United States Patent

Reynolds et al.

[15] **3,669,072**

[45] **June 13, 1972**

[54] DEVELOPER APPARATUS

[72] Inventors: **Robert W. Reynolds**, Los Angeles; **James K. Bibeau**, Monterey Park; **Francis J. Jansen**, Northridge, all of Calif.

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

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[21] Appl. No.: **10,539**

[52] **U.S. Cl.** **118/637**

[51] **Int. Cl.** **B05b 5/02**

[58] **Field of Search** 117/17.5, 98; 96/1.5; 252/62.1; 118/637

[56] **References Cited**

UNITED STATES PATENTS

3,301,152	1/1967	Mayo	118/637
2,854,947	10/1958	Giamo	117/17.5
3,176,652	4/1965	Mott et al.	118/637
3,196,831	7/1965	Sugarmann	118/637
3,278,439	10/1966	Blanchette et al.	117/17.5

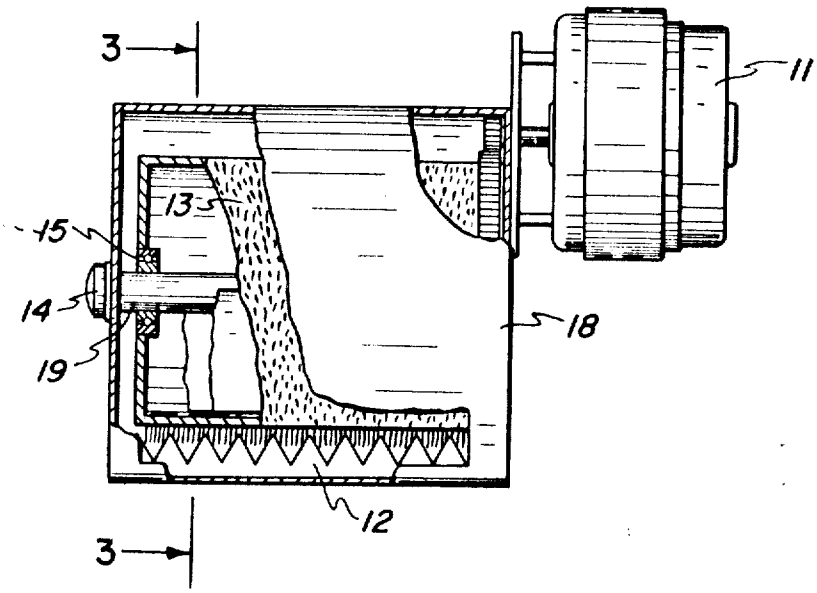
Primary Examiner—Henry S. Jaudon

Attorney—James J. Ralabate, Laurence A. Wright and John E. Beck

[57] **ABSTRACT**

An apparatus for developing electrostatic images wherein a drum or belt encircling a magnetic member has developer particles magnetically attracted to its surface in a serrated surface pattern by means of a brush shaper. A motor rotates the drum or belt carrying the shaped developer particles and deposits them on the charged surface for development. The motor in a reverse rotation phase mixes the developer particles in its container, preventing particle agglomeration.

