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XEROGRAPHIC DEVELOPMENT APPARATUS WITH WEB LOADING
MEANS TO REMOVE RESIDUAL DEVELOPER

Filed June 8, 1964

2 Sheets-Sheet 1

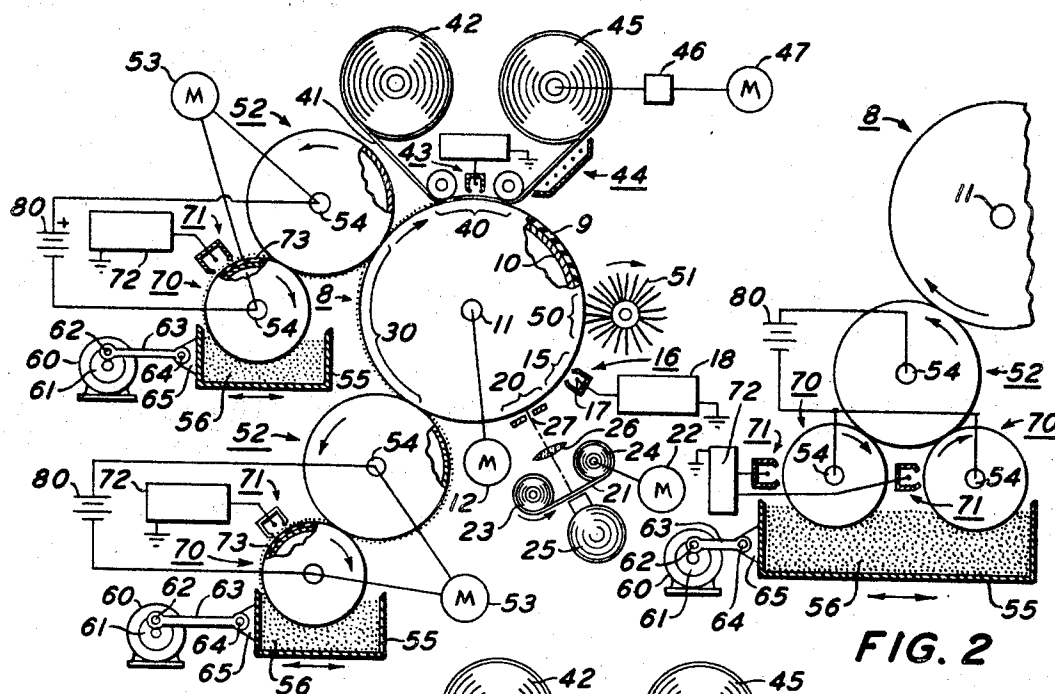


FIG. 1

FIG. 2

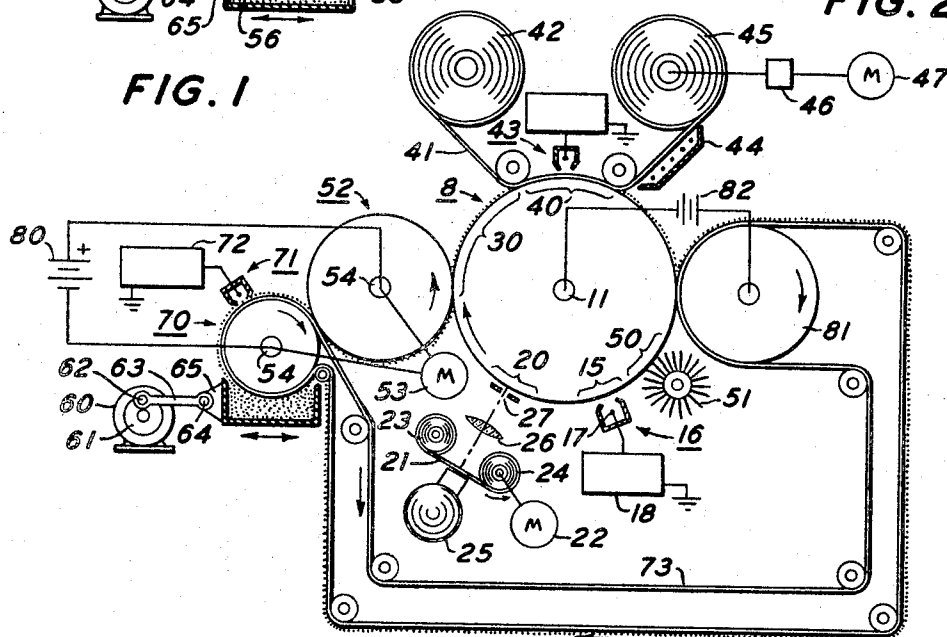


FIG. 3

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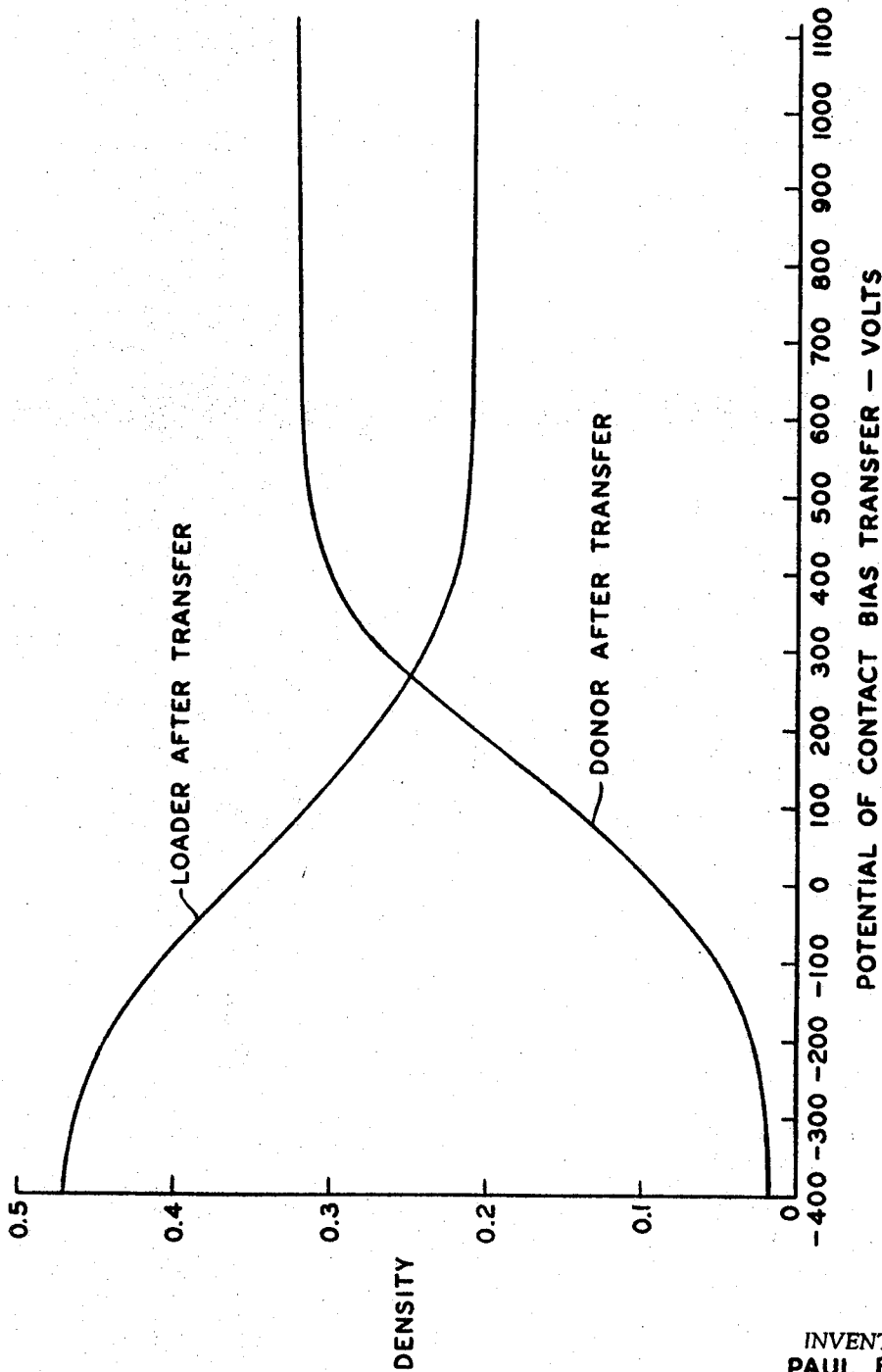


