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XEROGRAPHIC PLATE CLEANING METHOD UTILIZING THE RELATIVE MOVEMENT OF A CLEANING WEB

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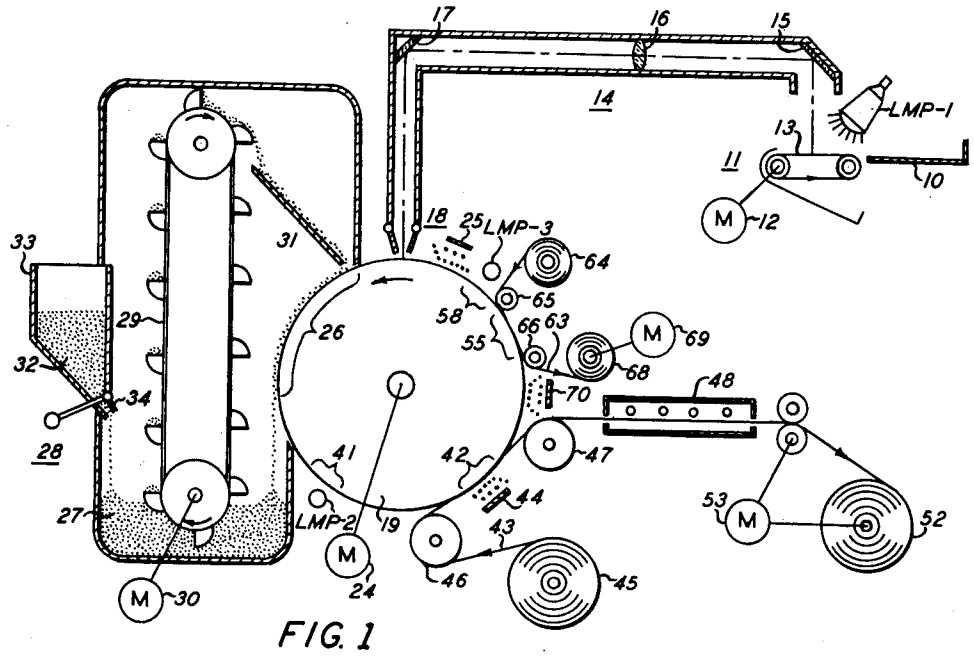


FIG. 1

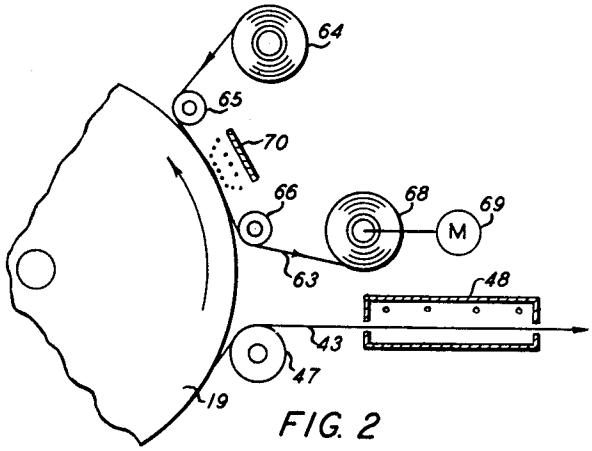


FIG. 2

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XEROGRAPHIC PLATE CLEANING METHOD UTILIZING THE RELATIVE MOVEMENT OF A CLEANING WEB

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This invention relates to xerography and, particularly, to improved method and apparatus for cleaning the surface of a xerographic plate from which a powder image has been transferred. More specifically, the invention relates to method and apparatus to remove a residual powder image from a xerographic plate after transfer of a powder image from the plate to a support surface.

In the process of xerography, for example, as disclosed in Carlson Patent 2,297,691, issued October 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 the plate areas in accordance with the radiation intensity that reaches them, 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 photo-conductive layer and is held thereon electrostatically in a pattern corresponding to the electrostatic latent image. Thereafter, the developed xerographic powder image is usually transferred to a support surface to which it may be fixed by any suitable means.

