

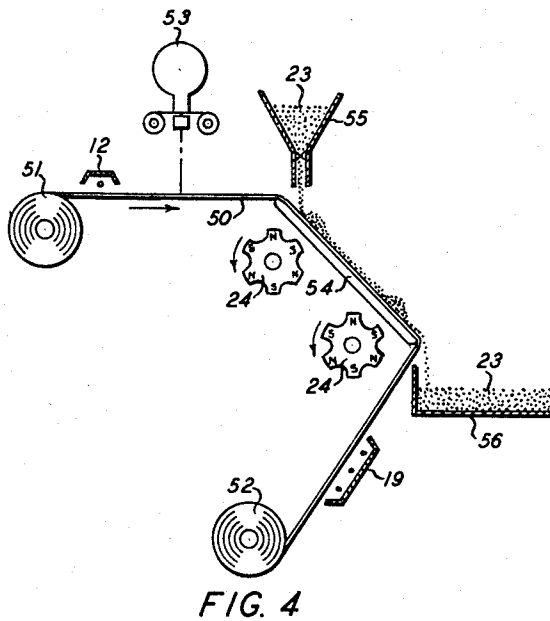
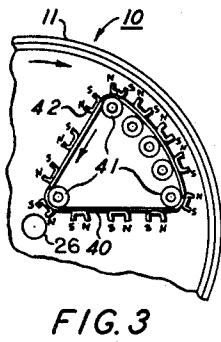
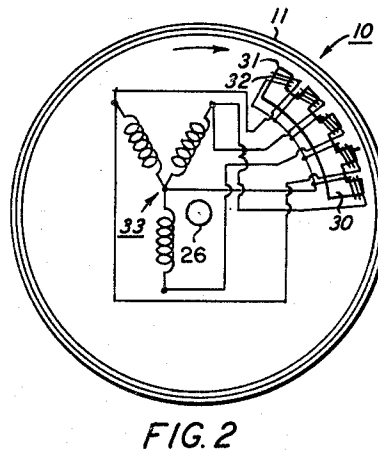
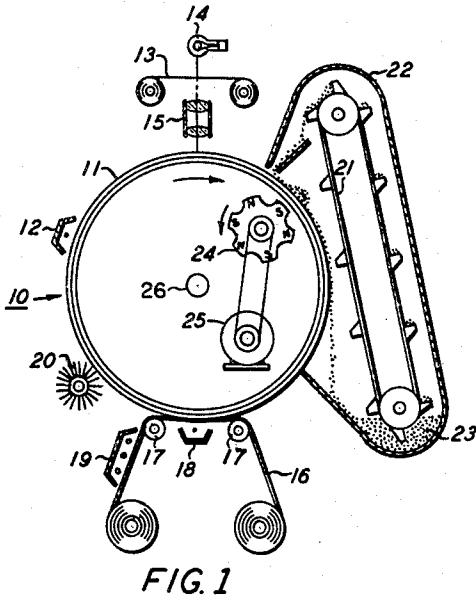
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XEROGRAPHIC APPARATUS

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2 Sheets-Sheet 1



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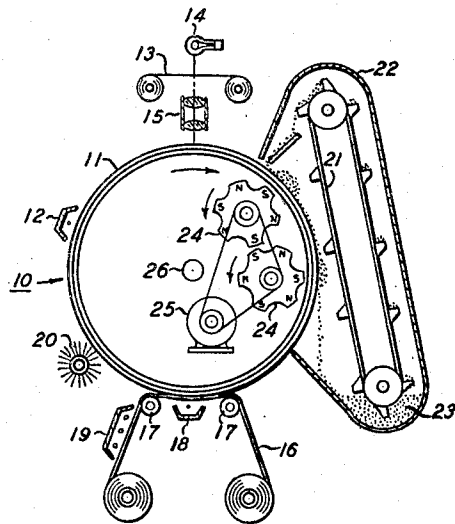


FIG. 5

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XEROGRAPHIC APPARATUS

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11 Claims. (Cl. 118—637)

This invention relates to xerography and more particularly to improved means for xerographic cascade development.

In the art of xerography, an electrostatic latent image is formed on a suitable surface and made visible through the selective electrostatically controlled deposition of particles on the latent image bearing surface. Various surfaces, as well as various techniques for forming the electrostatic latent image, are well known and are fully described in published material. Various systems of development are also known and are fully described in published material. The one most pertinent to the present invention is that commonly known as cascade development. In cascade development the developer material is a mixture of very fine particles called toner, which are generally resinous in character, and larger particles called carrier. The toner and carrier materials are so chosen that they acquire opposite electrical charges through triboelectrification whereby the toner particles stick to the carrier particles through electrostatic attraction. The triboelectric properties of the carrier particles are commonly achieved through the application of special surface coatings, and as a result, the body of the carrier particles may comprise diverse materials such as glass beads, carefully screened sand, etc. When this developer mixture is cascaded across a latent image bearing surface the toner particles are selectively detached from the carrier particles and deposit on the surface in accordance with the latent image thereon, thus forming a visible image. Various modifications of cascade developer are known including the use of a liquid dielectric medium as one component as well as the use of developer materials having a single component or three or more components as well as the more common two components.