FIG. 4

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XEROGRAPHIC DEVELOPMENT APPARATUS WITH WEB LOADING MEANS TO REMOVE RESIDUAL DEVELOPER

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ABSTRACT OF THE DISCLOSURE

Apparatus and method for development of a latent electrostatic image formed on or in a photoreceptive surface wherein a loading member is uniformly coated with fluidized developer powder, electrostatically charged by a corona-emissive apparatus, transferred to a donor member biased to a charge greater than that of the loading member and of a polarity opposite to that of the developer powder, and thereafter applied to the photoreceptive surface to render the latent image visible. The developed image may be transferred to a support surface and the loading member utilized to clean the residual image from the photoreceptor.

This invention relates to xerography and particularly to improvements for developing electrostatic latent images.

In the process of xerography, for example, as disclosed in Carlson Patent 2,297,691, issued Oct. 6, 1942, a xerographic plate comprising a layer of photoconductive insulating material on a conductive backing is given a uniform electric charge over its surface and is then exposed to the subject matter to be reproduced, usually by conventional projection techniques. This exposure discharges plate areas in accordance with the radiation intensity that reaches it and thereby creates an electrostatic latent image on or in the photoconductive layer. Development of the latent image is effected with an electrostatically charged, finely divided material such as an electroscopic powder that is brought into surface contact with the photoconductive layer and is held thereon electrostatically in a pattern corresponding to the electrostatic latent image. Thereafter, the developed image may be fixed by any suitable means to the surface on which it has been developed or may be transferred to a secondary support surface to which it may be fixed or utilized by means known in the art.

Whatever method is employed for forming electrostatic images, they are usually made visible by developing. Various developing systems are well known and include cascade, brush development, magnetic brush, powder cloud and liquid development, to name a few. Still another developing system is disclosed in Mayo patent, U.S. 2,895,847 in which a support member such as a web, sheet or other member termed a "donor" is employed which carries a releasable layer of electroscopic marking particles. These particles are presented via the donor into close contact with an image-bearing plate for deposit thereon in conformity with the electrostatic image.

The system of Mayo has been found highly advantageous for development of electrostatic images in that it effects high quality development without the attending problems of bulk handling of loose developer as is associated with other known development systems. However, in accordance with Mayo, in order to assure reproducible results with each successive development, it is necessary that the developer be surface loaded onto each donor, or each incremental area of the same donor, with a reproducible uniformity of density and distribution. It

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has been found that techniques of the prior art by which developer particles are applied onto the donor web by squeegeing, brushing, triboelectrification, or the like results in donor loading which is not entirely satisfactory. For various reasons, each of these prior loading techniques have not satisfactorily met the system requirements particularly when intended for continuous use as when incorporated into an automatic machine.

Now in accordance with the instant invention, there is provided novel improved method and apparatus for continuously loading developer particles onto a donor member, whereby greater and more consistent uniformity of loading than heretofore is achieved as to overcome the basic handicaps of such prior systems. In accordance with the method hereof, loading is achieved with such continuous uniformity as to render this developing method capable of utility in continuously operated automatic xerographic machines to result in consistently high quality reproductions.

