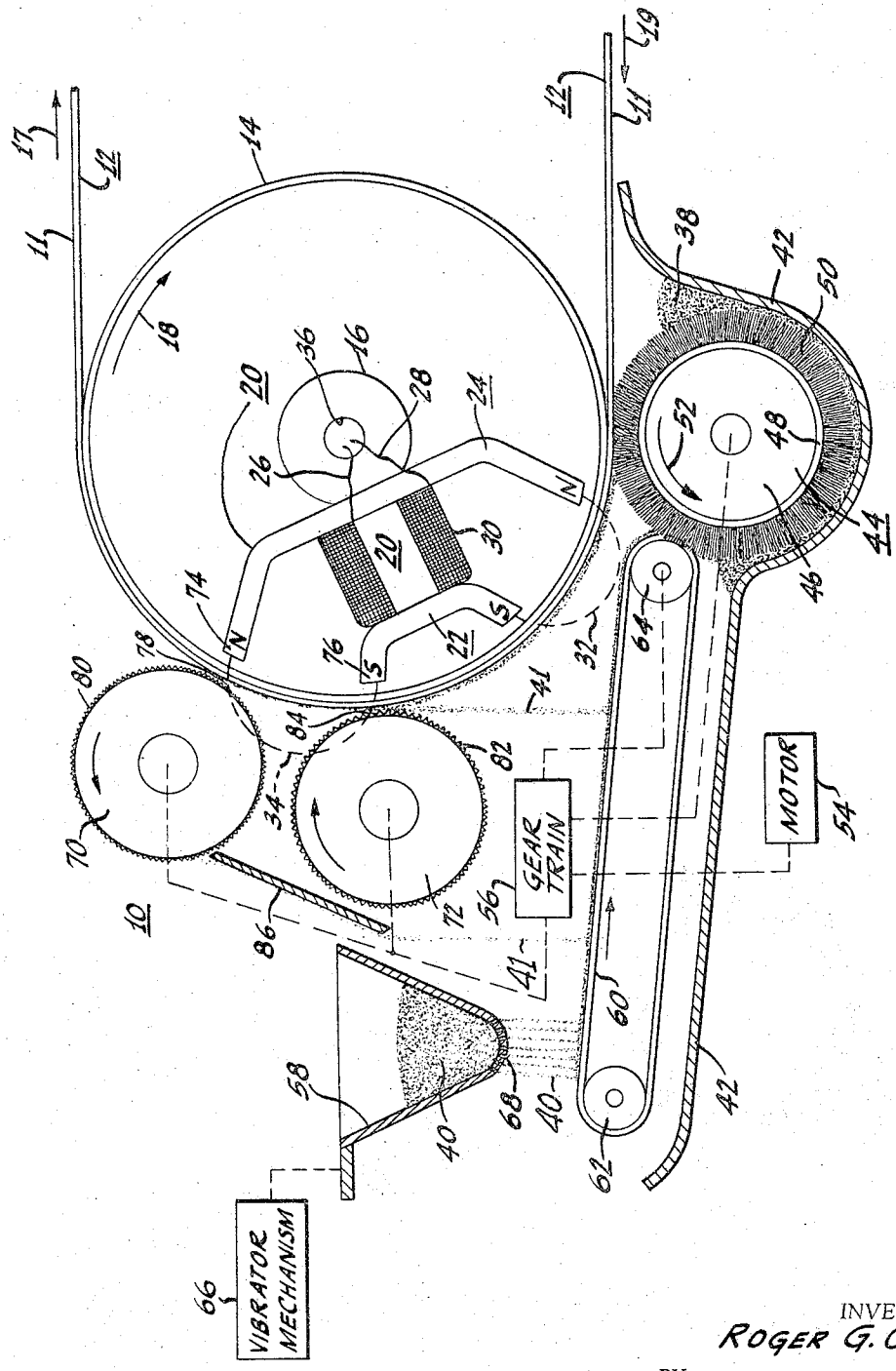
Aug. 1, 1967 R. G. OLDEN 3,333,572

ELECTROSTATIC PRINTING

Filed April 27, 1965



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United States Patent Office 3,333,572 Patented Aug. 1, 1967

3,333,572

ELECTROSTATIC PRINTING

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Filed Apr. 27, 1965, Ser. No. 451,266
6 Claims. (Cl. 118—637)

This invention relates generally to electrostatic printing, and more particularly to improved apparatus for developing an electrostatic latent image on an electrophotographic recording element. The improved apparatus is particularly useful for developing electrostatic latent images on a recording element in the form of a continuous web moving at a relatively high speed.