The cycle above described is typical for forming xerographic reproductions on a support surface and may be carried out manually, or automatically, as is done with mechanized equipment which performs the cycle repeatedly. In either case, however, after transfer of a powder image from a plate to a support surface, there usually remains on the plate a residue of unremoved developing material, usually in image configuration, that is referred to in the art as "a residual powder image." Before the plate can be reused for a subsequent cycle it is necessary to remove the residual image to prevent any portion thereof from subsequently reproducing.

In automatic xerographic equipment it is common to employ a xerographic plate in the form of a cylindrical drum which is continuously rotated through repeated cycles of sequential operations including charging, exposing, developing and transfer, during which copy is reproduced on a support surface and after which the plate is cleaned before repeating the cycle.

It is usual to charge the plate to positive polarity by means of a corona generating device of the type disclosed in Walkup Patent 2,777,957, which is connected to a suitable source of high potential. Development of an electrostatic latent image forms a powder image on the plate that is electrostatically transferred to a support surface by means of a corona generating device such as mentioned above. In the automatic type of equipment employing a rotating drum, a support surface to which a powder image is to be transferred is moved through the equipment at the same rate and in the same direction as the periphery of the drum and contacts the drum at the transfer position, interposed between the drum surface and the corona generating device. Transfer is effected by the corona generating device which imparts an electrostatic charge to attract the powder image from the drum to the support surface. The polarity of charge required

to effect image transfer is dependent upon the visual form of the original copy relative to the reproduction and the characteristics of the developing material employed to effect development. For example, when a positive reproduction is to be made of a positive original, it is usual to employ a developing material which is triboelectrically charged to negative polarity and, after formation of a powder image, positive polarity corona is used to effect transfer to the support surface. In contrast, to produce a positive reproduction from a negative original, it is usual to employ a positively charged developing material that is repelled by the non-image areas on the plate to the discharged image areas thereon, and negative polarity corona is employed to effect transfer.

In either case, a slight residue of developing material remains on the plate surface, in image configuration, after transfer. The reason for the residue is not fully understood, but is believed caused by a combination of retaining forces that include the tendency to cling as dirt to a surface, an induction effect at the points of contact between the residue and the plate surface, and, in positive-to-positive reproduction, the original electrostatic forces of the image to which the developing material adhered during development. The electrostatic transfer force applied to the paper support surface effects transfer of a preponderance of the developed image thereto, but apparently is inadequate to overcome the higher magnitude of forces that retain some of the particle to effect complete transfer thereof.

In negative-to-positive reproduction this residue may conveniently be removed by a mechanical brushing of the plate surface. However, in positive-to-positive reproduction it appears that the residual particles are less readily removed. The reason for this phenomenon is not fully understood. However, it is believed affected by the polarity of charge employed to effect transfer. In each instance the transfer charge is applied to the back of a support surface such as paper when in contact with the developed image, after which the support surface is gradually separated therefrom. As the air gap therebetween increases, it reaches a critical length at which the high field strength causes an air breakdown to occur. This air breakdown, it is believed, through ion and electron reaction, produces surface charges on the residue particles of like polarity as employed for transfer and whereby the particles become dipoles; that is, it is believed, the outer surfaces of the particles being nearest the removed paper become charged with like polarity as the transfer charge while the inner surfaces of the particles in contact with the plate retain their pre-transfer polarity.

The brush materials conventionally employed in xerography for plate cleaning are so selected that they acquire a positive charge triboelectrically during a brush cleaning operation. It is believed, therefore, that in negative-to-positive reproduction the negative charge on the outer surface of the particles attracts the particles to the rotating brush, whereas in positive-to-positive reproduction the positive charge on the particles' outer surface effectively repels the brush and thus prevents their removal. However, the removal difficulty in positive-to-positive reproduction was found not to be attributed solely to the acquired triboelectric charge of the brush since almost as much cleaning difficulty was experienced employing cleaning materials not having previously acquired a triboelectric charge.