Cascade development may be used with various forms of xerographic apparatus. A particularly common form is that in which the electrostatic image bearing surface is in the form of a rotating drum or cylinder with a horizontal axis. In this type of machine as well as in other forms of xerographic apparatus, it is always desirable to make the apparatus, and therefore the drum, as small as possible; to operate the drum at the highest possible linear speed to achieve maximum output; and also to achieve the highest quality reasonably obtainable. These requirements have been found to conflict with each other because smaller or faster rotating drums reduce the time during which a given portion of the image bearing surface is in contact with a developer mixture and image quality suffers when this time is made too small. Developer contact time may be somewhat increased without reducing drum speed or increasing drum size by maintaining the developer mixture in contact with the image bearing surface for a greater distance, but there are practical upper limits on this distance and these limits are particularly restricted where the image bearing surface is in the form of a drum. Normally, the developer is in contact with the drum surface for only about 30 degrees of rotation, although recently techniques have been found to increase this to as much as 120 degrees.

Now in accordance with the present invention, however, the effectiveness of cascade development is improved of any area being developed by achieving a more intimate and efficient contact between the developer material and the surface being developed. This inventive contribution to the art is also valuable in producing improved

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solid area coverage with cascade development systems in a novel manner.

It is accordingly an object of the invention to provide improved means for xerographic cascade development.

5 It is a further object of the invention to provide xerographic development means wherein the developer is magnetically agitated during the course of development.

10 It is a further object of the invention to provide xerographic developing apparatus including magnetic means to draw a flowing magnetically attractable cascade developer mixture against an image bearing surface and to agitate it against said surface.

These and other objects will become apparent in connection with the subsequent description and the drawings, in which:

FIG. 1 is a schematic sectional view of a drum-type xerographic machine according to the present invention;

FIG. 2 is a schematic sectional view of a portion of the machine of FIG. 1 including certain modifications;

20 FIG. 3 is a schematic sectional view of a portion of the machine of FIG. 1 including further modifications;

FIG. 4 is a schematic sectional view of a xerographic machine according to the invention employing a web-type image bearing member; and

25 FIG. 5 is a schematic sectional view of the machine of FIG. 1 including certain modifications.

Referring to FIG. 1, there is shown a schematic sectional view of a drum-type xerographic machine according to the invention. The principal element of the machine is a xerographic drum or plate 10 which is covered on its outer surface with a layer 11 of photoconductive insulating material such as vitreous selenium. Drum 10 itself is a thin-walled cylinder of non-magnetic material such as glass, plastic, aluminum, etc. Where drum 10 is fabricated of an electrically conductive material, it should be made as thin as possible to minimize eddy current effects from the magnetic means to be described later. Drum 10 is rotatable about its axis 26 in the direction indicated by conventional means, not shown. An electrostatic latent image is formed on drum 10 by means of a corona charging device 12 which deposits a uniform charge on the surface of photoconductive insulating layer 11 and projection means including a moving film strip 13, lamp 14, and lens 15 which together project on drum 10 an optical image whose movement is synchronized with that of the drum. The projected optical image causes selective charge dissipation on illuminated areas of the drum, thus forming an electrostatic latent image. Other means of forming electrostatic latent images including means for forming images on ordinary insulating surfaces are known in the art and may be used instead of the one shown.

After image development, which will be described later, the developed image is transferred from drum 10 to a web of paper or the like 16 between guide rolls 17 acting to position web 16 against drum 10 by a second corona discharge device 18. A heating element 19 is positioned to heat the transferred image and thus fix it and permanently bond it to the paper web 16. A rotating cylindrical cleaning brush 20 contacts drum 10 subsequent to image transfer and removes any residual image material from the drum, thus readying it for reuse. The above-described process and apparatus are conventional in the art and are found on the commercial "Copyflo" machines available from Haloid Xerox Inc. of Rochester, New York and any of the many known equivalents of process or apparatus elements may be employed in connection with the present invention.

