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W. H. BLISS

3,040,704

APPARATUS FOR DEVELOPING ELECTROSTATIC PRINTING

Filed April 16, 1957

Fig. 1.

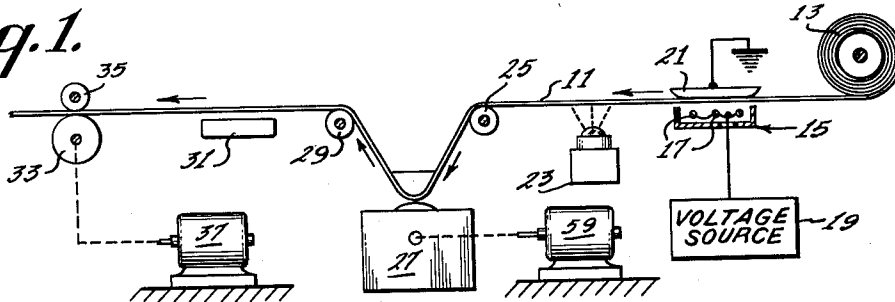


Fig. 2.

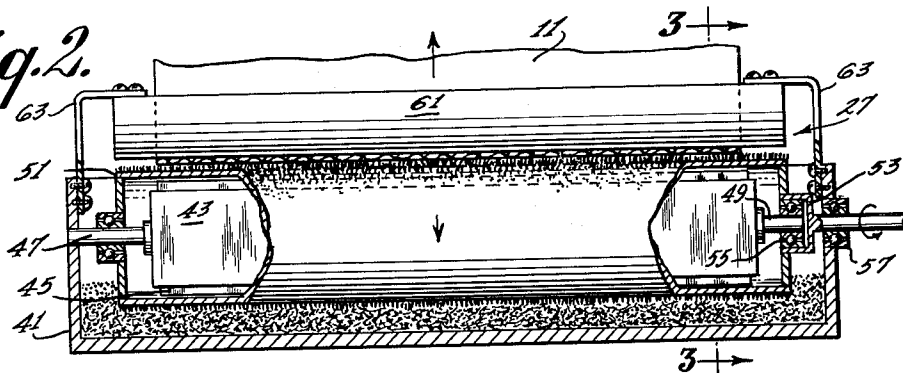


Fig. 3.

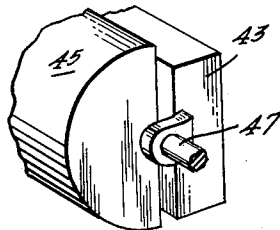
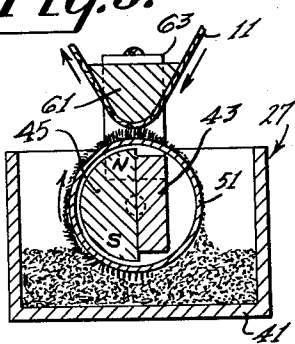


Fig. 4.

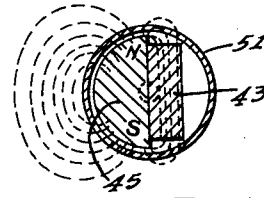


Fig. 5.

Fig. 7.

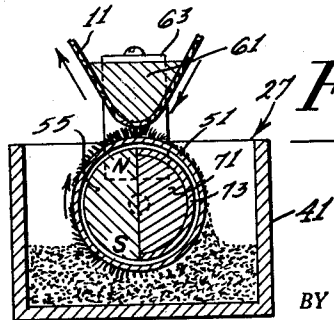
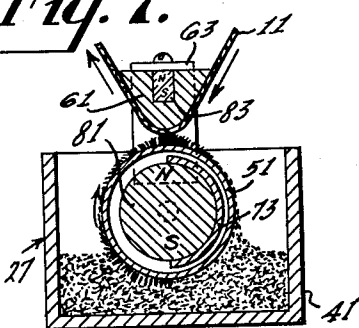


Fig. 6.

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3,040,704 APPARATUS FOR DEVELOPING ELECTRO- STATIC PRINTING

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This invention relates to electrostatic printing, and more particularly to an improved apparatus for applying developer powder to a record, such as a continuously moving web, bearing an electrostatic charge image.

A typical electrostatic printing process may include first producing a uniform electrostatic charge upon the surface of a photoconductive insulating material carried on one surface of a record. Then the charged surface of the photoconductive material is exposed to a light image through a photographic transparency or by other suitable means. The portions of the surface irradiated by the light rays become discharged while the remainder of the surface remains in a charged condition, thereby forming a latent electrostatic image corresponding to the light image. The latent electrostatic image is developed by applying a colored, electroscopic powder which is held electrostatically to selected areas of the surface. The visible powder image thus formed may be fixed directly to the photoconductive surface by fusing.