8 Claims, 6 Drawing Figures



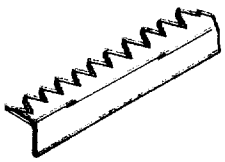


FIG. 2a

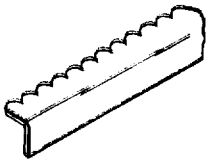


FIG. 2b

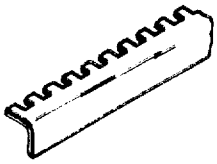


FIG. 2c

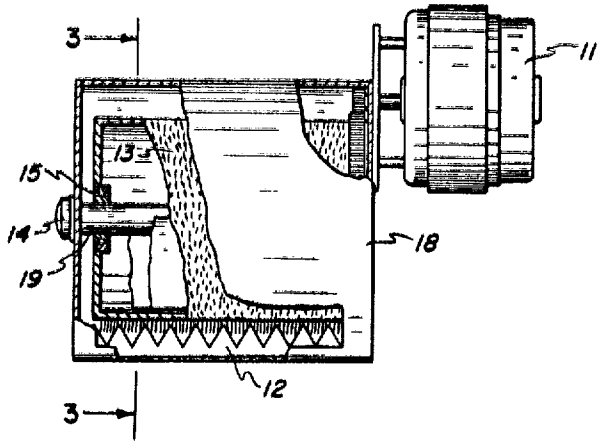


FIG. 1

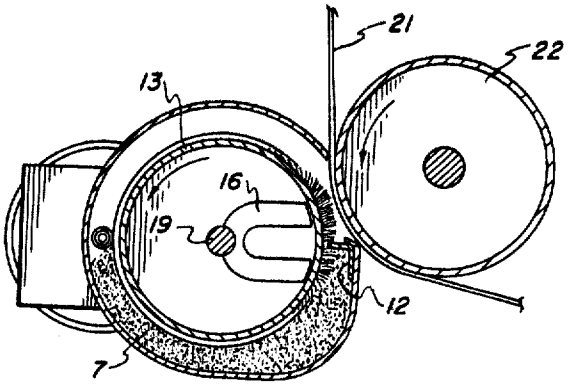


FIG. 3

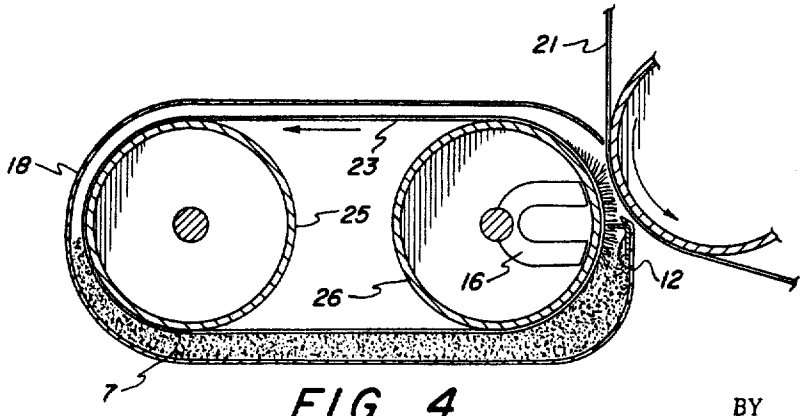


FIG. 4

INVENTORS
ROBERT W. REYNOLDS
JAMES K. BIBEAU
FRANCIS J. JANSEN
BY
Laurence A. Wright
ATTORNEY

DEVELOPER APPARATUS

This invention relates to an improved apparatus for developing electrostatic latent images by means of a magnetic brush.

BACKGROUND OF THE INVENTION

Conventionally, in the electrophotographic process a uniform electrostatic charge is placed upon a photoconductive insulating surface by a charging mechanism. Subsequently, parts of the surface are discharged as by exposure to light. In order to form a visible rendering of the resulting electrostatic image it is necessary to deposit an electroscopic developer material or toner to the charged surface. Assuming that the charged surface has a positive charge, a toner is selected such that it will be charged negatively. Negative charging of the toner may be achieved by mixing it with carrier particles made from any material having a higher position in the triboelectric series than the toner. Since the carrier will have the same charge as the latent electrostatic image it will be repelled when brought into contact therewith. However, when the negatively charged toner is deposited on the image surface having a positive polarity, the charge on the image exerts a force of attraction on the toner and retains the toner in the positively charged areas. By this means the image is made visible.

In developing the latent image the objective sought is a reproduction of the original that has sharp contrast and that is free of background smudging. The development of the electrostatic latent image can be achieved by employing various techniques. One technique is to cascade a toner-carrier mixture onto the surface carrying the electrostatic image and to transfer the developed toner image to a recording sheet or web while in contact with the image carrying surface and thereafter fixing the image by application of heat to the recording means. For an example of cascade development see U.S. Pat. No. to Carlson, 2,900,278.

Another developing technique conforms in many respects to that just described except that a powder cloud of developer particles is dispersed over the charged surface. The powder cloud developing technique is discussed further in U.S. Pat. No. 3,239,465.

A third technique of image development is to deposit toner thereon by means of a fibrous member or fur brush impregnated with toner, set forth in U.S. Pat. No. 3,251,706. In this system, the fibers act as the triboelectric charging source for the toner.

