

Nov. 8, 1960

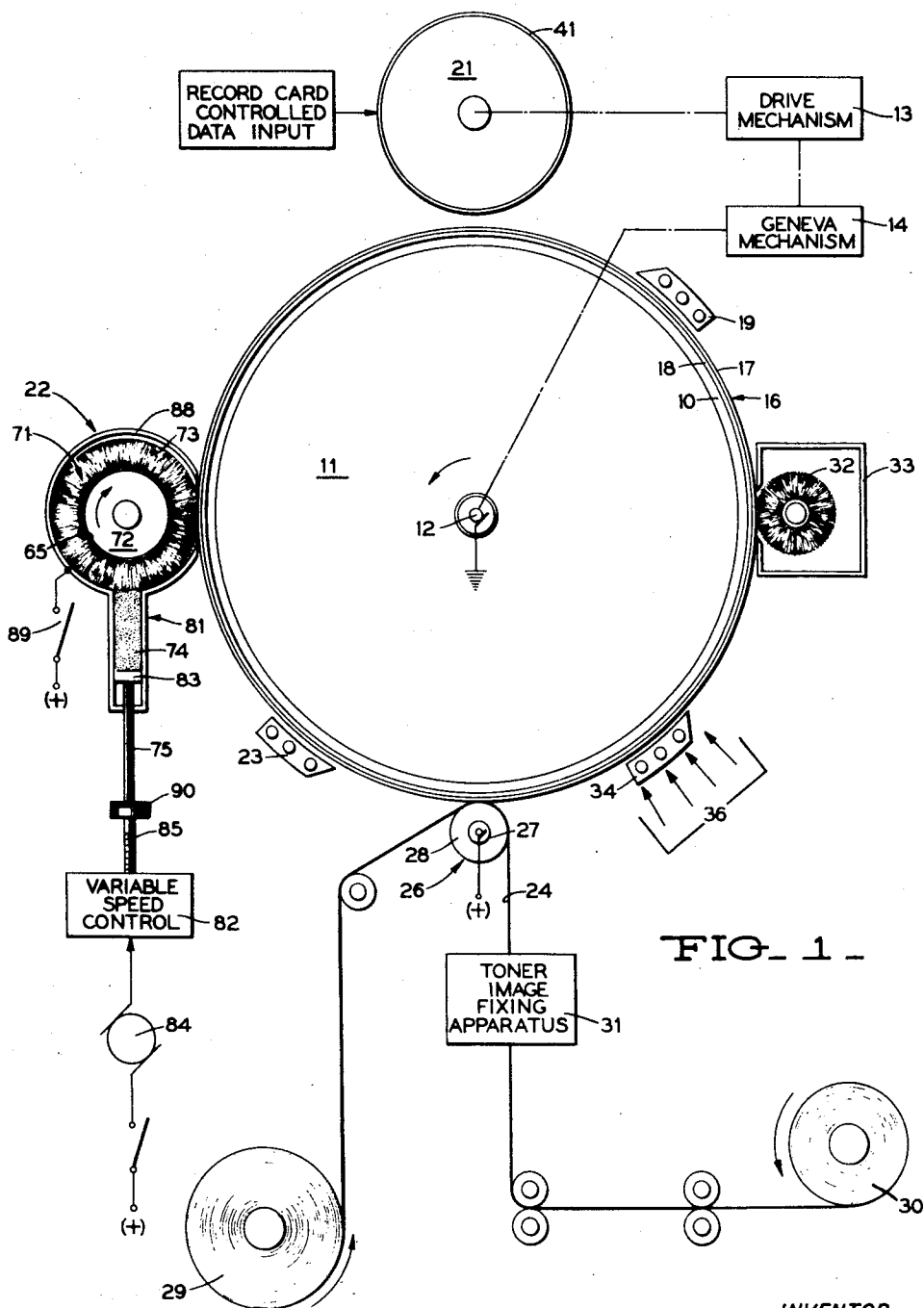
T. M. HIDER

2,959,153

XEROGRAPHIC IMAGE DEVELOPING APPARATUS

Filed Dec. 21, 1955

3 Sheets-Sheet 1



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XEROGRAPHIC IMAGE DEVELOPING APPARATUS