An object of this invention is to provide an improved apparatus for applying developer powder to the surface of a continuously moving record.

Another object of this invention is to provide an improved apparatus for applying developer powder, mixed with magnetic particles, to the surface of a continuously moving record.

A further object of this invention is to provide an improved apparatus for presenting a continuous supply of freshly mixed developer powder and magnetic particles to the surface of a continuously moving record.

A still further object of this invention is to provide an improved apparatus for mixing developer powder and magnetic particles and for presenting a continuous supply of mix to a continuously moving record.

In accordance with the present invention, a developer mix comprising an electroscopic developer powder and magnetizable carrier particles is applied to a surface bearing a charge image in the presence of a magnetic field. A cylindrical drum is rotatably supported adjacent a container for the developer mix. A non-rotating magnetic field producing structure is supported within the drum. A magnetic shunt means is associated with the field producing structure and reduces the magnetic field passing through a portion of the drum. A record bearing a charge image is directed adjacent a portion of the drum surface. By means of the magnetic field, the developer mix is caused to adhere to the drum surface and is carried from the container to the record. Certain of the developer powder is electrostatically attracted to the record. The developer mix remaining on the drum is then caused to drop from the drum surface because of the reduced magnetic field.

The novel features of the invention, as well as additional objects and advantages thereof, will be understood more fully from the following description when read in connection with the accompanying drawing, in which:

FIGURE 1 is a diagrammatic view illustrating an electrostatic printing system embodying the present invention;

FIGURE 2 is a view in elevation, partially broken away, of one embodiment of the present invention;

FIGURE 3 is a sectional view taken along the line 3—3

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of FIGURE 2 looking in the direction of the appended arrows;

FIGURE 4 is a fragmentary end view of the magnetic field producing means of FIGURE 3 and its supporting structure;

FIGURE 5 is a sectional view, similar in part to FIGURE 3, illustrating the magnetic field distribution;

FIGURE 6 is a view, similar to FIGURE 3, illustrating another embodiment of a magnetic field producing structure of the present invention; and

FIGURE 7 is a view similar to FIGURE 3 illustrating still another embodiment of a magnetic field producing structure of the present invention.

The apparatus to be described, embodying the invention in illustrative forms, may be operated with a developer mix comprising an electroscopic developer powder and a carrier material consisting of magnetic particles such as alcoholized iron. Generally, any of a large number of developer powders, known in the art, is suitable for mixing with iron particles to form a developer mix to be employed in operating the present invention. A developer powder above iron in the triboelectric series is generally suitable for developing a direct image upon a negatively charged surface, or a reverse image upon a positively charged surface. For purposes of illustration there is described herein, by way of example, the development of a direct image upon a negatively charged surface. Reference will be had to a record receiving member 11, in the form of a paper sheet or web, having a photoconductive coating which may comprise zinc oxide dispersed in an electrically-insulating film-forming vehicle, such as resin.

Referring now to FIGURE 1 of the drawing, an electrostatic printing system is shown diagrammatically. A continuous web 11 is fed from a supply spool 13 and is provided with a photoconductive coating on its lower surface as it is fed from the spool. The photoconductive surface is exposed to the influence of an electrostatic charging device 15 to provide a distributed electric charge over the surface. The charging device 15 may comprise a plurality of fine wires 17 carried by a pair of spaced insulating members. It will be understood that the insulating members are spaced in such a manner that the wires 17 span the width of the web 11. Light is preferably excluded during the charging step. A source of high voltage 19 is connected to the wires 17 so as to provide the wires with a negative charge with respect to a ground plate 21.

The charged web is next exposed to a light image from a luminous image projector of any known kind. The web now bears a latent image in the form of an electrostatic charge. The web next passes over a roller 25 to a developer powder applying apparatus 27 which will be described in detail hereinafter. The web next passes over a roller 29 which guides the web so that it is drawn past a heater or fuser 31 where the developer powder is fixed to the web surface to form a permanent image. The web is drawn through the various stages of the system by means of a feed roller 33 and an associated pressure roller 35. The feed roller 33 may be driven by an electric motor 37 of any suitable type.