To overcome the persistent adherence of the residual particles it has been found that an electrostatic charge of opposite polarity to the transfer charge and applied to the residue and surrounding discharged areas of the plate surface in advance of cleaning enhances cleaning efficiency particularly in positive-to-positive reproduction. The

reason for this is another not fully understood phenomenon. However, it is believed that with application of a precleaning charge both the outer surfaces of the residue particles and the surrounding area of the drum surface become charged unipolar such that when the residue is subsequently rubbed or brushed and the particles of the residue shift there is a mutually repelling force between the residue and the plate surface enabling residue removal to the cleaning material. As an alternative means, it has been found that a similar charge application, during the cleaning operation of opposite polarity to transfer and of sufficient magnitude being directed instead onto the cleaning material also enhances cleaning. It is believed that this charge has the effect of attracting residue loosened by rubbing or brushing action of the material to the oppositely charged material.

A typical brush cleaning apparatus is disclosed in Walkup Patent 2,832,977. In Walkup, reference is made to the types of brush materials which have proven most satisfactory for plate cleaning. In general, and desirably, any cleaning material must be sufficiently soft so that it does not unduly abrade the photoconductive plate surface and at the same time be sufficiently firm to remove the residual powder image without becoming matter or clogged after repeated use. Other factors, such as the triboelectric characteristics of the material also enter into its selection. Although various synthetic and vegetable fibers may be employed for brush cleaning in xerography, animal furs have proven most suitable for general application. However, brushes of the animal fur type are relatively expensive and at best have a limited cleaning life of approximately 35–40 hours before they ultimately become clogged and operate at decreased efficiency, when used, for example, to clean a 15 inch diameter drum rotating at approximately 5 r.p.m. Besides dispensing with the brush and a high speed drive required for brush rotation, the vacuum and filtering system required in conjunction with brush cleaning for exhausting the removed powder from the brush are also dispensed with.

The principal object of the invention is an improved method and apparatus for removing residual developing material from a xerographic plate.

Another object of the invention is to improve method and apparatus for cleaning a xerographic plate in a manner to increase the efficiency of the cleaning operation and to decrease the fabrication and operating costs of cleaning apparatus.

These and other objects of the invention are attained by the improved cleaning method and apparatus of the invention in which a web of dispensable fibrous material is continuously advanced from a supply reel into a rubbing contact with the residue bearing plate surface to remove the residue therefrom. Thereafter the web is advanced to a take-up reel from which the web may be disposed of. Application of an electrostatic charge by means of a corona generating device may be employed to enhance removal of the residue by the web.

Preferred forms of the invention are illustrated in the accompanying drawings in which:

FIG. 1 is a schematic sectional arrangement of a typical xerographic unit employing an apparatus of a type that could be used to clean a plate surface by the method of the invention;

FIG. 2 is an alternative embodiment of the invention.

For a general understanding of the xerographic processing system in which the invention is incorporated, reference is had to FIG. 1 in which the various systems components are schematically illustrated. As in all xerographic systems based on the concept disclosed in the above-cited Carlson patent, a radiation image of copy to be reproduced is projected onto the sensitized surface of a xerographic plate to form an electrostatic latent image thereon. Thereafter, the latent image is developed with a triboelectrically charged developing material to form a xerographic powder image, corresponding to the latent image, on the plate surface. The powder image is then

electrostatically transferred to a support surface to which it may be fused by any suitable form of fusing device, whereby the powder image is caused permanently to adhere to the support surface. After transfer the plate surface is cleaned in preparation for the next cycle.