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3 Sheets-Sheet 2

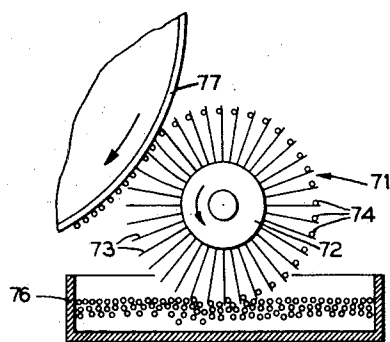


FIG. 2 -

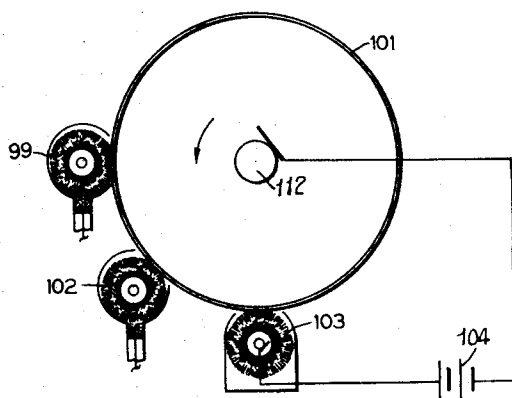


FIG. 3 -

Nov. 8, 1960

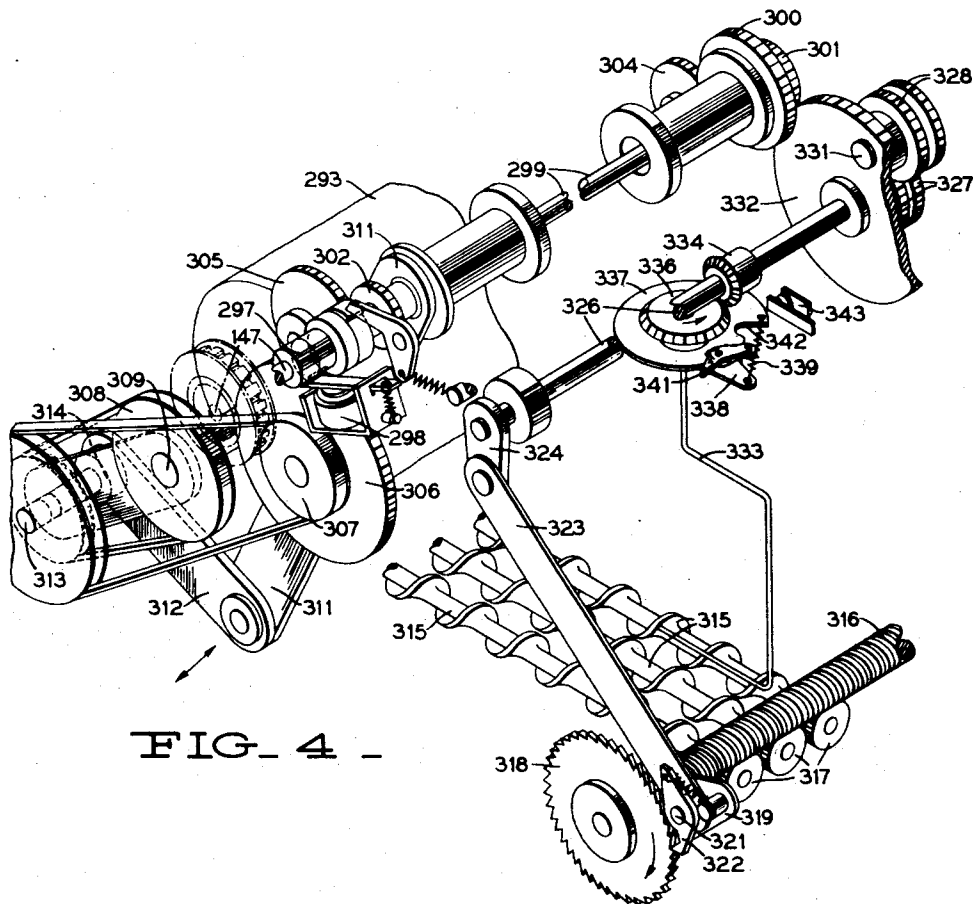
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2,959,153

XEROGRAPHIC IMAGE DEVELOPING APPARATUS

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Filed Dec. 21, 1955, Ser. No. 554,514

2 Claims. (Cl. 118—637)

This invention relates in general to electrographic printing machines and in particular to improved apparatus thereof for developing latent electrostatic images.

The preferred embodiment of the invention to be described herein is adapted for use in a type of electrographic printing machine commonly referred to as a xerographic printer. As is well known to persons familiar with this phase of the graphic arts, xerography is a term applied to a printing process in which latent electrostatic images are rendered visible, i.e., developed, by a pigmented electrosopic powder, often referred to as xerographic toner, the resulting electrosopic powder image thereafter first being transferred and then affixed to a print receiving sheet so as to afford a permanent printed copy which depicts the latent electrostatic image exactly. An apparatus employing such a printing process is shown and described in Carlson Patent No. 2,357,809 which issued on September 12, 1944, and follows the steps of electrically charging an electroplate having a photoconductive insulating layer on an electrically conductive backing member, exposing the charged plate to an optical image so as to form a latent electrostatic image thereof on the electroplate, dusting the latent electrostatic image with xerographic toner in order to develop this latent image so that the configuration thereof is rendered visible, transferring the xerographic toner image onto a print receiving sheet such as paper, and finally removing any excess toner which remains on the surface of the electroplate after the preceding transfer step but prior to the next electroplate charging step.

Another kind of xerographic printer employing a printing process somewhat different from the aforementioned one disclosed by the Carlson patent, is shown and described in Schaffert Patent No. 2,576,047 which issued on November 20, 1951. This printing machine embodies a continuously rotating drum on which an electrically insulating image layer is secured. This permanent design image layer is electrostatically charged prior to being dusted with xerographic toner. The toner will, of course, be attracted and adhere to the charged surface area of the permanent design image layer so that when the toner supported thereby is transferred onto a print receiving sheet, the xerographic toner so transferred will define a configuration similar to the permanent design image layer. This latter type of printing where the image layer is permanently formed, is commonly referred to as xeroprinting in order to distinguish the same from other types of xerographic printing. It is to be observed that a xeroprinting machine is in essence a printing duplicator because any number of copies may be produced from a single permanent design image layer.