It has been proposed to develop electrostatic latent images on a recording element in the form of a web by drawing the web through an electroscopic developer mixture of magnetic particles and toner particles. At relatively low speeds (about 1 inch/sec.) of travel of the web, this method of development is satisfactory. At relatively higher speeds (about 24 inches/sec.) of the web, however, the time of development is decreased and there is a tendency for the magnetic particles to adhere to the developed recording element. This is especially true when the ambient humidity is low.

It has also been proposed to increase the speed of conventional, prior art, low-speed developing apparatus to develop recording elements moving at a relatively higher speed, but such apparatus is unsatisfactory at higher speeds because it usually provides excessive agitation and inadequate mixing of the developer mixture. Excessive agitation of some electroscopic developer mixtures causes their toner particles to acquire charges of both positive and negative polarities, instead of a charge of a single desired polarity. Also, excessive agitation of the developer mixture may provide an excessive amount of unwanted toner dust.

It is an object of the present invention to provide improved apparatus for developing an electrostatic latent image on a recording element moving at a relatively high speed.

Another object of the present invention is to provide improved apparatus for removing magnetic particles of an electrostatic developer mixture from a recording element moving at a relatively high speed.

A further object of the present invention is to provide improved apparatus of the type described that is relatively simple in structure, easy to operate, and capable of producing electrostatic prints of good quality.

Briefly stated, the improved apparatus for developing a latent image on the surface of an electrophotographic recording element comprises means for guiding the recording element along a predetermined path, a rotatable brush disposed to apply a developer mixture to the recording element during the latter's movement, magnetic means disposed to provide magnetic circuits for removing magnetic particles of the developer mixture from the recording element, and means including an endless belt to replenish the developer mixture with toner particles as the latter are used. The speed of movement of the recording element is greater than the peripheral speed of the brush to provide a wiping action between the recording element and the brush. This is particularly important at high web speeds because, if the brush were moving faster than the recording element, the centrifugal force acting on the magnetic and toner particles would cause them to fly off and thus make them useless for the purpose intended. The peripheral speed of the endless belt is less than that of the brush to provide a good wiping action between the belt and the brush.

The novel features of the present invention both as to its organization and operation, as well as additional objects and advantages thereof, will be more readily understood from the following description, when read in connection with the accompanying drawing, the single figure of which is a partly schematic, cross-sectional, side elevational view of developing apparatus according to one embodiment of the present invention.

Referring now to the drawing, there is shown developing apparatus **10** for developing an electrostatic latent image on the outer surface **11** of an electrostatic recording element **12**. The recording element **12** may comprise a photoconductive layer on a suitable backing sheet, and an electrostatic latent image may be formed on the photoconductive layer by any suitable means known in the art. An example of a suitable recording element **12** and means for producing an electrostatic image thereon are described in RCA Review, December 1954, volume XV, No. 4.

The developing apparatus **10** comprises a drum **14** rotatably disposed on a stationary hollow shaft **16**. The drum **14** is coupled to the stationary shaft **16**, preferably by roller bearings (not shown), in a manner whereby the drum is free to rotate about the stationary shaft **16**. The recording element **12** is disposed about, and in contact with, the outer periphery of the drum **14** and is adapted to rotate the drum **14**, in the direction indicated by the arrow **18**, when the recording element **12** is moved, in the directions of the arrows **17** and **19**, by driving means (not shown) associated with the recording element **12**.

An electromagnet **20** is fixed to the stationary shaft **16** within the drum **14** by any suitable means. The electromagnet **20** has a pair of pole pieces **22** and **24** whose opposite edges are disposed adjacent to the inner periphery of the drum **14** and which extend parallel to the axis of the drum **14**. When a D.-C. voltage is applied between leads **26** and **28** of a coil **30** of the electromagnet **20**, the pole pieces **22** and **24** become magnetic poles of opposite polarities. Under these conditions, magnetic circuits **32** and **34**, indicated by dashed lines, are set up between the edges of the pole piece **22** and **24** when the electromagnet **20** is energized. The electromagnet leads **26** and **28** are brought outside of the drum **14** through a bore **36** in the shaft **16**.

Means are provided to apply a developer mixture **38** of toner particles **40** and magnetic particles **41**, such as iron filings, for example. Suitable developing mixtures for use with the apparatus **10** are described in U.S. Patent 2,986,521 for Reversal Type Electrostatic Developer Powder, issued May 30, 1961. The developer mixture **38** is disposed in a trough **42**, and rotatable cylindrical brush **44** is disposed in the developer mixture **38**.