Referring now particularly to FIGURES 2 through 5, one embodiment of the aforementioned developer powder applying apparatus 27 will be described in detail. A container, in the form of a rectangular trough 41, is provided for containing a supply of the developer mix. The trough is mounted so that it is open at the top. A magnetic field producing structure is mounted within the trough and is supported at each end of the trough. The trough is constructed of a non-magnetic material. The field producing structure includes a rectangular bar 43 of a magnetic material, such as soft iron, and a permanently magnetized bar 45 in the form of a semicylinder. The bar

43 is joined to the flat face of the semicylinder by means of brazing or soldering, for example. The bar 43 is provided with journal shafts 47 and 49 at either end. The shafts are offset from the face of the bar 43 so as to coincide with the axis of the semicylinder 45.

The above described field producing structure is supported by means of the journal shafts 47 and 49. The shaft 47 is secured in one end of the trough 41 and fixed against rotation so that the field producing structure remains fixed with respect to the trough.

A hollow cylindrical drum 51, of a non-magnetic material, encloses the above described field producing structure and has an internal diameter slightly larger than the diameter of the semicylindrical magnet 45. The drum 51 is mounted for rotation about the journal shafts 47 and 49. A bearing member 53 is secured to one end of the drum 51. The bearing member 53 includes a drum for supporting an internal bearing 55 for engagement with the journal shaft 49 of the bar 43. The bearing member 53 also provides a journal shaft for association with a bearing 57 mounted in the other end wall of the trough 41. The shaft of the member 53 is coupled to a suitable driving source, such as a motor 59 of any known type.

In the manner above described, the magnetic field producing structure and the drum 41 are concentrically supported in the trough, the drum 51 being rotatable about and completely enclosing the field producing structure.

Referring now particularly to FIGURES 3 and 5, it will be seen that the magnet bar 45 is magnetized to produce a field perpendicular to its longitudinal axis, the two magnetic poles lying along the opposite edges of the flat face of the bar 45. With this arrangement, the field distribution should appear approximately as is shown in FIGURE 5 of the drawing. The flux lines shown in the left hand portion of FIGURE 5 pass through the drum 51 and form a return path in air. The rectangular bar 43, which is secured to the flat face of the bar 45, acts as a magnetic shunt and distorts the field distribution as shown in the right hand portion of FIGURE 5. A substantial portion of the flux lines pass through the bar 43 to substantially reduce the strength of the magnetic field passing through the drum on this side of the magnetic structure. As a result of this structure, magnetic particles adhere to the drum on the left side of the structure, as shown in FIGURE 5, and do not adhere to the drum on the right hand of the structure, as shown in FIGURE 5.

An elongated shoe 61 of non-magnetic material is supported over the trough 41 by means of brackets 63. The shoe has a rounded face opposing the surface of the drum 51 and is spaced from the drum surface so that, as the web 11 is guided over the shoe, the developer mix held to the surface of the drum 51 will engage the charged surface of the web 11.

In operation, the trough 41 is filled with a developer mix, as above described, to a level somewhat above the lower surface of the drum 51. The web is fed between the shoe 61 and the drum 51 in a manner shown and described, and is carrying a latent charge image on its lower surface at this stage of the operation. Referring now to FIGURE 3, the drum 51 is rotated in a clockwise direction by the motor 59 and the web 11 is drawn past the shoe in a direction from right to left. In this manner the direction of motion of the web 11 and the drum 51 are opposite at the transfer area. As the drum is rotated, the developer mix is attracted from the trough to the drum, which preferably has a roughened external surface, and the mixture adheres to the drum in the form of bristles. The bristles may tend to lie flat as they are carried past the left side of the magnetic structure (FIGURE 3) due to the configuration of the magnetic field. However, as the drum carries the mix toward the top of the structure, the bristles again become erect due to the configuration of the magnetic field. At the top of the magnetic structure, the bristles engage the surface of the web 11 and,

due to electrostatic attraction, the developer powder particles are attracted from the bristles to the charged areas of the web. The magnetic particles of the mix are not attracted to the web.

As the drum carries the remaining developer mix, which now comprises largely the magnetic particles, past the top of the magnetic structure toward the right hand side thereof, the bristles collapse and the remaining mix falls, by gravity, back into the trough 41 due to the reduced magnetic field. As the drum rotates then, the forming, carrying, collapsing, and falling of the bristles of developer mix tend to mix the developer powder and magnetic particles. It will be apparent that fresh developer powder must be continuously supplied to the trough to provide for a continuous operation. Since the magnetic particles remain in the system, it is not necessary to replenish them.