Still another technique of electrostatic image development is to deposit developer onto the image bearing surface by means of a magnetic brush set forth in U.S. Pat. No. 2,791,949. The magnetic brush is composed of a mass of very small iron filings which form "fibers" under the influence of a magnetic field. When the toner is mixed with a magnetic powder it is charged triboelectrically and upon being picked up by a magnet a brush is formed with charged toner particles adhering in a random manner to the iron fibers. The brush is then brought into contact with the latent image in order to develop it. It should be noted that a one component magnetizable toner can also be used in a magnetic brush developing system. The invention disclosed herein may be practiced with a single component magnetizable toner.

All the above approaches to the development of electrostatic images have application in practical devices. However, each of these methods have advantages and disadvantages which make one more acceptable over the other in a given apparatus. For example, the technique of cascade developing may be undesirable because it depends on gravity flow, is expensive to construct and is bulky. Similar objections can be ascribed to the method of powder cloud development. There, the powder cloud is usually created by dispersing the toner particles under air pressure through a nozzle onto the image surface. The mechanism necessary to create the powder cloud is also generally expensive and bulky. Fur brush development

processes have the disadvantage that the amount of toner applied to the brush is not easily controlled. Where unequal amounts of toner are deposited on the fur brush developed images may have light and dark areas as well as undesirable background smudges.

Some prior art magnetic brush developer devices were formed on polar members producing magnetic brush-like tufts directly on these members. The disadvantages of this construction are that the brush eventually includes a greater portion of magnetizable particles than toner powder and that the surface area of the brush is non-uniform. Another disadvantage of prior art magnetic brushes is that the iron filings of the straight fiber brush become compacted and when applied to the recording medium or charged surface actually become embedded therein. This results in poor quality development of the electrostatic image and excessive background. The magnetic brush taught by the present invention provides a uniform brush surface area, low mechanical pressure on the recording medium and a means of controlling the mixture of toner and carrier particles.

It is an object of the present invention to provide apparatus for the deposition of developer onto a charged surface by means of a magnetic brush which is shaped to expose a larger brush area from a given brush length.

It is also an object of the invention to provide a brush shaper for a magnetic brush which provides a softer brush for applying developer material to a charged surface.

It is another object of the invention to provide a reversible magnetic brush motor which mixes the toner and carrier particles in order to prevent agglomeration of the developer material.

Yet another object of the invention is to provide a plurality of low cost magnetic members for utilization as a magnetic brush developer.

BRIEF DESCRIPTION OF THE INVENTION

The present invention provides an improved and comparatively inexpensive magnetic brush developer system. Specifically, the developer apparatus of the present invention comprises a drum or belt mounted rotatably in a housing which contains developer material consisting of a carrier such as iron filings and a toner such as a resin type material. Fixedly mounted and encircled by the drum or belt is a magnetic member. Alternately, a plurality of spaced magnetic members may be encircled by the drum or belt where the magnetic brush is required to develop a wide surface area. A brush shaper having a serrated edge configuration is also mounted on the housing and its edge is positioned perpendicularly to the periphery of the drum or belt and parallel to the drum or belt shaft. The brush shaper of the invention forms a serrated magnetic brush pattern on the drum or belt and provides a larger brush area for a given brush length, a uniform deposition of developer particles and no scrubbing action to the charged surface. The motor which drives the drum has a reverse phase of operation whereby the developer material in the container or reservoir is mixed, preventing particle agglomeration and stimulating triboelectric charging of the toner particles.

The nature of the present invention having been set forth, there will now be presented a more detailed description in illustration but not limitation of the invention in the following specification and drawings in which:

FIG. 1 is a plan view of the reversible motor, drum and brush shaper;

FIGS. 2*a*, 2*b* and 2*c* are isometric views of several brush shaper means;

FIG. 3 is a simplified side elevation view of FIG. 1 taken along the line 3—3; and

FIG. 4 is a side elevation view similar to FIG. 3 showing a belt encircling the magnetic member.

The same reference numerals represent the same elements in all of the figures.

The present invention is particularly intended and adapted for the development of an electrostatic latent image. The latent image may be of relatively fine detail and composed of relatively charged and uncharged areas on an insulating surface. The development technique taught by the present invention may be employed to apply toner to an electrostatic latent image or either a photoconductive insulating surface or to an insulating paper. The toner may then be fixed by heat fusing an imagewise configuration on the charged surface or transferred to a support sheet and then fused.