The xerographic apparatus described herein may be an adaptation of the type disclosed in copending application Serial No. 837,173, filed August 31, 1959, in the name of Cerasani, et al. In the apparatus, opaque copy is placed on a support tray 10 from which it is fed onto a transport mechanism generally designated 11. Suitable drive means are provided for the transport mechanism from motor 12 to endless belts 13 whereby the copy is caused to move past the optical axis of projection lens system 14 that is illuminated by a projection lamp LMP–1. The image of the copy is reflected by mirror 15 through an adjustable objective lens 16 and then reflected by mirror 17 downwardly through a variable slit aperture assembly generally designated 18 and onto the surface of a xerographic plate in the form of drum 19.

Xerographic drum 19 includes a cylindrical member mounted in suitable bearings in the frame of the machine and is driven in a counter-clockwise direction by a motor 24 at a constant rate that is proportional to the transport rate of the copy, whereby the peripheral rate of the drum surface is identical to the rate of movement of the reflected light image. The drum surface comprises a layer of photoconductive material on a conductive backing that is sensitized prior to exposure by means of a screened corona generating device 25, which may be of the type disclosed in the Walkup patent first cited, that is energized from a suitable high potential source.

The exposure of the drum to the light image discharges the photoconductive layer in the areas struck by light, whereby there remains on the drum a latent electrostatic image in image configuration corresponding to the light image projected from the copy. As the drum surface continues its movement, the electrostatic latent image passes through a developing station 26 in which a two-component developing material 27, which may be of the type disclosed in Walkup Patent 2,638,416, is cascaded over the drum surface by means of developing apparatus 28 which may be of the type disclosed in copending application S.N. 393,058, filed November 19, 1953, in the name of Mayo et al.

In the developing apparatus, developing material is carried up by conveyor 29 which is driven by suitable drive means from motor 30 and the material released onto chute 31 wherefrom it cascades down over the drum surface. Toner component 32 of the developer that is consumed in developing is stored in dispenser 33 and is released in amounts controlled by gate 34.

After developing, the xerographic powder image passes a discharge station 41 at which for positive-to-positive reproduction the drum surface is illuminated by a lamp LMP–2, whereby residual charges on the non-image areas of the drum surface are completely discharged. Thereafter, the powder image passes through an image transfer station 42 at which the powder image is electrostatically transferred to a support surface web 43 by means of a second corona generating device 44 similar to corona charging device 25, mentioned above.

The support surface to which the powder image is transferred may be of any convenient type such as paper and is obtained from a supply roll 45 and is fed over guide rolls 46 and 47 and over suitable tensioning rolls being directed into surface contact with the drum in the immediate vicinity of transfer corona generating device 44. After transfer, the support surface is separated from the drum surface and guided through a suitable fusing apparatus 48, which may be of the type disclosed in Crumrine Patent 2,852,651, whereby the powder image is permanently affixed to the support surface. Thereafter, the support surface is fed over a further system of guide

and tensioning rolls and onto a take-up roll 52 that is driven by motor 53.

After transfer, the xerographic drum surface passes through a cleaning station 55 whereat a residual powder image on its surface is removed. Cleaning apparatus constructed in accordance with the method of the invention, and generally designated 56, is described in detail below. Thereafter, the drum surface passes through a second discharge station 56 at which it is illuminated by a fluorescent lamp LMP–3, whereby the drum surface in this region is completely flooded with light to remove any electrostatic charge that may remain thereon. Suitable light traps are provided in the system to prevent any light rays from reaching the drum surface, other than the projected image, during the period of drum travel immediately prior to sensitization by corona generating device 25 until after the drum surface is completely passed through the developing station 26.

Cleaning apparatus constructed in accordance with the method of the invention is illustrated in both FIGS. 1 and 2, and is adapted to be suitably supported in the xerographic unit in proper cleaning relation to drum 19.