The present invention which is adaptable for use in either type xerographic printer, is directed to improvements in the latent electrostatic image developing apparatus over and beyond those improvements disclosed and claimed in copending U.S. patent application Serial No. 554,515, filed on December 21, 1955, by W. D. Bolton et al., and has for its broad object the provision of an

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improved latent electrostatic image developing apparatus.

As is brought out in the aforementioned copending Bolton et al. application, it is well recognized that xerography, or "dry-printing" as it is so often called, requires the application of the pigmented powder onto an electroplate surface in order to develop the latent electrostatic images thereon. It might be well at this time to point out that in view of the fact that an electrophotoplate is a member comprising a photoconductive insulating layer on a conductive backing, and since an electroplate is a member comprising an insulating layer, photoelectric and otherwise, on a conductive backing, it is intended to include an electrophotoplate by the use of the expression electroplate. In connection with the statement hereinabove that xerography requires the application of a pigmented powder onto an electroplate surface, it is recognized by persons familiar with this phase of the graphic arts that this has been accomplished heretofore in a number of different ways, such as by dusting, brushing, etc. For example, the aforementioned Schaffert patent discloses a so-called cascade type developer apparatus for causing a mixture of xerographic toner particles and much larger carrier particles to cascade over each portion of the xerographic drum surface. As a result, toner particles adhere to the surface thereof to define latent electrostatic images thereon, whereas the carrier particles simply roll over the xerographic drum surface and into a suitable reservoir. The mixture of toner and carrier particles is used because of a triboelectric relationship therebetween whereby a negative charge is imparted to the toner particles and a positive charge is imparted to the carrier particles, by the physical contact therebetween. This, of course, is desirable in view of the fact that in the machine under consideration, the latent electrostatic images are defined by positive charges.

The image developing apparatus described in the aforementioned copending Bolton et al. application, utilizes a soft fur brush for transferring xerographic toner particles from a suitable source onto an electroplate surface. In addition to transferring the toner particles, the soft fur brush causes a negative triboelectric charge to be imparted to these particles actually brought into physical contact with the brush hairs. In addition to rotating the soft fur brush whereon toner particles are first deposited and then transferred onto the surface of a xerographic drum by the gentle wiping action of the brush in the direction of drum movement, the rotating fur brush may be stippled with respect to the xerographic drum surface. This can be accomplished by using a mechanism for oscillating the rotating developer brush towards and away from the xerographic drum surface so that the brush hair ends are moved into and out of contact with the drum surface, respectively.

It has been discovered, however, that as the xerographic machine printing speed is increased, various undesirable results are realized insofar as the developing of the latent images is concerned. One such undesirable result is non-uniformity of printed copy; that is, the density of the xerographic toner image as developed is not uniform throughout the entire printed copy, but instead some portions of the image are very dark whereas other portions are extremely light. This problem appears to have been solved by using two or more adjacent developing brushes for applying toner to the electroplate surface. Accordingly, in keeping with the foregoing, another object of this invention is to provide an improved latent electrostatic image developing apparatus for use in high speed xerographic printers.

Another object of this invention is to provide a latent electrostatic image developing apparatus for producing uniform density printed copy.

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Still another object of this invention is to provide a latent electrostatic image developing brush apparatus utilizing a plurality of developing brushes.

It has been discovered through actual trial and experimentation that at times when there is an endeavor to increase the density of the toner image, there is also a considerable increase in the density of the background portion of the image. This, of course, is undesirable in view of the fact that a good developed image is one which has high contrast between the image and its background, and would be one wherein the printed symbol configuration areas were dark, i.e., the toner density within these areas was quite high, and the background areas were white, i.e., the toner density of the background areas was extremely low. In line with this, another object of this invention is to provide a latent electrostatic image developing apparatus for producing printed copy having developed toner images of high density and background areas of extremely low, and for all practical purposes no, toner density.

Another object of this invention is to provide an apparatus for removing image background toner from the surface of an electroplate without disturbing the toner density of the image per se.

Other objects of the invention will be pointed out in the following description and claims and illustrated in the accompanying drawings, which disclose, by way of examples, the principle of the invention and the best mode, which has been contemplated, of applying that principle.

In the drawings:

Fig. 1 is a diagrammatic view of a continuously operating xerographic printer employing brush development.

Fig. 2 is a schematic showing of a brush developer apparatus.

Fig. 3 is a diagrammatic view of a plural brush developing apparatus for a xerographic printer.

Fig. 4 is an isometric view of a single brush apparatus used in a latent electrostatic image developing station for effecting a series of separate, overlapping, gentle brush wiping action relative the surface of a xerographic drum.

General description

Referring to Fig. 1 wherein the preferred embodiment of this invention is shown, the metal cylinder 10 of xerographic drum 11 is mounted for rotation on a drive shaft 12 which is driven in a counterclockwise direction by an electric motor (not shown) within drive mechanism 13 via a conventional Geneva mechanism 14. This drum 11 has secured thereto an electroplate 16 which includes an insulating layer 17 of amorphous selenium, for example, on an electrically conductive backing member 18 of aluminum, for instance. The electroplate 16 is flexed around cylinder 10 as shown, and is attached thereto in any one of the numerous conventional ways of attaching a printing plate to a supporting cylinder. It is important, however, that in whatever manner this attachment is made, the backing member 18 be in intimate contact with the insulating layer 17 as well as in good electrical contact with the drum cylinder 10 which is connected to ground potential via shaft 12.