Turning now to FIG. **1**, there is shown in a plan view a reversible motor **11** which is suitably mounted for support on main housing **18**. Motor **11** may be any conventional electrical motor wired to have reverse rotation. Drum **13** which may be made of magnetizable or non-magnetizable material is connected to motor **11** by a shaft **19**. The drum **13** is secured for rotation about shaft **19** in main housing **18** by shaft locking screw **14** and sealed bearing **15**. A brush shaper **12** is also mounted on the main housing and is positioned parallel to drum shaft **19**. The length of brush shaper **12** is approximately coextensive with the length of the drum. Brush shaper **12** shown isometrically in FIG. **2a** may be made of a sturdy metal such as steel or a hard plastic material and has a serrated or sawtooth configuration. This configuration provides a magnetic brush with more surface area to pass over the latent electrostatic image and also reduces the scrubbing action of the formed brush against the image bearing surface. It is noted that prior art magnetic brushes were so stiffly formed that in many cases the iron filings were actually embedded into the recording medium. This invention reduces by the shaper means the amount of "fibers" which form the brush and thus the scrubbing action as well as the possibility of embedding iron filings into the recording medium. Although brush shaper **12** is shown as formed into a sawtooth configuration, the brush shaper may be formed into other shapes. For example, the brush shaper may take the form of a series of joined semi-circles as shown in FIG. **2***b* or of a form of a series of square teeth as shown in FIG. **2***c*. All of these variations would be analagous to the sawtooth configuration and would likewise furnish more surface area, a softer brush action and reduced mechanical pressure.

Referring to FIG. **3**, there is shown a side elevation view of FIG. **1** taken along the line **3**—**3**. It should be noted the drawing of FIG. **3** has been simplified in that the side bearing has been eliminated for purposes of clarity. The shape of main housing **18** may conform generally to the shape of drum **13** and may have an opening to allow the replenishment of developer **7** and entry of photoconductive insulating paper **21** driven by roller **22**. Developer **7** which is maintained at a level in the housing **18** to be influenced by the magnetic member comprises a mixture of toner and carrier particles. The toner may comprise Vinsol resin (an extract from long leaf yellow pine stumps composed principally of an oxidized form of abietic acid and manufactured by Hercules Powder Company, Wilmington, Delaware) dyed with an azo oil black; polystyrene resin and carbon black dye; or Vinsol resin and nigrosine. The carrier may comprise particles such as alcoholized iron (i.e. iron particles free from grease and other impurities soluble in alcohol), ferromagnetic magnetite or ferromagnetic ferrites: $MeFe_2O_4$. The toner and iron particles are preferably of small dimensions with toner particles size of 5 to 20 microns and iron particles in the range 0.001 to 0.020 inch. The toner particles may constitute 2 percent of the developer mix. However, it is understood that the particle size and the mixture given is only intended to be illustrative and not a limitation in the practice of the invention. It will occur to those skilled in the art that the developer mixture utilized in a given developer system will depend on the results desired.

In the instant case the charged surface is assumed to have a positive sign. The toner and carrier particles are selected in accordance with their triboelectric properties so that when mixed the carrier particles are positively charged and the toner particles are negatively charged. Where the charged surface has a negative sign a developer would be selected having charges on the carrier and toner particles reversed from the above.

Fixedly mounted on shaft **19** and completely encircled by the periphery of drum **13** is a horseshoe magnet **16**. Although only one magnet **16** is shown mounted upon shaft **19**, a plurality of spaced horseshoe magnets or other sources of an interrupted magnetic field may be mounted along the shaft **19** coextensive with the length of drum **13**. Horseshoe magnet **16** may also be made to rotate about the shaft **19** while the drum is held stationary. Brush shaper **12** is mounted upon the main housing and is positioned parallel to the shaft of drum **13** with the serrated shaper edge perpendicular to the surface of drum **13**.

In lieu of a drum, an endless belt system movable about roller members **25** and **26** shown in FIG. **4** may be used to transfer developer to the electrostatically charged surface. In such a system the belt **23** may have a magnetizable layer and the magnetic member **16** may be placed at the point where the brush shaper **12** is in close proximity with the belt surface. Thus, the belt picks up developer from the container and as it rotates past the brush shaper the developer particles on the belt are shaped and later deposited on the charged surface **21** at the development station.