Referring now to FIGURE 6 of the drawing, another embodiment of a field producing structure will be described. The structure of trough 41, the drum 51, and the shoe 61 are as described above. In this form, however, the shoe 61 is made of a magnetic material. A semicylindrical magnet 55 is the same as that previously described. A non-magnetic supporting bar 71, also semicylindrical in cross-section, is secured to the flat face of the magnet bar 55 and may be provided with journal shafts similar to those described for the bar 43. The diameter of the bar 71 is smaller than that of the magnet bar 55 and a semicylindrical sleeve member 73 is secured to the cylindrical surface of the bar 71. The sleeve 73 is made of a magnetic material, such as soft iron, and acts as a magnetic shunt in a manner similar to that of the bar 43 to reduce the magnetic field at the right hand portion of the structure. The structure consisting of the magnet bar 55, the support bar 71, and the sleeve 73 then forms a completely cylindrical structure enclosed by the drum 51.

The shoe 61 is of a magnetic material which tends to confine and strengthen the magnetic field in the transfer area. As a result of this the bristles of the developer mix may be stiffer as they are presented to the surface of the web 11. The operation of this embodiment of the invention is the same as that of the first described embodiment.

Referring now to FIGURE 7 of the drawing, still another embodiment of the invention will be described. The trough 41 and the drum 51 are as described heretofore. The magnetic field is produced by a cylindrical magnet supported in a manner similar to the field producing structure described above and polarized in a direction transverse to its longitudinal axis. A semicylindrical sleeve 73, of a magnetic material, is secured to and encloses the right hand half of the magnet 81. The sleeve 73 again acts as a magnetic shunt to reduce the magnetic field in this portion as described above. The shoe 61 has a configuration substantially as described above and is made of a non-magnetic material. The shoe is provided with a longitudinal groove located opposite from the rounded surface at the transfer area of the structure. An elongated bar magnet 83 is secured in this groove and is polarized in a direction perpendicular to its longitudinal dimension. The pole nearest the transfer area is of a polarity opposite from the pole of the cylindrical magnet 81 nearest the transfer area.

This structure is provided to again further strengthen the magnetic field in the transfer area so as to increase the stiffness of the bristles of the developer mix. Care must be taken to insure that the field provided by the magnet 83 is not so strong as to cause the magnetic particles of the developer mix to be attracted to, and to adhere to, the surface of the web 11.

A significant feature of the above described embodiment of the invention is the structural simplicity of the apparatus for providing continuous development of a moving web. Another significant and important feature of the apparatus is the fact that the magnetic field pro-

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 ducing structure is completely enclosed in a non-magnetic drum. With this structure there is little tendency for the magnetic particles to collect in areas where they serve no useful purpose and where they may interfere with the operation of various parts of the mechanism.

What is claimed is:

1. Apparatus for developing a latent electrostatic charge image on a record receiving member comprising means for driving and moving a record receiving member bearing a latent electrostatic charge image, a container 10 for a developer mix comprising electroscopic developer powder particles and magnetic particles, a magnetic field producing structure rigidly supported in said container, a cylindrical drum of non-magnetic material rotatably mounted in said container and enclosing said magnetic field producing structure, said field producing structure producing a field which passes through said drum, means associated with said field producing structure for reducing the magnetic field passing through a portion of said drum, means for guiding said record receiving member adjacent said drum, and means for rotating said drum to carry said developer mix from said container to said record.

2. Apparatus for developing a latent electrostatic charge image on a record receiving member comprising means for driving and moving a record receiving member bearing latent electrostatic charge image, a trough for containing a developer mix comprising electroscopic developer powder particles and magnetic carrier particles, a magnetic field producing structure rigidly supported in said trough, a cylindrical drum of non-magnetic material rotatably mounted in said trough and enclosing said magnetic field producing structure, drive means for said drum, said field producing structure producing a field acting in a direction transverse to the rotational axis of said drum and passing through said drum to cause said developer mix to adhere to the surface of said drum, means for reducing the magnetic field produced by said field producing structure over a portion of said drum to effect the release of said mix from said drum surface, and means for guiding said record receiving member adjacent said drum to effect the transfer of said developer powder from said drum to said record receiving member.

3. Apparatus for developing a latent electrostatic charge image on a record receiving member comprising means for driving and moving a record receiving member bearing a latent electrostatic charge image, a trough for containing a developer mix comprising electroscopic developer powder particles and magnetic carrier particles, a magnetic field producing structure rigidly supported in said trough and extending longitudinally thereof, a closed cylindrical drum of non-magnetic material rotatably mounted in said trough and enclosing said magnetic field producing structure, said field producing structure producing a field acting in a direction transverse to the rotational axis of said drum to cause said developer mix to be attracted to the surface of said drum and to be maintained on said drum in a bristle-like formation, means for reducing the magnetic field produced by said field producing structure over a portion of said drum to effect the release of said developer mix from said drum surface, and means for guiding said record receiving member adjacent said drum, and means for driving said drum whereby said developer mix is carried from said trough into engagement with said record receiving member and released to said trough.