Image development is effected by apparatus including 70 a bucket conveyor 21 operating in a housing 22. Conveyor 21 lifts developer material 23 from a supply at the bottom of housing 22 to a point above drum 10 and

then drops the developer onto drum 10 over which the developer material cascades or slides, returning to the bottom of housing 22. The developer material employed in the invention preferably comprises a mixture of relatively large carrier particles having a diameter of about 20 to 30 mils and smaller pigmented resinous particles having a diameter on the order of 5 microns. The toner may comprise any conventional xerographic toner material including those commercially available. The carrier particles in accordance with this invention comprised magnetically attractable material such as iron filings or iron oxide or ferrite particles. Experimental effort in connection with this invention included work with Plast Iron Powder 175 available from Plastics Metal Division of the National Radiator Co., Johnstown, Pa., which comprises an uncoated iron powder having about a 10 mil diameter. The carrier particles may be provided with the same conventional surface coatings generally used in the art with non-magnetic carriers to provide suitable triboelectric properties in relation to those of the toner particles. As developer material 23 cascades over drum 10, the toner particles are selectively detached from the carrier particles and deposit on the surface in accordance with the latent image thereon, thus forming a visible image.

Positioned within drum 10 paraxially therewith and closely adjacent to the region over which developer 23 flows is a substantially cylindrical permanent magnet 24. Magnet 24, which may be of substantially the same length as drum 10, has a plurality of alternating, lengthwise extending magnetic poles along its surface and is rotatable in a direction opposite to that of drum 10 by a motor 25. Magnet 24 causes cascading developer 23 to be drawn more closely against drum 10. Additionally as magnet 24 is rotated, waves of magnetic fields pass through the developer flow stirring up the developer presented to the surface to be developed. This is believed to be due to a turning or rotation of the magnetic carrier particles on themselves in response to the magnetic field which results in a new surface contact between carrier and plate presenting more toner in closer contact with the plate over a shorter area than prior art techniques or devices. There may also take place a momentarily reverse in direction and flow uphill against the surface of drum 10. There is thus provided through the combination of these effects a much more intimate and extensive contact between developer 23 and drum 10 leading to a much more effective utilization of developer 23 and a much more effective and rapid development of the latent image on drum 10.

FIG. 2 is a schematic sectional view of a portion of the machine of FIG. 1 illustrating a modified form of magnetic means replacing magnet 24 of FIG. 1. The magnetic means illustrated on this figure includes a bar 30 of iron or other magnetic material having a plurality of pole pieces or teeth 31 extending substantially longitudinally adjacent the inner surface of drum 10. Each such pole piece has an electrical coil 32 wound therearound and each such coil is connected to one winding of a three phase transformer 33. Successive coils 32 are connected in sequence to the windings of transformer 33 to successively energize in an upwardly moving direction successive coils 32 and therefore successively magnetize successive pole pieces 31. There is thus provided within drum 10 an upwardly moving magnetic field which performs a function similar to magnet 24 of FIG. 1. This type of magnetic structure is more fully described in a different connection in co-pending application entitled "Stationary Conveyor for Magnetic Material" by Richard Harrison Hall, Serial Number 23,274, filed April 19, 1960, and the various equivalent structure described therein may also be employed in the present invention.

FIG. 3 is a schematic sectional view of a portion of the machine of FIG. 1 including a further form of modified magnetic means. Here the magnetic means comprises an endless flexible belt 40 which is carried on a set of rollers 41 at least one of which is driven by a motor, not

shown, to move the belt in the direction shown. As shown, the belt is so mounted and rollers 41 are so positioned that a portion of belt 40 is always adjacent to the inner surface of drum 10 and is in about the same configuration. Belt 40 carries on its outer surface a set of transversely mounted channel form permanent magnets 42. These magnets are magnetized so that opposite edges of the channels have opposite magnetic poles. As these permanent magnets are moved past the inner surface of drum 10 by belt 40, they function in substantially the same manner as magnet 24 of FIG. 1 and perform essentially the same function.