As successive incremental areas of the insulating layer 17 are moved in a counterclockwise direction past ion-producing charging unit 19 of the type shown and described in Carlson Patent No. 2,588,699 issued on March 11, 1952, the aforesaid layer 17 of dielectric material is electrostatically charged positive. These positively charged incremental areas are then moved past an optical image producing unit 21 which projects optical images of the text or matter to be copied, onto the electrically charged surface of photoconductive insulating layer 17. The apparatus by which the optical images are produced and projected onto the surface of layer 17

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of electroplate 16, is described in the copending U.S. patent application, Serial No. 554,513, filed on December 21, 1955, by W. D. Bolton. In view of the fact that the optical image producing apparatus per se is not a part of this invention, the same will not be described in detail herein.

Consequent upon the exposure of the photoconductive insulating layer 17 to the optical images produced by, and directed from, optical unit 21, latent electrostatic images thereof are produced on electroplate 16. This is for the reason that those electrically charged incremental areas of insulating layer 17, onto which light rays are directed, are discharged, whereas those areas not illuminated by light rays remain charged. Hence, after the positively charged electroplate 16 is exposed to the aforesaid optical images, latent electrostatic images thereof corresponding to the optical information projected onto the surface of xerographics drum 11, will remain.

Continued rotation in a counterclockwise direction will cause the latent electrostatic images appearing on electroplate 16 of drum 11 to be moved into a latent electrostatic image developing chamber 22. This chamber which will be described in more detail hereinafter is one wherein xerographic toner of the general type described in Copley Patent No. 2,659,670 which issued on November 17, 1953, is applied to the exposed surface of electroplate 16, and, of course, over the latent electrostatic images thereon. As a result, the pigmented toner particles will adhere to only the afore-mentioned image defining charged areas of electroplate 16, whereby a corresponding number of developed toner images which now visibly define their respective latent electrostatic images appear on the surface of the electroplate.

A still further counterclockwise rotation of xerographic drum 11 will cause the toner images developed on the surface of electroplate 16, to move out of developing chamber 22 and into the realm of a negative ion-producing unit 23 which is similar to afore-mentioned unit 19. The effect of this second electrostatic field produced by unit 23 is to decrease somewhat the magnitude of the image defining positive electrical charge stored in non-conducting layer 17. This is to condition the developed toner images being carried on the surface of electroplate 16 for ready transfer onto a print receiving web 24. In addition thereto, the negative electrostatic field to which the photoconductive insulating layer 17 is subjected, corrects an unfavorable condition known generally as "selenium fatigue."

Further rotation of drum 11 causes the developed toner images thereon to move into a xerographic toner image transfer, or printing, station, whereat a transfer roller 26 comprising a metallic conductive portion 27 and an outer portion 28 of a very resilient material having a high electrical resistance of at least 10^6 power ohms per cubic centimeter, is used to transfer the xerographic toner images from the surface of electroplate 16 onto the surface of print receiving web 24. The transfer roller 26 is similar to one shown and described in detail in copending U.S. patent application Serial No. 419,314, filed by C. J. Fitch on March 29, 1954, now U.S. Patent No. 2,807,233, and for this reason, the same will not be described in detail herein. The print receiving web 24, which is preferably a paper strip, is advanced by conventional means (not shown) from a web supply roll 29 to a web take-up roll 30 via the afore-mentioned transfer station whereat transfer roll 26 is located, and a toner image fixing station 31. The positive potential applied to transfer roller 26 causes the xerographic toner particles on the drum surface and which define the latent electrostatic images, to migrate from the surface of electroplate 16 to the opposite surface of print receiving web 24. It might be well to mention here that web 24 is advanced at a lineal speed that corresponds to the peripheral speed of xerographic drum 11.

In order to remove any excess xerographic toner par-

titles that might remain on the surface of electroplate 16 after the toner image transfer but prior to charging the incremental areas of the photoconductive insulating layer 17 again by ion-producing unit 19 during another machine cycle, a rotating plush cleaning roller 32 is positioned within a housing 33 for retaining the toner so removed from the surface of electroplate 16 by roller 32. A vacuum cleaner unit (not shown) may also be utilized within the housing 33 in order to remove the xerographic toner caused to be accumulated therein. As is shown in Fig. 1, prior to subjecting the incremental areas of the photoconductive insulating layer 17 to the cleaning action of plush roller 32, the electroplate 16 is preferably subjected to another negative electrostatic field produced by corona unit 34 which is similar to afore-mentioned unit 23. A beam of light rays from a source 36 is also projected onto the surface of electroplate 16 so as to assure discharge of all of the areas of the photoconductive insulating layer 17. The negative field produced by unit 34 tends to avoid the previously mentioned unfavorable condition selenium fatigue, and also conditions the drum surface for easy removal of the toner particles remaining on the surface of the electroplate after transfer.