4. Apparatus for depositing electroscopic developer powder from a mixture of such powder and a quantity of magnetic particles onto a member bearing an electrostatic charge image, said apparatus comprising means for supporting and advancing a member bearing an electrostatic charge image, a rotatably mounted cylindrical drum, a non-rotatable field producing means supported within said drum, said magnetic field producing means producing a field which passes through the cylindrical wall of said drum to cause said mixture to adhere to said drum in the

form of bristles, means associated with said magnetic field producing means for reducing said magnetic field passing through a portion of said drum wall to effect the release of said magnetizable particles from said wall, means for introducing a quantity of said developer mixture to said drum wall, and means for directing said member bearing an electrostatic charge image adjacent said drum to effect transfer of said electroscopic developer powder from said drum to said member.

5. Apparatus for depositing electroscopic developer powder from a mixture of such powder and a quantity of magnetic particles onto a member bearing an electrostatic charge image, said apparatus comprising means for supporting and advancing a member bearing an electrostatic charge image, a rotatably mounted cylindrical drum, a non-rotatable field producing means supported within said drum, said magnetic field producing means producing a field which passes through the cylindrical wall of said drum to cause said mix to adhere to said wall in the form of bristles, means associated with said magnetic field producing means for reducing said magnetic field passing through a portion of the path of said cylindrical drum wall to effect the release of said magnetizable particles from said wall, means for providing a quantity of the developer mixture adjacent to said drum wall, and means for directing said member bearing an electrostatic charge image adjacent said drum, and means for rotating said drum to carry said mixture to said member to effect transfer of said electroscopic developer powder from said drum to said member.

6. Apparatus for depositing electroscopic developer powder from a mixture of such powder and a quantity of magnetic particles onto a member bearing an electrostatic charge image, said apparatus comprising means for supporting and advancing a member bearing an electrostatic charge image, a rotatably mounted cylindrical drum, a non-rotatable field producing means supported within said drum, said field producing means comprising a semi-cylindrical magnetized bar polarized in a direction transverse to its axis, said bar producing a field which passes through the cylindrical wall of said drum to cause said mixture to adhere to said drum in the form of bristles, a magnetic member associated with said magnetized bar for shunting a portion of the magnetic field to effect the release of said magnetizable particles from said drum wall, means for introducing a quantity of said developer mixture to said drum, and means for directing said member bearing an electrostatic charge image adjacent said drum, and means for rotating said drum to carry said mixture to said member to effect transfer of said electroscopic developer powder from said drum to said member.

7. Apparatus for depositing electroscopic developer powder from a mixture of such powder and a quantity of magnetic particles onto a member bearing an electrostatic charge image, said apparatus comprising means for supporting and advancing a member bearing an electrostatic charge image, a rotatably mounted cylindrical drum, a cylindrical magnetized bar completely enclosed by said drum, means for supporting said bar against rotation, said bar being polarized in a direction perpendicular to its longitudinal axis to produce a magnetic field which passes through the cylindrical wall of said drum to cause said mixture to adhere to said drum in the form of bristles, a semi-cylindrical magnetic shield associated with said bar, said shield acting as a magnetic shunt to reduce the magnetic field passing through a portion of said drum wall to effect the release of said mixture from said drum wall, means for introducing a quantity of developer mix to said drum, means for directing said member bearing an electrostatic charge adjacent said drum, and means for rotating said drum to carry said mixture to said member to effect transfer of said electroscopic developer powder from said drum to said member.

8. Apparatus for developing a latent electrostatic charge image on a record receiving member comprising

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means for driving and moving a record receiving member bearing a latent electrostatic charge image, a container for a developer mix comprising electroscopic developer powder particles and magnetic particles, a magnetic field producing structure rigidly supported in said container, a cylindrical drum of non-magnetic material rotatably mounted in said container and enclosing said magnetic field producing structure, means for guiding said record receiving member adjacent said drum, and means for rotating said drum to carry said developer mix from said container to said record, said magnetic field producing structure producing a field which passes through only that portion of said drum which carries said developer mix from said container to said record, leaving the portion of

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said drum, during the rotation thereof, which has passed said record substantially devoid of said magnetic field so that the developer mix thereon is no longer held by magnetic attraction and is discharged from said latter portion into the developer mix in said container.

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