FIG. 4 is a schematic sectional view of a xerographic machine according to the invention employing a web-type image bearing member rather than the drum 10 of FIGURES 1 through 3. The image forming material is in the form of a web 50 which passes from a supply roll 51 to a takeup roll 52. Web 50 may be of a variety of materials including, but not necessarily limited to, a paper web coated with a photoconductive insulating mixture of zinc oxide particles in a resinous binder. A corona charging device 12 applies a uniform electrostatic charge to web 50 in the same manner as a charge is applied to drum 10 in FIG. 1. Alternatively charging may be accomplished as is fully described in U.S. Patent 2,855,556. A photographic enlarger or the like 53 is provided to project a light image onto web 50. Enlarger 53 is particularly adapted to work with a web 50 if periodically stopped for exposure. On the other hand, if web 50 is continuously moving, projection means of the type shown in FIG. 1 may be employed. For purposes of development, web 50 is passed over an inclined guide plate 54 constructed of non-magnetic material. Guide plate 54 cannot be a perfect electrical conductor since this would prevent passage of the magnetic fields therethrough. However ordinary thin layers of metal work well in this invention. While web 50 is drawn against guide plate 54, developer mixture 23 fed from a feed hopper 35 is cascaded over the web and then falls into a receiving tray 56. A heating element 19 is provided to fuse and fix the developed image to web 50. Solvent fixing systems and devices known to the art may also be used. A pair of magnets 24 which are substantially the same as the similarly numbered magnet in FIG. 1 are rotatably positioned beneath guide plate 54 close thereto and substantially perpendicular to the direction of travel of web 50. They are rotated in the direction shown by motors or other means, not shown, and influence development in the manner described in connection with other embodiments of the invention. In this embodiment, however, guide plate 54 can extend as far as desired in the direction of travel of web 50 and it is therefore extremely convenient to employ two or more rotating magnets 24 to further increase the effectiveness of development. It should however be appreciated that two or more rotating magnets can also be employed in the embodiment illustrated in FIG. 1.

The invention has been described in terms of specific embodiments for illustrative purposes only and various modifications may be made within the scope of the appended claims.

What is claimed is:

1. Xerographic apparatus comprising a cylindrical xerographic drum, means to rotate said drum, means to form on the surface of said drum an electrostatic latent image, developer feed means positioned to flow a cascade developer material downward across the drum surface at a point along said drum following image formation, a cylindrical magnet positioned paraxially with said drum and within said drum adjacent to a drum segment across which developer flows, and means to rotate said cylindrical magnet in a direction opposite to the direction of movement of said cylindrical drum.

2. Apparatus according to claim 1 including a second cylindrical magnet positioned paraxially with said drum and within said drum adjacent to the drum segment across

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which developer flows and spaced apart from the other cylindrical magnet, and means to rotate said second cylindrical magnet in a direction opposite to the direction of movement of said cylindrical drum.

3. Xerographic apparatus comprising a cylindrical xerographic drum, means to rotate said drum in a first direction, means to form on the surface of said drum an electrostatic latent image, developer feed means positioned to flow a stream of magnetically attractable granular cascade developer material downward across the drum surface at a point along said drum following image formation, magnetic means positioned within said drum and adjacent to a segment of said drum across which developer flows adapted to attract substantially all of said stream of magnetically attractable developer material toward the surface of the drum, and means to cause upward movement of the magnetic field from said magnetic means in a direction opposite to the direction of movement of said cylindrical drum.

4. Apparatus according to claim 3 in which said magnetic means comprises a plurality of stationary pole pieces and in which said means to cause movement of said magnetic field comprises electric means to successively re-energize said magnetic pole pieces in an upwardly moving direction.

5. Apparatus according to claim 3 in which said magnetic means comprises a flexible linear array of permanent magnetic poles of alternating polarity supported on an endless belt and in which said means to cause movement of said magnetic field comprises a drive means to move the endless belt.

6. Xerographic apparatus comprising a xerographic plate, means to advance the plate, means to form on a surface of the plate an electrostatic latent image, developer feed means positioned to gravitationally flow a magnetically attractable granular cascade developer material downward across the upwardly facing inclined image bearing surface of the plate following image formation, magnetic means positioned beneath the segment of the plate over which the developer material flows adapted to produce a magnetic field of sufficient strength to attract developer material toward the image bearing surface of the plate, and means connected to the magnetic means to

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move the magnetic field therefrom in an upward direction opposite to the flow of developer material.

7. Apparatus according to claim 6 in which said xerographic plate comprises a flexible web of material and in which said plate is fed from a supply spool to a takeup spool over an inclined member permeable to the magnetic field and in which development takes place while said plate is across said member.

8. Apparatus according to claim 7 including at least one rotatable cylindrical magnet positioned and disposed against said member in magnetic contact with developer cascading across said plate and in which each said magnet is rotated in a direction to move the magnetic field emanating from each said magnet in a direction opposite to that of the cascading developer flow.

9. Apparatus according to claim 6 in which said magnetic field means comprises at least two separate magnets.

10. Xerographic apparatus comprising a cylindrical xerographic drum, means to rotate said drum, means to form on the surface of said drum an electrostatic latent image, developer feed means positioned to flow a cascade developer material downward across the drum surface at a point along said drum following image formation, cylindrical magnet means positioned paraxially with said drum and within said drum adjacent to a drum segment across which developer flows and having alternating magnetic poles on the periphery thereof, and means to rotate said cylindrical magnet in a direction opposite to the direction of movement of said cylindrical drum.

11. Apparatus according to claim 10 in which said cylindrical magnet means comprises at least two cylindrical magnets.

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