The xerographic toner images transferred onto the surface of print receiving web 24 may be affixed thereto by any one of several known methods which include fixing by pressure, heat and toner chemical solvent. Pressure fixing rollers within unit 31 are employed in the preferred embodiment of this invention, and a sufficient line contact pressure of approximately 500 pounds per lineal inch of contact is employed to cause the xerographic toner supported by the surface of the web to flow into the fibers thereof. In order to assure that the web is not torn or mutilated by being pulled through the pressure fixing rollers (not shown), the rollers are connected to the main drive mechanism 13 so as to be rotated in step with movement of xerographic drum 11.

Electroscopic toner

In xerographic printers, latent electrostatic images are developed by applying an electroscopic or xerographic toner to the surface of the insulating material whereon said latent images appear. The constituent make-up and characteristic properties of this toner that make the same suitable for developing such latent electrostatic images, are described in Copley Patent No. 2,659,670 which is issued on November 17, 1953. One of the most important properties of xerographic toner resides in its property to become charged triboelectrically. Thus, the constituent toner and carrier parts of an electroscopic or xerographic developer, such as is described in Walkup et al. Patent No. 2,638,416 which issued on May 12, 1953, are selected in accordance with their triboelectric properties so that when brought into mutual contact, one material part, e.g., the carrier, is charged positive if the other material part is below it in a triboelectric series, and the other material part, e.g., the toner, is charged negative if the first material part is above it in the triboelectric series. The carrier particles may be of a size in the order of 30 to 60 mesh, so that these particles will flow easily over the electroplate by gravity. As brought out in the afore-mentioned Schaffert patent, satisfactory latent electrostatic image development is obtainable by cascading xerographic developer comprised of carrier and electroscopic toner over the surface of the electroplate whereon the latent images are formed. However, experimental and field use to date has very decidedly shown that the comparatively large and hard granular carrier particles have a deleterious effect on the surface of the insulating layer 17 (Fig. 1) of the electroplate 16 due to abrasion. This is particularly the case when delicate amorphous selenium is used as the insulating layer.

Brush development

Introduction.—It has already been brought out that xerographic developer includes comparatively large and

hard granular carrier particles as well as fine electroscopic toner particles. It has also been brought out that physical contact between the carrier particles and the toner particles causes a triboelectric charge of one polarity to be imparted to the toner and of the other polarity to the carrier particles. The toner charge is such as to be electrically opposite to the charge which defines the latent electrostatic images appearing on the insulating layer of the electroplate. In brush development to be described herein, a soft fur brush is used in place of the coarse granular carrier particles necessary for cascade development, to impart the necessary triboelectric charge to the toner particles. It is by the somewhat vigorous agitation of the soft fur brush hairs relative the xerographic toner particles that the triboelectric charge is imparted to the toner particles. It might be well to mention here that the brush hairs also have a triboelectric charge imparted thereto as did the afore-mentioned carrier particles. As is to be expected, the brush is also used to convey toner particles from a suitable source of toner supply to the surface of the insulating layer of the electroplate whereon the latent electrostatic images are formed.

General.—Referring to Fig. 2, the principle of brush development as it is now understood in its simplest form may be explained quite easily. A brush 71 of either beaver or red fox skin, for example, is secured to a rotatable drum or cylinder 72 which, in turn, is so arranged that the brush hairs 73 move through a mass of xerographic toner 74 in a source reservoir 76, and also in physical contact with the surface of a dielectric layer of an electroplate 77. The physical contact, and resulting agitation, between the brush hairs 73 and the toner particles 74 causes a triboelectric charge to be imparted to the toner particles so acted upon. The use of a fur skin such as the beaver or the red fox referred to hereinabove, as well as use of xerographic toner such as described previously, causes a negative triboelectric charge to be imparted to the toner particles and a positive triboelectric charge to be imparted to the brush hairs. Thus, as incremental areas of the insulating layer of electroplate 77 having positively charged latent electrostatic images thereon, are subjected to the negatively charged toner particles 74, the charged particles are caused to adhere to the positively charged surface areas of electroplate 77. As a result, the said latent electrostatic images are caused to be developed. It should be evident that the use of a soft fur brush in place of the granular carrier particles eliminates the deleterious abrasive action of the carrier particles, particularly as they tumble over the delicate surface layer of an electroplate such as amorphous selenium.

The application of brush development in a xerographic printer is shown in Fig. 1. A continuously rotating brush 71, the conventional drive for which is not shown, is moved in a clockwise direction at a greater speed than is the drum 11 so that the brush hairs 73 effect a gentle wiping action relative the insulating layer surface of electroplate 16. For example, the peripheral speed of the drum 11 can be 700 inches per minute, whereas the speed of the brush hair ends can be 1700 inches per minute. These brush hairs 73 initially pick up, or have deposited thereon, toner particles 74 from the orifice end of a piston-type toner feeding mechanism 81. Then, during the course of clockwise movement of brush 71, the toner particles so deposited contact the fur brush hairs 73, whereby a negative triboelectric charge is imparted to these particles. Stirrer rods (not shown) or the like, are normally used in order to effect a better and more intimate contact between the individual toner particles and the brush hairs. Finally, as the negatively charged toner particles are transferred from brush 71 onto the surface of electroplate 16, there is of course adherence to the charged surface thereof due to an attraction between the positively charge latent electrostatic images and the negatively charged toner particles.

Toner feed device.—Xerographic toner can be supplied

to the brush hairs 73 via the piston toner feed mechanism 81 at a rate which may be varied either manually or automatically. There is shown in Fig. 1 a variable speed control apparatus 82 driven by motor 84, which apparatus may be manually governed in order to change the advancing movement of piston 83 and therefore the amount of toner being deposited on the brush hairs.