Accordingly, it is an object of the invention to provide improved method and apparatus for effecting development of electrostatic images.

It is a further object of the invention to provide improved method and apparatus for donor type development in the process of xerography.

It is a further object of the invention to effect improved method and apparatus for loading electroscopic developer particles onto a donor member for subsequent presentation to an electrostatic image.

These and other objects of the invention will appear in the specification when read in conjunction with the following drawings, the novel features being pointed out in the claims at the end of the specification.

In the drawings:

FIG. 1 is a schematic illustration of an apparatus embodiment utilizing the improved developer loading technique hereof;

FIG. 2 is a fragmentary view illustrating a variation of the developer loading device as could be incorporated in FIG. 1;

FIG. 3 is a schematic of an automatic apparatus showing a further variation of the embodiment of FIG. 1; and

FIG. 4 is a representative graph of operational characteristics of a loading apparatus hereof.

Referring now to FIG. 1, there is illustrated a continuous machine adapted to form a xerographic print on a continuous web member. The apparatus includes a xerographic plate in the form of a cylindrical drum 8 which comprises a photoconductive insulating surface 9 on a conductive substrate 10. The drum is mounted on an axle 11, journaled for rotation and is driven by a motor 12 through conventional belts, gears, or the like connected to the shaft 11.

Positioned adjacent to the path of motion of the surface of the drum 8 is a charging station 15 comprising, for example, a positive polarity corona discharge device 16 containing a fine wire electrode 17 connected to a high voltage source 18 of potential high enough to cause a corona discharge from the electrode wire onto the photoconductive surface of drum 8. Subsequent to the charging station 15 in the direction of drum rotation is an exposure station 20 generally comprising suitable means for imposing a radiation pattern reflected or projected from an original copy onto the surface of the xerographic drum. As here shown, the original copy comprises a microfilm strip 21 being advanced via motor 22 from a supply reel 23 onto a take-up reel 24. The film is advanced synchronously with the rotational rate of the xerographic drum past the exposure station which is shown to include a light source 25 and a projection lens 26. Operation

is with slit projection methods to focus the moving image at an exposure slit 27.

Next, subsequent to the exposure station is a developing station, generally designated 30, as will be further described at which the latent image formed on exposure is developed with electrosopic developer particles.

Beyond the developing station is a transfer station 40 adapted to transfer the developed image from the surface of the drum to a transfer web 41 that is advanced from a supply reel 42 into contact with the surface of the xerographic drum at a point beneath a transfer electrode 43. After transfer, the web desirably continues through a heat emitting fusing or fixing device 44 onto a take up reel 45 being driven through a slip clutch arrangement 46, from motor 47. Fusing device 44 permanently fixes the transferred powder image onto the web to yield a xerographic print. Desirably electrode 43 has its corona discharge electrode operably connected to a high voltage source of like or positive polarity with respect to high voltage source 18 whereby a powder image developed on the surface of the drum is transferred to the web surface.

After transfer, the xerographic drum 8 continues to rotate past a cleaning station 50 at which residual developer on the drum surface is removed. This may include, for example, a rotating brush 51 whereby the bristles of the brush bear against the surface of the drum to remove residual developer powder therefrom. Vacuum means, not shown, maintains the brush relatively free of developer. Optionally, further charging means, illumination means, or the like may effect electrical or control operations.

It is to be noted that each of the structural elements described above in connection with the charging, exposing transfer, fixing, and cleaning steps illustrate conventional apparatus for thus purpose as is known in the art, not comprising the invention hereof and may be replaced with any other conventional systems or apparatus as may be known.