The brush **44** comprises a rod **46** about which a strip **48** of "Nylon" velour is wound. The nap **50** of the brush **44** should be at least ¼ inch long. The brush **44** is mounted for rotation so that its nap **50** brushes against the surface **11** of the recording element **12** and applies the developer mixture **38** to the latent image on the recording element **12** to develop the latent image. The axes of the drum **14** and the brush **44** are substantially parallel to each other, and the brush **44** is rotated, in a direction indicated by the arrow **52**, by a motor **54** coupled to the brush **44** through a gear train **56**, so that their tangential motions at their line of mutual contact are in the same direction.

Means are provided to replenish the developer mixture **38** with toner particles that are removed from the developer mixture **38** by the development of the latent image on the recording element **12**. To this end, a V-shaped container **58** is disposed above an endless belt **60**, the latter being made of a thin rubber-coated fabric and being disposed between two rollers **62** and **64** to carry toner particles to the brush **44**. The axes of the rollers **62** and **64** are parallel to the axis of the brush **44**, and the

roller 64 is disposed to cause the belt 60 to brush against the nap 50 of the brush 44. The width of the belt 60 is coextensive with that of the brush 44. A vibratory mechanism 66 is connected to the container 58 to agitate the latter and to cause the replenisher toner particles 40 to fall through a 100-mesh screen 68 forming a bottom portion of the container 58. The roller 64 is coupled to the gear train 56 to transport the toner particles 40, that have fallen from the container 58 onto the belt 60, to the brush 44. The brush 44 mixes the toner particles 40 with the developer mixture 38, thus restoring the mixture 38 to its original concentration of toner particles. The trough 42 extends beneath the belt 60 to catch any toner particles 40 that may fall from the belt 60.

A pair of spaced-apart rollers 70 and 72 of magnetic material are disposed adjacent to ends 74 and 76 of the pole pieces 24 and 22, respectively. The rollers 70 and 72 have knurled cylindrical surfaces 80 and 82, respectively. The axes of the rollers 70 and 72 are parallel to the axis of the drum 14, and the rollers 70 and 72 form a part of the magnetic circuit 34 between the ends 74 and 76 of the pole pieces. The gap 78 between the outer surface 11 of the recording element 12 and the knurled cylindrical surface 80 of the roller 70 is less than the distance between the outer surface 11 of the recording element 12 and the end 74 of the pole piece 24. Similarly, the gap 84, between the knurled cylindrical surface 82 of the roller 72 and the surface 11 of the recording element 12 is smaller than the distance between the end 76 of the pole piece 22 and the surface 11. Under these conditions, any magnetic particles 41 that may adhere to the surface 11 of the recording element 12 are attracted more to the rollers 70 and 72 than to the pole pieces 22 and 24. The rollers 70 and 72 are rotated by the motor 54 through the gear train 56 and may rotate in either the same direction or in opposite directions. A baffle plate 86 is disposed, by any suitable means, adjacent the lower portion of the roller 70 and the upper portion of the roller 72 to prevent magnetic particles, picked up by the roller 70, from falling onto the roller 72 and to direct the magnetic particles onto the belt 60.

The operation of the developing apparatus 10 will now be described: The motor 54 is energized, thereby rotating the brush 44, the belt 60, and the magnetic rollers 70 and 72. The vibratory mechanism 66 is also energized. A quantity of developer mixture 38, comprising toner particles 40 and magnetic particles 41, is disposed on the belt 60 from where it is taken up by the brush 44, until the brush 44 and the trough 42 are fully loaded. When the recording element 12, having an electrostatic latent image on the outer surface 11 thereof, is moved past the nap 50 of the rotating brush 44, the latter rotating in the direction of movement of the recording element 12, a quantity of the developer mixture 38 is brought into contact with the surface 11 to develop the latent image thereon. Since the peripheral speed of the brush 44 is different from the speed of movement of the recording element 12, a wiping action takes place between the recording element 12 and the brush 44, insuring good development of the recording element 12.

In the developing process, magnetic particles 41 tend to adhere to the surface 11 of the recording element 12. As the developer mixture 38 on the recording element 12 passes through the magnetic circuit 32, the magnetic particles 41 tend to press the toner particles 40 firmly against the outer surface 11. This is beneficial in producing a crisp electrostatic print with a clean background. Most of the metallic particles 41 fall from the surface 11 as they emerge from the magnetic circuit 32 and fall onto the belt 60 for return to the developer mixture 38. Thus, the magnetic particles 41 need rarely be replenished in the developer mixture 38.