The drum **13** of FIG. **3** and the belt **23** of FIG. **4** may be made of either magnetizable or non-magnetizable material. For example, drum **13** may be made of aluminum coated with plastic layer to prevent drum abrasion. Alternately, drum **13** may be made of a non-magnetic material such as copper. Similarly, belt **23** may be made of a non-magnetic material such as rubber or made magnetic by impregnating the rubber with magnetic material.

The development of the latent electrostatic image existing on the recording medium **21** is performed by the magnetic brush as described hereinafter. When the toner and carrier particles are mixed the particles become charged through triboelectric action. In the case at hand, carrier particles become positively charged and the toner particles become negatively charged. Also in the case at hand, we shall assume that the drum is made of a non-magnetic material such as copper. At the point during rotation of the belt or drum where the shaper is in close proximity therewith, the magnetic field will be perpendicular to the surface of the drum or belt. Lines of flux pass through the drum or belt and attract the magnetic developers to its surface. This developer is shaped into a serrated pattern by the shaper. Thus, a brush is formed having fibers generally in the form of a sawtooth. Also excess developer is removed from the drum or belt surface by the shaper preventing compaction of the iron filings. As the motor rotates the drum or belt, the brush is placed in contact with charged surface **21**. The tips of the brush are flattened providing full brush coverage and low mechanical pressure on the recording medium. The negatively charged toner particles are attracted to and adhere to the positively charged surface rendering the latent electrostatic image visible. Subsequently, the image may be fixed upon the recording medium by fusing with the application of heat.

Since the carrier particles of the invention are magnetizable they will form a brush-like appearance under the influence of the magnetic field generated by the horseshoe magnet. The toner particles adhere to the brush fibers through triboelectric action. The carrier particles which have a charge of the same sign as the charged surface is repelled thereby. Because the formed magnetic brush has a larger surface area for a given brush length all areas of the charged surface has toner equally applied to it. The formation of the developer material into a brush by the shaper of the invention permits light contact with the electrostatic image bearing surface, thereby making possible the controlled development of the image bearing surface. The developer particles which continue to adhere to the drum or belt as it rotates out of the influence of the magnetic field fall back into the container to be used again in the development process.

During periods of non-developing, the motor is reversed and the brush is rotated back into the container. This reduces background and developer spillage. It also prevents developer particle agglomeration by mixing the developer and helps to charge the developer particles triboelectrically.

From the foregoing, an improved magnetic brush developer system has been described.

We claim:

1. Apparatus for transferring electroscopic developer particles to a charged surface for the development of an electrostatic latent image thereon comprising:

a quantity of developer material of magnetizable carrier particles mixed with the electroscopic developer particles;

magnetic means for attracting said developer material;

means for enlarging the surface area of the developer material attracted to said magnetic means; and

means for depositing said developer particles onto said charged surface whereby the latent image thereon is rendered visible.

2. The apparatus of claim 1 including a drum adapted to rotate about said magnetic means.

3. The apparatus of claim 1 including a belt adapted to rotate about said magnetic means.

4. The apparatus of claim 1 in which said magnetic means comprises a plurality of spaced magnets.

5. The apparatus of claim 1 in which said magnetic means is fixedly mounted.

6. The apparatus of claim 1 in which said enlarging means includes shaping means having a serrated edge.

7. Apparatus for transferring electroscopic developer particles to a charged surface for the development of an electrostatic latent image thereon comprising:

a reservoir adapted to hold a quantity of developer material of magnetizable carrier particles mixed with the electroscopic developer particles;

a magnetic member positioned on a support means adjacent said developer material for attracting said developer material;

means encircling and adapted to rotate about said magnetic member,

means positioned adjacent the surface of said encircling means for controlling the amount of the developer material attracted by said magnetic member and serrating the surface area formed by said developer particles to enlarge the surface area thereof; and

means for driving said encircling means with respect to said magnetic member whereby said marking particles are deposited on said charged surface.

8. The apparatus of claim 7 including means for reversing the direction of rotation of said driving means for mixing said developer materials in said reservoir.

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