Referring now specifically to the developing station 30, developer for presentation to the surface of drum 8 is contained on the surface of one or more donor members 52 which are operative continuously for contact against the surface of the rotating xerographic drum 8. Surface properties of the donor are important to the extent that they should preferably be wear resistant, moderately smooth, dimensionally stable and insensitive to humidity and may, for example comprise coated woven nylon supported independently or secured to a more rigid member such as a rubber coated drum. Where a sliding action is to be effected between the donor surface and the xerographic plate as described below, the donor surface should preferably be selected to afford some degree of triboelectrification to the developer contained thereon. Further, as will be understood, the donor serves as an electrode for the field transfer of developer thereto. Accordingly, either the donor surface or an underlying support should provide the necessary conductivity. The donor may be shaped cylindrical as shown for tangential contact or can be any other suitable form of a preferably endless surface as a continuous belt or web member advanced into and out of contact with the xerographic drum. The width of the donor member is generally coextensive with the width of drum 8, and, as a minimum, is sufficiently wide and arranged to at least present developer to all peripheral areas of drum 8 on which latent images are being formed.

Movement of the donor in the embodiment shown is effected by means of a motor 53 connected to an axle 54 supporting the donor roll preferably to drive the roll in the same direction as the surface rotation of the xerographic drum. The speeds of the donor member and the drum may be substantially the same or the donor member can travel at surface speeds as high as 5 to 10 times as fast as the peripheral speed of the drum to effect a

skidding or sliding action thereagainst. When a sliding action is used, there is achieved a dual purpose of ensuring an extremely quick contact between all points of the surface of the drum and the donor member, while further bringing to each point of the drum surface a substantially greater quantity of developer material than is carried by any one point of area on the donor surface.

In accordance with the invention hereof, a quantity of developing particles for loading onto the donor surface and which may, for example, be a resin powder of the type described in Carlson patent U.S. Reissue 25,136 is contained in a hopper or bin type container 55 adapted and supported for substantially horizontal movement. The bin is enclosed along the sides and open at the top to receive a loading member 70 on which developer is loaded and in turn is transferred to the donor. To effect loading the bin is reciprocated rapidly in order to effect a relatively high degree of turbulence or "fluidizing" of the developer particles, being a condition at which the developer is highly agitated. Reciprocation of the bin is effected by means of a continuously operable motor 60 supporting on its output shaft a face plate 61 containing a rotatable crank pin 62 to which is connected one end of a crank 63. The opposite end of the crank is pivotally secured to a pin 64 secured in a flange 65 integral and extending outward from the rear wall of bin 55. As motor 60 rotates, a rapid reciprocating motion is transmitted to bin 55 at a velocity, frequency and length of stroke that is effective to produce the necessary turbulence of the developer contained therein. As will be understood, the rate of bin movement in order to effect the minimum degree of developer turbulence must be at least sufficient to generate the fluidized condition of the developer. At the same time, the maximum degree of turbulence for obvious reasons should not be so violent as to throw developer out from the confines of the bin into other working components of the surrounding apparatus. It was found in some instances that small metal pellets such as commonly available B-B shot, when mixed in with the developer particles will tend to prevent lumping or unduly heavy developer loading onto the loading member to be described below.

Passing through the developer in its fluidized condition for the purpose of being loaded uniformly with developer is a recycling loading member 70 shown cylindrical, and which like or unlike donor member 52 may be a web or other endless member. The top or peripheral surface of the loader which may comprise an overcoating 73 is characterized in the ability to retain developer particles which in its fluidized state come in contact thereagainst. Generally, the surface free energy of surface 73 as selected such that the developer particles are adhesively held to the surface. Materials found particularly suitable for this purpose as possessing these qualities and described by way of example are Fletcher's Alpena paper, polyethylene sheet, preferably preoxidized, and Kodak blotting paper, each of which have sufficient inherent durability to be independently supported or can optionally be attached to a firmer or stronger support member. In the case of Kodak blotting paper the mechanism of developer pick up is not thought to be one of adhesion but rather it is believed the developer is caught and held by the tooth of the paper. The materials are generally electrically insulating with an underlying conductive electrode by which field transfer can be effected to the donor. With some commercially available brands of polyethylene, it was found preferably in order to render it developer retentive, to pre-age as by subjecting it to ultraviolet radiation or corona discharge. Surface charge due to corona pre-aging was neutralized by subjecting the surface to a treatment that includes a neutralizing corona discharge and/or exposure to radioactive material. More specifically, as will be understood, the loading material in accordance with this invention is characterized by the ability to be mechanically loaded with developer, to