Some metal particles 41, especially at recording element speeds of a few feet per second, are carried upward by the recording element 12 into the magnetic circuit 34. Since the metal particles 41 in passing through the gaps 84 and 78 are nearer to the magnetic rollers 72 and 70 than to the pole piece ends 76 and 74, the metal particles 41 are attracted to the rollers 72 and 70 and are subsequently returned to the belt 60. Metal particles 41 attracted to the roller 70 are eventually dropped onto the baffle 86 and, from there, onto the belt 60, the latter returning the metal particles 41 to the developing mixture 38. Thus, as the rollers 70 and 72 rotate, the magnetic force on the metal particles 41 decreases as they move away from the gaps 78 and 84, and the metal particles 41 eventually drop onto the belt 60 which then carries them back to the brush 44 and into the trough 42.

At relatively low speeds of travel of the recording element 12, such as five inches per second, a single roller 72 may be sufficient to clean excess metal particles 41 from the recording element 12. At speeds of several feet per second, however, many metal particles 41 are not removed by a single roller, and the two magnetic rollers 70 and 72 are necessary. At the higher speeds, it is advantgeous to rotate the roller 70 in a direction opposite to that of the roller 72 so that the metal particles 41 dropped by the roller 70 are not picked up by the roller 72.

As the latent images on the outer surface 11 of the recording element 12 are developed, toner particles 40 are consumed and removed from the toner mixture 38. Replenisher toner particles 40 from the container 58, however, are shaken onto the belt 60 and thus carried to the brush 44. The replenisher toner particles 40 are intermingled on the belt 60 with the metal particles 41 dropped from the rollers 70 and 72 and mixed with the developer mixture 38 by the brush 44. The peripheral speed of the belt 60 is relatively much less than that of the brush 44 so that the brush 44 effectively wipes the toner off the belt 60. The peripheral speed of the brush 44 may be about one-half the speed of the movement of the recording element 12 so as to provide a good wiping action between the brush 44 and the outer surface 11 of the recording element 12.

From the foregoing description, it can be seen that there has been provided improved developing apparatus for developing an electrostatic latent image on a recording element which is moving several feet per second. Because the brush 44 and the belt 60 have peripheral speeds that are relatively much slower than the movement of the recording element 12, the operation of the apparatus 10 is substantially dust-free, and yet the agitation of the mixture 38 is adequate. While only one embodiment of the developing apparatus has been shown and described, variations in the components of the apparatus, as well as in its method of operation, all coming within the spirit of this invention, will, no doubt, suggest themselves to those skilled in the art. Hence, it is desired that the foregoing shall be considered as illustrative and not in a limiting sense.

What is claimed is:

1. Apparatus for developing a latent image on the surface of the recording element comprising:

record-element guiding means for guiding said record-element along a predetermined path,

a rotatable brush disposed to brush against said surface of said recording element during the movement of said recording element along said path,

means disposed beneath said brush for holding a developer mixture of toner particles and magnetic particles to be applied to said surface by said brush to develop said latent image,

an endless belt disposed adjacent said brush,

means to rotate said endless belt and said brush,

means to feed replenisher toner particles to said belt,

magnetic means disposed to create two spaced-apart magnetic circuits along said path, each of said circuits traversing said path, and

at least one roller of magnetic material disposed adjacent to said surface and forming a part of one of said magnetic circuits for attracting magnetic particles that are on said surface and for causing them to fall onto said belt.

2. Apparatus for developing an electrostatic latent image on the surface of an electrophotographic recording element comprising:

a drum disposed for guiding said record element along a predetermined path,

a rotatable brush having a fabric nap disposed to brush against said surface of said recording element during the latter's movement along said path,

a trough disposed beneath said brush for holding an electroscopic developer mixture of toner particles and magnetic particles to be applied to said surface by said brush to develop said latent image,

an endless belt, having substantially the same width as that of said brush, disposed adjacent said brush,

means to rotate said endless belt and said brush at different relative speeds,

a container for holding replenisher toner particles disposed above said belt,

means connected to said container to agitate it, said container being formed with openings whereby said replenisher toner particles can fall onto said belt when said container is agitated,

magnetic means disposed within said drum to create two spaced-apart magnetic circuits along said path which are transversely disposed thereto, and

a pair of driven rollers of magnetic material disposed adjacent to said surface and forming a part of one of said magnetic circuits for attracting magnetic particles that may adhere to said surface and for causing them to fall onto said belt for return to said trough.