External voltage application.—The brush 71 (Fig. 1) is shown to be secured to a rotatable cylinder which has an electrically conductive cylinder 65 attached thereto for supporting brush 71 within an electrically conductive shell 88 whose inner surface is always in physical contact with brush hairs 73 of brush 71. Cylinder 65 is, of course, in contact with the brush pelt or skin. By applying a positive potential to this electrically conductive cylinder 65, for example, being careful, of course, to electrically isolate this cylinder from ground, the transfer or toner particles from the brush hairs 73 onto the latent electrostatic image bearing surface of electroplate 16 is prevented. The action that takes place to preclude toner transfer is not too clear, although it is believed that the high positive potential applied to cylinder 65 directs a positive charge to the brush hairs which therefore have a greater attraction for the triboelectrically charged negative toner particles than do the positively charged latent electrostatic images appearing on the surface of the xerographic drum. Once again, it is not too clear just what the physical action is that takes place to cause the afore-described results actually realized. One explanation for this behavior, however, might be that the natural triboelectric action between the xerographic toner particles and the brush hairs, such as those found in the skins of beaver or red fox for example, produces negatively charged toner particles and positively charged brush hairs. When these brush hairs are subjected to an outside positive voltage, the negatively charged toner particles are simply attracted that much more to the brush hairs so as to prevent the migration of the negatively charged toner particles to the charged image defining areas on the surface of the electroplate. This is probably for the reason that with the application of an external positive potential to the brush, the brush hairs are charged to a higher positive value than are the latent electrostatic image areas. On the other hand, the application of a negative potential to the brush hairs repels the negatively charged toner particles so that more toner particles are caused to be attracted to and/or driven towards, the positively charged image areas of the electroplate. In fact, the slightly positive residual potential of approximately 50 volts which nearly always appears to remain in the background areas of the latent electrostatic images on the electroplate, attracts more of these negatively charged toner particles when the brush is subjected to a negative voltage.

Brush stippling.—Improved toner images have been realized by reciprocating axially and by stippling the rotating developing brush relative the surface of the electroplate whereon the latent electrostatic images are formed. The stippling action is performed by moving brush 71 (Fig. 1) towards and away from the electroplate 16 so that the hairs 73 thereof are caused to produce a "patting" or "powdering" action relative to the electroplate surface. It has been found that good results are obtainable by moving the brush 71 from one limit whereat the brush hair ends are barely in contact with the electroplate surface to another limit whereat the brush has been moved radially towards the xerographic drum along a line defined by the brush and xerographic drum centers, a distance of approximately $\frac{3}{4}$ ". This is not to be taken as a limitation but rather as an example. It will be clear to those persons having ordinary skill in the art that other arrangements and/or parameters might be employed to produce a satisfactory stippling action.

It has been found that a rate of 1200 stipples per minute is very effective for good image development.

This, for all practical purposes and within presently known engineering limits, appears to be independent of the xerographic drum rotational speed. However, once again, the foregoing is not to be taken as a limitation in view of the fact that acceptable results are obtainable when the stippling action occurs at a rate other than 1200 per minute. It is believed that brush stippling is as effective as it is because the uniformity of toner particle charge depends on the effectiveness of agitation between the brush hairs and the toner. During the course of the stippling action, the brush becomes fully extended in the direction of oscillation so as to afford a violent motion which is believed necessary to realize the desired toner charge. The toned brush, i.e., the toner applying brush, is rotated slightly faster in the direction of movement of the xerographic drum 11 than is the peripheral surface speed of the xerographic drum. Thus, the freshly toned brush hairs 73 are presented in a wiping motion to every portion of the surface whereon the latent electrostatic images are to be found. Since the stippling action is in a direction substantially normal to the xerographic drum surface, the brush hairs bend randomly upon contact with the surface. The over-all effect is to produce a combined patting-wiping action relative the electroplate surface; that is, one whereby a series of separate, overlapping, gentle brush wiping actions are realized in the direction of drum rotation.

Plural brush developing

As stated previously, very often and especially when the xerographic machine printing speed is made quite high, the density of the images produced on the printed copy is non-uniform. Thus, the density of the images of a portion of the printed copy may be high, whereas the density of the images in another portion of the printed copy may be very low. This difficulty can be corrected by employing two or more developing brushes each of which is similar to brush 71 of Fig. 1. Various brush arrangements may be used depending upon the design limits of a xerographic printer as well as the requirements for the printed copy desired. Referring to Fig. 3, the first toned brush 99, i.e., a brush for transferring electroscopic toner from a suitable source onto the surface of the xerographic drum, is employed to develop the latent electrostatic images on the surface of electroplate 101 in the manner described previously. The second toned brush is similarly used, and may be spaced apart from the first brush approximately 6 to 8 inches, for example. A developed toner image is produced, of course, by the gentle patting-wiping action of the first brush 99 relative the surface of electroplate 101. However, if the peripheral speed of the xerographic drum having electroplate 101 attached thereto, is sufficiently high, the non-uniform printed copy referred to hereinbefore will result. This failure is corrected by the succeeding toned brushes, such as toned brush 102. Interestingly enough, the patting-wiping action produced by the second toned brush 102 increases the density of the developed toner image in only those areas where the initial image toner density produced by the first toned brush 99, is low. On the other hand, the action of the second toned brush 102 does not noticeably add to the density of the image background area or to those regions of the developed toner image as produced by only the first toned brush 99, which regions initially had a high density to provide a good image. Thus, the over-all effect of the second toned brush is to equalize the density of the entire toner image depicted by the printed copy without noticeably adding to the density of the image background area per se.