In the embodiments of both FIGS. 1 and 2, a web of cleaning material 63 described below is drawn from a rotatable supply reel 64, wherefrom it is continually advanced over a guide roll 65 into contact against the moving surface of drum 19. The web is advanced at a slower rate of movement than the movement rate of the drum surface, and preferably, although not necessarily, is advanced in a direction substantially opposite to the direction of the drum for the reasons described below. A rubbing action is incurred thereby of the web against the drum surface for a predetermined length of contact during which the web is effective to remove the residue of developing material from the drum. Minimum contact length has been found to occur when the web and plate are moved in substantially opposite directions whereby the cleanest portion of the web contacts the cleanest portion of the plate surface. Thereafter the web continues advancing over guide roll 66 and onto rotatable take-up reel 68. To effect advancement of the web, take-up reel 68 is driven through suitable drive means operative from motor 69.

After the supply of cleaning material on supply reel 64 has been exhausted, it is contemplated that the consumed web on take-up reel 68 that has become soiled from the cleaning operation will be disposed of or reclaimed by an external process and that a fresh supply of material will be installed for continuance of the operation.

To enhance cleaning, corona generating device 70, which may be similar to device 25 mentioned above applies an electrostatic charge either on the residual powder image on the drum surface or on the back of the web and for reasons set forth above is opposite in polarity to the transfer polarity of transfer corona generator 44. Alternate locations and application for the corona generating device 70 are illustrated in FIGS. 1 and 2. In the arrangement of FIG. 1 a precleaning charge is applied on the drum surface in advance of the drum surface being contacted by the moving web. In FIG. 2, the corona generator is arranged to apply charge to the web concomitantly with web contact against the drum surface. In the latter arrangement, as the residual developing material is loosened and is being wiped from the drum surface by the web, it is attracted by the electrostatic force of the charge into the interstitial spaces of the web to accumulate harmlessly on the reverse side.

Any cleaning material must of necessity have good cleaning and abrasion properties, being sufficiently soft to clean the relatively soft photoconductive plate surface without unduly abrading the surface. For this purpose, many materials such as paper toweling, cheesecloth, flannel, etc. were tested and of those tested many were found to yield satisfactory cleaning results with varying degrees of abrasion. Of the materials tested, optimum results were achieved by means of a rayon-cotton fiber manufactured by the Chicopee Mills, Inc. of Milltown, New Jersey.

The rate at which a web of cleaning material is consumed is a function of the rate of plate movement and the relative rate of the web required to yield satisfactory cleaning. This has been found to vary to some degree dependent upon the particular cleaning material employed. It should be apparent that the consumption rate will be economically optimum with the minimum web speed relative to the speed of the plate at which good cleaning is still attained. For materials tested relative web speeds were found to vary in the order of $\frac{1}{40}$ to $\frac{1}{100}$ of the plate speed, or in other words it was necessary to present one clean inch of web to clean every 40 to 100 linear inches of photoconductive plate surface.

By the above description there is disclosed improved method and apparatus for cleaning a xerographic plate. The method and apparatus therefor compared to cleaning methods and apparatus employed heretofore is more efficient and considerably less expensive to fabricate and operate. The method and apparatus of the invention utilizes a relatively inexpensive fibrous material of extended length that is rolled into a web and then gradually advanced in contact against a plate surface having a residue of developing material to be removed. When the entire web length is exhausted it may be disposed of and readily replaced with a new length of clean web. A corona generating device may be employed in conjunction therewith to enhance removal of the residue to the web.

Whereas it is apparent that the method and apparatus of the invention can be used to clean the surface of any xerographic plate, it is to be noted that its use is intended primarily for automatic machines in which there is continuous relative movement between the plate and cleaning web and the cleanliness of the plate is not readily available for visual observation.

Since many changes could 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 shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. In the method of xerography in which to reproduce copy a xerographic plate is moved through a sequence of operations that include placing an electrostatic charge on the plate surface, exposing the charged plate to a radiation image of copy to be reproduced to form an electrostatic latent image of the copy thereon, applying developing material to the latent image to form a powder image of the copy to be reproduced, electrostatically transferring the powder image from the plate to a support surface, whereby after transfer there remains on the plate surface a residue of developing material, the improvement in cleaning developing material residue from a plate surface including

the steps of applying electrostatic charge on the powder residue,

presenting a moving web of fibrous material against the residue on the plate surface at a predetermined rate relative to the rate of plate movement,

maintaining a relative movement between the web and plate surface wherein the linear speed of the web material is on the order of $\frac{1}{40}$ to $\frac{1}{100}$ of the plate speed,

and removing the web from the plate surface after a predetermined length of contact.