3. In combination,

a trough for a developer mixture of magnetic particles and toner particles,

a rotatable brush having a fabric nap disposed within said trough and adapted to mix said developer mixture when rotated,

an endless belt disposed between a pair of rollers,

one of said rollers urging said belt against said nap of said brush,

means to feed toner particles disposed to said belt,

a recording-element guiding drum adapted to guide a moving recording-element web along a path in contact with said nap of said brush,

magnetic means fixedly mounted within said drum and providing a pair of parallel spaced-apart magnetic circuits along said path transversely disposed to the direction of movement of said web, said drum being adapted to guide said record-element web past said magnetic circuits,

a magnetic roller disposed in one of said magnetic circuits for attracting magnetic toner particles from said web, and

means connected to said brush, to one of said pair of rollers, and to said magnetic roller for rotating said brush, said belt, and said magnetic roller.

4. In combination,

a trough for an electroscopic developer mixture of magnetic particles and toner particles,

a driven rotatable brush having a fabric nap disposed within said trough and adapted to mix said developer mixture when rotated,

an endless belt disposed between a pair of rollers,

one of said rollers urging said belt against said nap of said brush,

a container for replenishing toner particles disposed above said belt,

means connected to said container to agitate it, said container being formed with openings through which said toner particles can fall onto said belt, when said container is agitated,

a drum adapted to guide a web recording-element along a predetermined path in contact with said nap of said brush, whereby to apply said developer mixture to said recording-element,

magnetic means fixedly mounted within said drum and providing a pair of parallel spaced-apart magnetic circuits transversely disposed to said path, said drum being disposed to guide said web record-element past said magnetic circuits,

means connected to said brush and to one of said pair of rollers for rotating said brush and said toner belt at different speeds with respect to each other, said drum being adapted to rotate freely,

a pair of magnetic rollers having axes disposed parallel to the axis of said drum and forming a part of one of said magnetic circuits, whereby to attract any magnetic particles thereto, and

means connected to said pair of magnetic rollers to rotate them, whereby to cause said attracted magnetic particles to fall therefrom and onto said belt for return to said trough.

5. In electrostatic developing apparatus of the type wherein a latent electrostatic image on a moving web recording-element is developed with toner particles from an electroscopic developer mixture including magnetic particles,

the improvement comprising, in combination,

a rotatable drum disposed to guide said recording-element web along a predetermined path,

a trough for holding said developer mixture,

a rotatable brush disposed within said trough and having a fabric nap in contact with said recording-element web to apply said developer mixture to said latent image when said brush is rotated,

a toner feed belt,

means disposing said belt for rotation with a portion of said belt in contact with said nap of said brush,

a container for replenisher toner particles disposed above said belt,

means to agitate said container, said container having openings therein through which said replenisher toner particles can fall onto said belt when said container is agitated,

magnetic means disposed within said drum for providing two spaced-apart magnetic circuits along said path,

at least one magnetic roller disposed adjacent to said drum and forming a part of one of said magnetic circuits, and

means to rotate said brush, said belt, and said magnetic roller at different speeds with respect to each other, whereby said developer mixture is applied to said recording-element web to develop said latent image, replenisher toner particles are conveyed to said developer mixture to replace toner particles used to develop said latent image, and magnetic particles are removed from said recording-element web by said magnetic roller and returned to said belt for mixing with said developer mixture.

6. In an electrostatic developing apparatus of the type wherein a latent electrostatic image on a web recording-element is developed with toner particles from an electroscopic mixture including magnetic particles,

the improvement comprising:

a rotatable drum disposed to guiding said recording-element web along a predetermined path,

a trough for holding said developer mixture,

a rotatable brush disposed within said trough and having a fabric nap in contact with said recording-element web to apply said developer mixture to said latent image when said brush is rotated,

a toner feed belt having a width substantially co-extensive with that of said brush,

means disposing said belt with a portion thereof in contact with said nap of said brush,

a container for replenisher toner particles,

means to agitate said container, said container having openings therein through which said replenisher toner particles can fall onto said belt,

magnetic means disposed within said drum for providing two spaced-apart magnetic circuits along said path,

a pair of spaced-apart magnetic rollers disposed adjacent to said drum and forming a part of one of said magnetic circuits, and

means connected to said brush, said belt and said rollers to rotate said brush, said belt, and said rollers at different speeds with respect to each other, the peripheral speed of said brush being less than the speed of movement of said recording-element, and the peripheral speed of said belt being less than that of said brush, whereby said brush produces a wiping action on said recording-element, and said belt produces a wiping action on said brush.

References Cited

UNITED STATES PATENTS

2,061,692	11/1936	Bagley.	
2,910,964	11/1959	Stavrakis et al.	118—637
3,133,834	5/1964	Sowiak	118—637
3,176,652	4/1965	Mott et al.	118—637

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