It might be expected on first impression that the second brush 102 would either smear and/or wipe off the toner particles transferred to electroplate 101 by the first toned brush 99. This does not occur, of course, and probably so for one reason that the patting-wiping action of the

second brush relative the surface of the electroplate is extremely gentle. For another thing, it is believed that action between the electroscopic toner particles and the brush hairs of each of the developing brushes is such that various ones of the said toner particles are caused to adhere to either the electroplate surface whereat areas define the latent electrostatic images thereon, or the brush hairs per se that have a triboelectric charge imparted thereto which is opposite to the triboelectric charge of the toner particles.

At times when two or more toned brushes are used successively with respect to the incremental areas of the electroplate, the toner density of the image background area may be raised to an undesirable level. This occurs for reasons which are not too clear at the present time. Accordingly, the need to remove this objectionable toner density image background area is of prime importance. This can be done by employing still another developing brush arrangement which, however, does not include a toner supply source. That is, this latter-mentioned developer brush apparatus does not have provision for applying toner to the electroplate surface, but instead, this brush is caused to run "dry" in order to remove the image background toner from the surface of the electroplate. Such an over-all arrangement is shown in Fig. 3 wherein one or more toner applying brushes are used, such as brushes 99 and 102 for example, along with the so-called toner image background removing brush 103. As stated previously, this latter-mentioned brush is one which is similar to and is operated the same as the brushes 99 and 102, except for the fact that the hairs of brush 103 which could be of beaver skin for example, are not moved through a toner source in order to add more toner to the surface of electroplate 101. Instead, as stated previously, brush 103 is caused to run "dry" as it were, and to contact only the surface of electroplate 101 whereon there is a toner image already. There is, however, a potential of approximately +600 volts to +1000 volts applied to the hairs of brush 103 via a source of D.C. potential 104, the positive output of which is connected to a cylindrical conductor similar to cylinder 65 (Fig. 1), to which cylinder the brush is attached for rotation. The negative output of D.C. source 104 is connected to electroplate 101 through shaft 112 with which it is in electrical contact as explained in connection with electroplate 16 of Fig. 1. As a result, it has been found that such use of a brush causes the removal of nearly all, and for practical purposes, all of the image background toner particles without noticeably altering the toner density of the developed images, thereby producing a clear, clean background printed record copy; i.e., one having maximum contrast between the image per se and the background thereof. It is believed that the action which takes place due to the image background "cleaning" brush is one wherein the triboelectric attraction between the brush hairs of brush 103 and the toner particles adhering to the electroplate surface areas defining the image background, is greater than the attraction between the residual charge and the triboelectrically charged toner particles. The triboelectric attraction between the brush hairs of brush 103 and the toner particles defining the image to be printed, however, appears not to be greater than the attraction afforded by the latent electrostatic image stored in electroplate 101. Accordingly, as stated previously, the use of such a brush as brush 103 permits the removal of nearly all, and for practical purposes, all of the background toner without noticeably altering the toner density of the developed images.

Developer mechanism description

A latent electrostatic image developer mechanism employing a single brush for effecting a series of separate, overlapping, gentle brush wiping movements relative the surface of an electroplate, is shown in Fig. 4. Thus, to apply the mechanism of Fig. 4 to the arrangement shown

in Fig. 3, three such mechanisms would be necessary. Inasmuch as brush 103 in Fig. 3 is the background "cleaning" brush, there would be no toner feeding apparatus associated with the brush 103 latent electrostatic image developer mechanism. In fact, there would more than likely be a vacuum cleaning unit associated with this latter-mentioned brush in order to remove from the brush hairs thereof any toner particles transferred from the surface of electroplate 101 to the said brush hairs.

Referring to Fig. 4, shaft 147 normally rotates continuously so long as the drive motor (not shown) for the xerographic printer is operating. This means then that the driven portion of spring clutch 297 will also operate continuously. In response to the energization of clutch magnet 298 by circuit means (not shown), the spring clutch 297 is caused to engage, and the driven shaft 299 together with gears 300—302 secured to said shaft 299, are caused to operate. Gears 300 and 302 are engaged with gears 304 and 305, respectively, both of the latter-mentioned gears being secured to a common shaft. Gear 305, in turn, engages gear 306 which has secured thereto for movement therewith a pulley 307. By the belt and pulley arrangement shown, the power directed to pulley 307 is transmitted to another pulley 303 which is secured to a shaft 309. The developing brush 293 is fastened to the same shaft 309, so that whenever the clutch magnet 298 is energized, a rotary motion is imparted to developer brush 293 via shaft 299, gears 302, 305 and 306, and pulleys 307—303.