2. In the method of xerography in which to reproduce copy a xerographic plate is moved through a sequence of operations that include placing an electrostatic charge on the plate surface, exposing the charged plate to a radiation image of copy to be reproduced to form an electrostatic latent image of the copy thereon, applying developing material to the latent image to form a powder

image of the copy to be reproduced, and electrostatically transferring the powder image from the plate to a support surface, whereby after transfer there remains on the plate surface a residue of developing material, the improvement in cleaning developing material including

the steps of applying electrostatic charge on the powder residue of polarity opposite to the polarity of charge by which transfer was effected,

presenting a moving web of fibrous material against the powder residue on the plate surface at a predetermined rate relative to the rate of plate movement,

maintaining a relative movement between the web and plate surface wherein the linear speed of the web material is on the order of 1/40 to 1/100 of the plate speed,

and removing the web from the plate surface after a predetermined length of contact.

3. In the method of xerography in which to reproduce copy a xerographic plate is moved through a sequence of operations that include placing an electrostatic charge on the plate surface, exposing the charged plate to a radiation image of copy to be reproduced to form an electrostatic latent image of the copy thereon, applying developing material to the latent image to form a powder image of the copy to be reproduced, and electrostatically transferring the powder image from the plate to a support surface, whereby after transfer there remains on the plate surface a residue of developing material, the improvement in cleaning developing material residue from a plate surface including

presenting a moving web of fibrous material against the residue on the plate surface at a predetermined rate relative to the rate of plate movement and then removing the web from the plate surface after a predetermined length of contact.

maintaining a relative movement between the web and plate surface wherein the linear speed of the web material is on the order of 1/40 to 1/100 of the plate speed,

and applying an electrostatic charge on the web concomitantly with contact of the web against the residue.

4. The method of cleaning residual powder from the surface of a xerographic plate after transfer of a powder image from the plate surface to an image receiving member including

placing a portion of a web of fibrous material into contact with the residual powder on the plate surface,

imparting a relative movement between the plate surface and the portion of the web of fibrous material in contact with the residual powder on the plate surface whereby the linear speed of the web material is on the order of 1/40 to 1/100 of the plate speed,

and moving the web of fibrous material so that the portion of the web in contact with the residual powder on the plate is constantly changing during said movement between the plate surface and the web of fibrous material.

5. The method of claim 4 including

the additional step of freeing residual powder from the plate surface by the application of an electrostatic charge.

6. The method of claim 5 wherein said electrostatic charge is applied directly to the residual powder on the plate surface.

7. The method of claim 5 wherein said electrostatic charge is applied to the back of said web of fibrous material at the point of contact of said web with the residual powder on the plate surface.

References Cited by the Examiner

UNITED STATES PATENTS

1,401,012	12/21	Teitel	15—100
1,949,868	3/34	Keuffel	15—100
2,576,047	11/51	Schaffert	96—1
2,732,775	1/56	Young et al.	95—1.7
2,741,959	4/56	Rheinfrank	96—1
2,752,271	6/56	Walkup et al.	96—1 X
2,752,833	7/56	Jacob	95—1.7
2,832,977	5/58	Walkup et al.	15—1.5
2,859,673	11/58	Hix et al.	95—1.7
2,878,120	3/59	Mayer et al.	95—1.7
2,924,519	2/60	Bertelsen	96—1
2,947,625	8/60	Bertelsen	96—1

OTHER REFERENCES

Bunzey: "Background Reduction in Electrostatic Printing," IBM Technical Disclosure Bulletin vol. 2, No. 2, pages 2–3, August 1959.

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