United States Patent

Lancia et al.

[15] **3,645,618**

[45] **Feb. 29, 1972**

[54] VACUUM NOZZLE TO REMOVE AGGLOMERATES ON A TONER APPLICATOR

[72] Inventors: **Fredrick Lancia; Gerald L. Miller,** both of Columbus, Ohio

[73] Assignee: **Xerox Corporation,** Stamford, Conn.

[22] Filed: **Dec. 18, 1970**

[21] Appl. No.: **99,556**

[52] **U.S. Cl.** **355/15,** 118/637, 355/17

[51] **Int. Cl.** **G03g 15/00**

[58] **Field of Search** .....355/15, 17, 3; 118/637; 15/1.5 R

[56] **References Cited**

UNITED STATES PATENTS

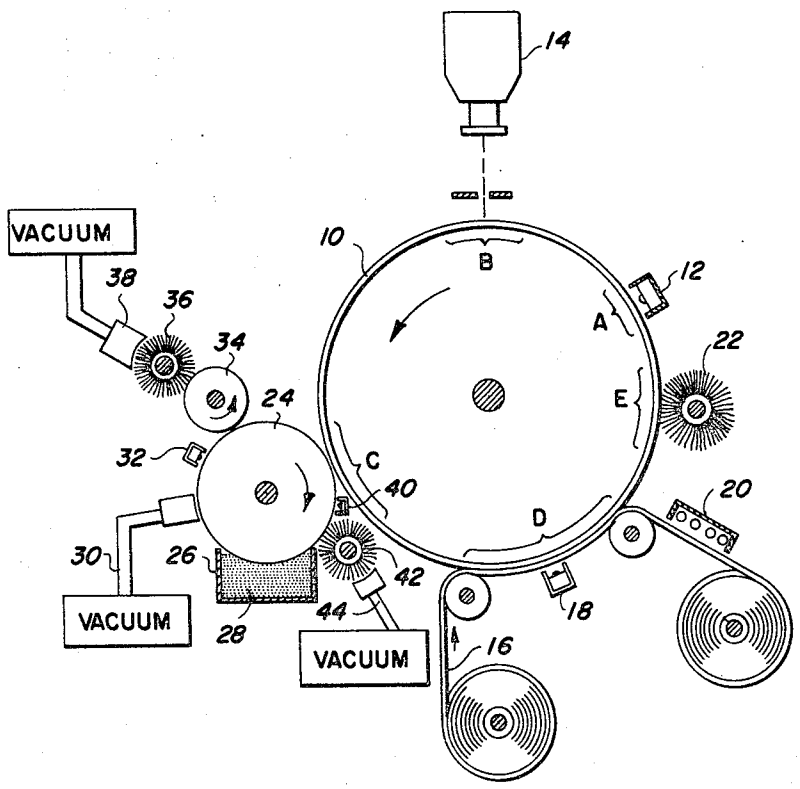
2,732,775	1/1956	Young et al.	118/637 X
3,013,890	12/1961	Bixby	118/637 X
3,152,012	10/1964	Schaffart	355/3 X
3,405,682	10/1968	King et al.	355/15 X

Primary Examiner—Joseph F. Peters, Jr.
Assistant Examiner—Richard L. Moses
Attorney—James J. Ralabate, James P. O'Sullivan and Donald F. Daley

[57] **ABSTRACT**

Development method and apparatus employing a donor member adapted to retain toner on its periphery and a number of processing stations arranged around its periphery, including a toner loading station having means to load toner on the peripheral surface of the donor member, and a toner layer preparation station having means to prepare the toner layer on the donor member prior to presentation of the toner layer to the imaged region of a photoconductor development station.