The requisite stippling action is imparted to brush 293 whenever driven shaft 299 is caused to operate, by way of link 311 which is eccentrically mounted at its upper end on shaft 299. Thus, as shaft 299 is caused to rotate, arm 311 is caused to oscillate, whereby arm 312 is caused to rock about its shaft 313. The brush shaft supporting link 314 is secured to shaft 313 for movement therewith. As a result, the arm 314 along with the pulley 308 and brush 293 is caused to rock about shaft 313 whenever arm 312 is caused to rock.

Normally there is a sufficient quantity of xerographic toner within the latent electrostatic image developer apparatus reservoir (not shown) so as to completely cover the fluted toner feeding members 315. The arrangement is such that whenever threaded shaft 316 is caused to rotate, the afore-mentioned fluted members 315 are also caused to rotate via their respective gears 317. As the fluted members 315 rotate, their respective flutes move, or push, a quantity of xerographic toner in the direction of brush 293. This action then assures that a quantity of xerographic toner will always be available in the realm of brush 293. As is shown in Fig. 7, threaded shaft 316 is attached to notched disc 318. A dog carrying member 319 is freely mounted on shaft 316, and has projecting therefrom a stud 321, whereon a dog 322 is freely mounted. Arranged intermediate this dog and arm 319, is a connecting link 323 which is connected by way of another link 324 to shaft 326. Shaft 326 has connected thereto for movement therewith a pair of driven gears 327 which are engaged with planetary drive gears 328. The latter-mentioned gears are supported by stud shaft 331 that projects from gear 332. The latter-mentioned gear is engaged with gear 301 which, as will be recalled, is secured to shaft 299. Thus, whenever clutch magnet 298 is energized, so as to permit the spring clutch 297 to engage, whereby shaft 299 and gear 301 are caused to rotate, motion is imparted to gears 327 via gears 328 and 332. Of course, due to the particular gear arrangement used, gears 327 and their corresponding shaft 326 are not caused to rotate one complete revolution for each complete revolution effected by gear 301. The reason for this is that the amount of xerographic toner needed to be pushed or fed to brush 293 is of a limited quantity. However, as shaft 326 rotates, the link 324 attached thereto also rotates and causes link 323 to reciprocate. Hence, as link 323 is moved in a generally upward di-

rection, the dog 322 simply rides over the teeth appearing on notched disc 318. However, as the link 323 is moved in a generally downward direction, the dog 322 engages a tooth on ratchet 318, whereupon the ratchet and its associated shaft 316 is caused to move a given amount.

While there have been shown and described and pointed out the fundamental novel features of the invention as applied to a preferred embodiment, it will be understood that various omissions and substitutions and changes in the form and details of the device illustrated and in its operation may be made by those skilled in the art, without departing from the spirit of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. A xerographic printer comprising a rotatable drum and a cylindrical electroplate mounted thereon, said electroplate having an outer peripheral surface adapted to have electrostatic images stored thereon; means for developing said electrostatic image forming a developing station along the path of travel of said surface comprising a pair of fur brushes supported proximate said surface, each of said brushes having fibers movable into contact with said surface at spaced successive locations, means for applying a quantity of electroscopic toner powder to each of said brushes, said fibers of each of said brushes and said powder being triboelectrically related so as to be mutually electrostatically charged on contact whereby said powder is retained on said fibers for deposition on the image bearing portions of said electroplate surface; means for rotating said drum so as to advance said electroplate surface past said development station; and means for effecting successive series of separate, overlapping, wiping actions of each of said brushes in the direction of said electroplate surface advance and over every portion of said electroplate surface so as to obtain a more uniform development of said images including means for oscillating each of said brushes radially relative to said electroplate surface so as to move said fibers of each of said brushes into and out of physical contact with said electroplate surface, and means for rotating each of said brushes simultaneously and continuously with said oscillating movement in the direction of and at a greater linear velocity than said electroplate surface advance.

2. In a xerographic printer comprising a rotatable drum and a cylindrical electroplate mounted thereon, said electroplate having an outer peripheral surface adapted to have electrostatic images stored thereon; means for developing said electrostatic images forming a developing station along the path of travel of said surface comprising a plurality of image developing fur brushes supported proximate

said surface, each of said brushes having fibers movable into contact with said surface at spaced successive locations, means for applying a quantity of electroscopic toner powder to said image developing brushes, said fibers of each of said brushes and said powder being triboelectrically related so as to be mutually electrostatically charged on contact whereby said powder is retained on said fibers for deposition on the image bearing portions of said electroplate surface, a background removing fur brush supported proximate said surface having fibers movable into contact with said surface at a location succeeding said image developing brushes, said fibers of said background removing fur brush and said powder being triboelectrically related so as to be mutually electrostatically charged on contact whereby said powder is retained on said fibers for removal from the nonimage bearing portions of said electroplate surface, a source of D.C. potential, means for connecting the negative output of said source to said electroplate and the positive output of said potential to said background removing brush; means for rotating said drum so as to advance said electroplate surface past said development station; and means for effecting successive series of separate, overlapping, wiping actions of each of said brushes in the direction of said electroplate surface advance and over every portion of said electroplate surface so as to obtain a uniform high density developed toner image with low density background including means for oscillating each of said brushes radially relative to said electroplate surface so as to move said fibers of all of said brushes into and out of physical contact with said electroplate surface, and means for rotating each of said brushes simultaneously and continuously with said oscillating movement in the direction of and at a greater linear velocity than said electroplate surface advance.

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