of low field intensity, insufficient for holding the developer powder, is situated at the side of the screen remote from the magnet, the screen having a thickness sufficient to provide the necessary weakening of the magnetic field.

Certain embodiments of the invention are illustrated, by way of example, in the accompanying diagrammatic drawings, in which:

FIGS. 1, 2 and 3 are cross sectional views of three alternative constructions of magnetic brush and

FIG. 4 is a sectional view of a developing apparatus embodying a magnetic brush as shown in any of the preceding Figures.

The magnetic brush shown in FIG. 1 consists of a rotatable hollow cylinder 2, which contains a stationary magnetic excitation system 1 constituted by a permanent magnet 3 and a magnetic screen 4. The magnet 3 is a cylindrical bar magnet which extends axially in the cylinder and is offset from the axis of the cylinder. Its axis of magnetization is diametrical and extends radially with respect to the cylinder 2, one pole, for example the N pole, being closely adjacent to the inner wall of the cylinder, while being out of contact with it. The screen 4 is of magnetizable material and is disposed adjacent the other, or S pole, of the magnet 3 and has outwardly fanned or thickened ends 7 positioned near the

inner wall of the cylinder 2. It is preferably fixed to the magnet 3.

The magnet 3, the screen 4 and the cylinder 2 are all of the same or substantially the same length and the diameter of the magnet 3 is preferably not less than the radius of the cylinder 2. The cylinder is of non-magnetic material, e.g. brass. The screen 4 serves to guide magnetic lines of force to certain zones of the cylinder and to screen a further zone. It is therefore made of material of high magnetic permeability, e.g. Mumetal.

In the zone γ of the cylinder 2 near the N pole of the magnet 3 the intensity of the magnetic field is a maximum and the lines of magnetic force 14 extend radially with respect to the surface of the cylinder. In the zones α and α' opposite the ends 7 of the screen 4 the magnetic lines of force tend to fan out from the surface of the cylinder 2 and the intensity of the magnetic field is lower than in the zone γ . In the zones β and β' between the zone γ and the zones α and α' the magnetic lines of force extend almost parallel to the surface of the cylinder and the intensity of the magnetic field is at a value intermediate between that in the zone γ and in the zone α or α' , and the zone δ behind the screen 4 the intensity of the magnetic field is only a small fraction of that in the zone γ . Since the presence of the screen 4 shortens the path through air of the lines of force between the N and S poles of the magnet 3 the intensity of the magnetic field in the range defined by the zones β' , γ , β is greater than it would be in the absence of the screen.

In use for development of latent electrophotographic images the magnetic brush 12 is placed, as shown in FIG. 4, with the axis of the cylinder 2 horizontal in a developing apparatus, including a container 10 for developer powder 5 which is agitated by contra-rotating stirrers 11. The cylinder 2 is rotated counterclockwise as indicated by the arrow by any conventional means not shown. At the zone α it picks up developer powder. In the zone β the powder picked up lies more or less flat on the surface of the cylinder. After passage past a scraper 13, which controls the thickness of the layer of powder picked up by the cylinder, the powder reaches the zone γ at which the intense magnetic field causes the iron particles in the developer powder to project as filaments or bristles 6 from the surface of the cylinder. In this zone a sheet 15 carrying an image to be developed is traversed past the bristles 6 which apply the toner powder to it. At zone δ the developer powder is shed from the cylinder 2 and falls back into the container 5.

In the embodiment shown in FIG. 2, the screen 4' consists of laminations of soft iron having outwardly fanned ends 7' and attached to the magnet 3 in the region of its S pole, for example by epoxy resin or other adhesive or by a clamp disposed behind the screen and attached to the ends of the magnet. Trunnions can be attached to the ends of the clamp to permit of mounting of the magnetic brush for rotation in roller bearings. The screen 7 in FIG. 1 can be attached to the magnet 3 in similar fashion.