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transport the loaded developer through a charging step and to give up the developer to the donor under the influence of an electric field. Further, it is preferably adapted for continuous recycling operation.

As the loader surface is advanced by means of motor 53 through the region of bin 55 it receives a uniform loading of developer powder. The loader surface area bearing the powder then passes under a corona discharge device 71 energized from a potential source 72 to apply a uniform electrostatic charge on the developer passing thereunder. Polarity of the applied charge is a function of whether development is to be direct or reversed as to be attracted or repelled respectively by the latent image as is further described below. After charging the charged developer continues on the rotating loader into surface contact against donor member 52 whereat transfer from the former to the latter is effected under the influence of an electric field.

The electric field to effect developer transfer to the donor member is maintained in the form of a continuous bias supplied from a potential supply 80 and applied between the loading and donor members in the manner shown. The bias is of such magnitude as to be effective during the period of tangential contact to transfer the predominance of the developer particles from the surface of member 70 to the surface of donor member 52. A typical resulting characteristic developer transfer curve of developer density as related to the applied electrical transfer bias is illustrated in FIG. 4 and will, of course, vary as a function of the individual properties of the materials comprising loading member 70 and donor member 52, as well as the particular properties of the developer material being utilized. As can be seen, negative bias produced low density on the donor while maximum density of about 0.32 was achieved at about 550 volts positive and above. The charged developer continues on the moving donor to be presented into surface contact against the electrostatic image on the drum to effect development thereof. With a loading potential of about 200 volts approximately three repeated contacts were required with a freshly loaded surface to obtain an initial donor density adequate for image development. Thereafter, developer from the loader transferred to the depleted donor areas in preference to other areas still containing ample developer.

As shown in FIG. 1 there is illustrated two separate substantially identical combinations of loading and donor members. The number of these combinations required whether one or more or two as shown, is a function of the ultimate quantity and density of developer material transferred to the donor surface which to some degree is a further function of the velocity at which the various components are operative as well as the relative movement, if any, between the donor surface and the xerographic plate. At high velocities a decrease in donor density has been noted such that in order to present the xerographic drum with an optimum amount of developer two or more donor members are utilized and loaded as described above. Thus, for illustrative purposes as shown in FIG. 1, two separate donor members are utilized although one or more may be required depending on operating conditions. Also, in FIG. 1 they are shown loaded by two separate loading members. A variation of the above arrangement is illustrated in the embodiment of FIG. 2 which effects the necessary loading of a single donor member by means of two separate loaders acting thereon.

Referring now to FIG. 3 there is disclosed an embodiment similar to that described above in connection with FIG. 1 but having an added feature in which substantially large quantities of residual toner retained on drum 8 following transfer is returned to the loading member and consequently returned to the donor member for re-presentation. In the embodiment hereof, loading member 70 comprises a cylindrical member over which an end-

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less surface member 73 passes around and after loading extends over a series of guide rolls over and about a soft resilient type roll 81 mounted for rotation. Web 73 in passing over roll 81 is urged into contact against the photoconductive surface 9 of drum 8, preferably with a slight sliding action, while a bias potential 82 is maintained between drum 8 and roll 81. This arrangement has been found effective to transfer substantial amounts of residual toner from the drum to the web. The developer thus removed is conveyed by means of web 73 over suitable guide rolls to return through bin 55 whereat it receives additional developer loading as aforesaid.