In the embodiment shown in FIG. 3, the permanent magnet consists of a bar magnet 3' of rectangular cross-section and soft iron pole pieces 8 and 9 fixed to its poles S, N. The pole piece 8 is of a semi-circular cross-section and is disposed with its curved portion facing the inner wall of the cylinder 2. The other pole piece 9 is of rectangular cross-section and carries a screen 4'

constituted by a stack of soft iron laminations having outwardly fanned ends 7'. The following field intensities were measured with a magnetic brush of this construction including a cylinder 2 of 58 mm outside diameter made of brass sheet having a thickness of 1.5 mm, a bar magnet 3' of "Ferroxdur FXD 33" having a rectangular cross sectional area of 25 mm $\times$ 10 mm, an outer soft iron pole piece 8 of semicircular cross section of 10 mm radius, an inner soft iron pole piece 9 having a 25 mm $\times$ 10 mm cross sectional area and a shield 4' of five soft iron sheets each having a thickness of 0.5 mm:

Measuring Points	Field Intensity in gauss
A	250
B	400
C	600
D	810
E	355
F	320
G	80
H	70

With these or similar values of field intensity the magnetic brush fulfils all its necessary functions, namely picking up of toner, transport of toner, forming of brush filaments in the area of development and return of developer powder to the storage container for re-mixing.

In all of the embodiments slippage of the developer powder on the cylinder 2 can be minimised by providing the cylinder with a roughened or fluted external surface.

The positions of the magnet and the screen in the cylinder shown in FIGS. 1 and 3 are appropriate for a developing apparatus in which, as shown in FIG. 4, the sheet carrying the image to receive the toner powder is disposed vertically in a plane intersecting the horizontal plane through the axis of the cylinder 2. If development is required to take place at a higher or lower level, the excitation system 1 will be appropriately rotated with respect to the cylinder 2. It may be necessary to deform the screen 3 to ensure that the zones α and α' will be correctly positioned and in this case field intensification, should it be necessary, can be provided by including additional magnets in the cylinder. Singular points in the field distribution and consequent deposit of toner powder on undesired parts of the cylinder can be avoided by the provision of such auxiliary magnets. The field intensity can be increased in exceptional cases in the range α to cause the developer powder shed in the zone δ to be re-attracted at once so that a layer of developer powder is maintained on the whole surface of the cylinder.

The magnetic brushes described above consist of but few mechanical parts and permanent magnets of simple design and small size, the surfaces of which do not need to be specially treated. The brushes can therefore be manufactured cheaply and rapidly.

What we claim as our invention and desire to secure by Letters Patent is:

1. A magnetic brush for use in applying to a latent electrophotographic image on a carrier sheet a developer powder composed of a mixture of particles of magnetizable material and a powdered toner, comprising a rotatable hollow cylinder of non-magnetic material and a stationary magnetic excitation system dis-

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posed within the cylinder and producing at the surface of the cylinder successive magnetic field zones of medium intensity sufficient to take up the developer powder zones, of higher intensity for causing filaments to project radially from the cylinder for application of toner powder to the image and zones of intensity low enough to shed the developer powder from the cylinder, the magnetic excitation system comprising a permanent magnet extending axially of the cylinder in a position offset from the axis of the cylinder with its axis of magnetization extending radially with respect to the cylinder and one pole in close proximity to the inner wall of the cylinder, and a screen of magnetizable material also extending axially of the cylinder and disposed adjacent the other pole of the magnet.

2. A magnetic brush according to claim 1, in which the screen has fan shaped ends extending to the vicinity of the inner walls of the cylinder.

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3. A magnetic brush according to claim 2, in which the screen consists of laminations attached to the magnet.

4. A magnetic brush as claimed in claim 1, in which the magnet is a cylindrical bar magnet and has a diameter not less than the radius of the cylinder.

5. A magnetic brush as claimed in claim 1, in which the magnet is a rectangular bar magnet and has a curved pole piece facing the inner wall of the cylinder.

6. Apparatus for developing latent electrophotographic images, comprising a container for developer powder, means for agitating the developer powder, and a magnetic brush as claimed in claim 1 rotatably mounted in the container with its axis horizontal and in position to pick up developer powder from the container and transfer it to the images.

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