By the above description, there has been disclosed novel method and apparatus for loading a donor member with developer particles for presentation of the particles to an electrostatic latent image to be developed. Consistently high quality image developments have been effected employing this apparatus, particularly when utilized in automatic machines in that the apparatus when operated continuously achieves an extremely high consistency of continuous loading of the donor member. Whereas the invention has been described primarily for use with direct development, i.e., developing charge areas on the xerographic plate, by applying a bias to the donor approximately equal and of like polarity as the initial xerographic plate potential while charging the developer on the donor to the same polarity uncharged rather than charged areas will be developed. Further, although the invention has been described primarily for use with development of electrostatic images formed directly on exposure, it is intended to be useful with electrostatic images formed by whatever means including the art of xeroprinting, charge transfer and the like.

Since many changes can be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the drawings and specification shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. Apparatus for transferring electroscopic developer particles to a charged surface for the development of a latent electrostatic image and to remove residual electroscopic developer particles therefrom including
 - a support means supporting an insulating member bearing a latent electrostatic image thereon,
 - means for supplying a quantity of electroscopic developer particles,
 - transfer means including a movable web loading member positioned in cooperative relation with said electroscopic developer particle supplying means to transfer electroscopic developer particles to said insulating member bearing a latent electrostatic image for the development thereof,
 - means to present a support surface adjacent said insulating member bearing a developed image thereon,
 - means to transfer substantially all of the developed image from said insulating member to said support surface leaving a residual of electroscopic developer particles on said insulating member, and
 - said movable web loading member operable to remove said residual of electroscopic developer particles from said insulating member for re-presentation to said insulating member.
2. The apparatus of claim 1 wherein said loading member comprises an endless web extending from contact with said electroscopic developer particle supplying means into contact with a donor member to transfer electroscopic developer particles from said loading member to said donor member for presentation to said latent electrostatic image bearing insulating surface and into contact with said surface at a position removed from said transfer means for re-presentation of said residual electroscopic developer particles to said donor member.
3. The apparatus of claim 2 including biasing means

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between said latent electrostatic image bearing insulating surface and said movable web loading member in contact with said surface at a position removed from said transfer means to facilitate the transfer of electroscopic developer particles from said surface to said loading member at the contact area thereof.

4. The apparatus of claim 2 including biasing means between said movable web loading member and said donor member in contact therewith to facilitate the transfer of electroscopic developer particles from said loading member to said donor member at the contact area thereof.

5. The apparatus of claim 4 including biasing means between said latent electrostatic image bearing insulating surface and said movable web loading member in contact with said surface at a position removed from said transfer means to facilitate the transfer of electroscopic developer particles from said surface to said loading member at the contact area thereof.

6. Apparatus for developing a latent electrostatic image comprising

- 20 container means containing a fluidized quantity of electroscopic developer particles,
- 25 a movable loading member characterized in its ability to retain on its surface fluidized developer particles in contact therewith,
- drive means to advance said loading member into contact with the fluidized particles in said container to receive a loading thereof,
- 30 charging means exposed about said loading member to apply an electrostatic charge to developer particles thereon,
- 35 a movable donor member arranged to be advanced sequentially from a position in contact with the charged developer on said loader to a position in contact with an electrostatic image bearing surface for development of the latent image thereat,
- means to generate an electric field between said load-

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ing and donor members during the contact period thereof to effectively transfer charged developer from the contact areas of said loading member to said donor member,

5 a secondary support surface passing adjacent to said developed image bearing surface for the transfer of substantially a completely developed image thereto leaving a residual of developer particles on said surface, and

10 said loading member including an endless web advancing from donor contact into a transfer relation with the residual developer on the developed image bearing surface to transfer the residual developer particles to the loading member.

15 7. Apparatus according to claim 6 including means for applying an electrical bias between the electrostatic image bearing surface and said loading member during said transfer relation to expedite the transfer of residual developer.

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