20 Claims, 2 Drawing Figures



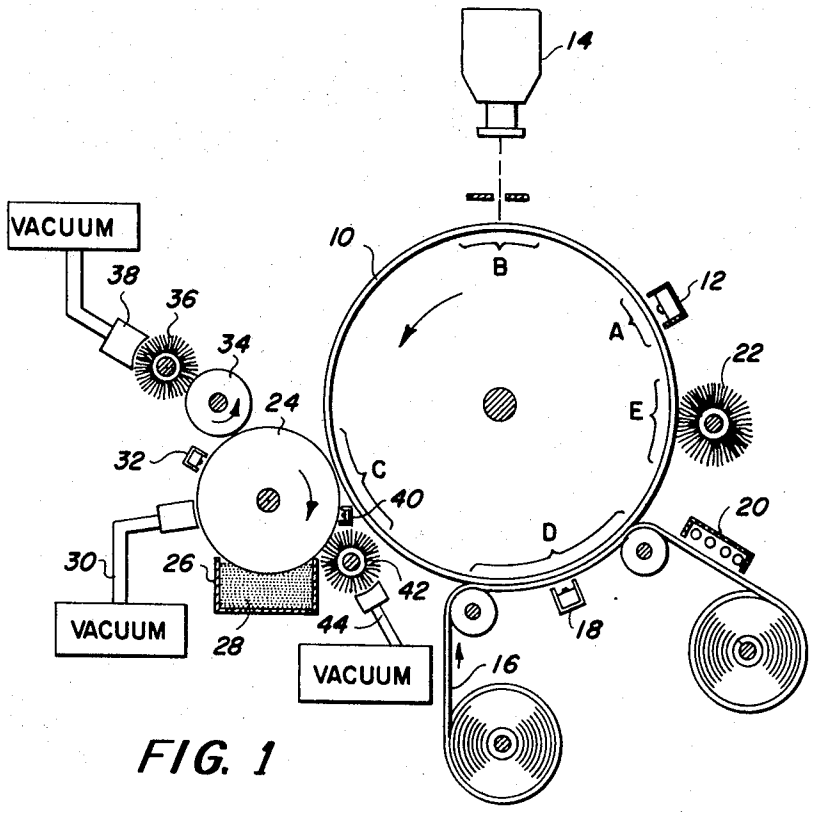


FIG. 1

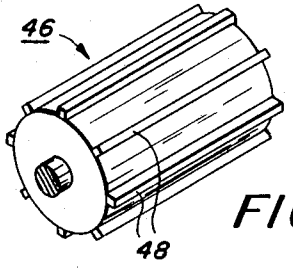


FIG. 2

INVENTORS
FREDRICK N. LANCIA
GERALD L. MILLER
BY James Paul O'Sullivan
ATTORNEY

VACUUM NOZZLE TO REMOVE AGGLOMERATES ON A TONER APPLICATOR

BACKGROUND OF THE INVENTION

This method and apparatus relates to xerography and more particularly to an improved method and apparatus for the development of electrostatic images by which a toner layer which is of controlled thickness and uniformity, and which is agglomerate-free is presented to the latent image to develop it.

In the reproduction process of xerography, a photoconductive surface is charged and then exposed to a light pattern of the information to be reproduced, thereby forming an electrostatic latent image on the photoconductive surface. Toner particles, which may be finely divided, pigmented, resinous material, are applied to the latent image where they are attracted to the photoconductive surface. The toner image can be fixed and made permanent on the photoconductive surface or it can be transferred to another surface where it is fixed.

One known method of developing latent images is by a process called transfer development. Transfer development broadly involves bringing a layer of toner to an imaged photoconductor where toner particles will be transferred from the layer to the image areas. In one transfer development technique, a layer of toner particles is applied to a donor member which is capable of retaining the particles on its surface and then the donor member is brought into close proximity to the surface of the photoconductor. In the closely spaced position, particles of toner in the toner layer on the donor member, are attracted to the photoconductor by the electrostatic charge on the photoconductor so that development takes place.

In one embodiment of a transfer development system, a cylindrical donor member is rotated while closely spaced from the moving surface of a photoconductive drum bearing an electrostatic latent image thereon. As the donor member turns, its peripheral surface, which is adapted to retain toner particles thereon, rotates through a reservoir of toner and a layer of toner particles is deposited on this surface. As rotation continues the toner layer is brought adjacent the photoconductive surface where the toner particles in the layer are attracted to the imaged areas. The donor member then continues to rotate so that the portion of its surface which gives up toner to the photoconductive surface recirculates, after development through the toner reservoir and is retoned. In this manner, a continuous development process is carried out.

Although the toner layer formed on the surface of the donor member in the manner described above is normally adequate to develop the latent image on the photoconductive surface, the toner images produced are not always of the highest quality. A degradation in quality can occur for a number of reasons. For instance, the thickness of the toner layer on the donor member may not always be uniform and as a consequence when the toner layer in the greater regions of thickness will be greatly compacted between the photoconductive surface and the donor member surface. This will result in a compaction of toner particles and the compacted mass may be transferred to the photoconductive surface or, no toner at all may be transferred. Also, those regions of the toner layer that have been compacted between the donor and the photoreceptor have a tendency to cause the toner to deposit in nonimage areas. In regions of least thickness, the toner will be too far away from the photoconductive surface to respond to the development.

Another problem associated with touchdown development systems known heretofore, is that under certain conditions, toner particles have a tendency to agglomerate, i.e., several particles will cling together so that they act as one. Whatever the cause, it prevents each individual particle in the agglomerate from being effectively influenced by the attractive forces emanating from specific areas of the photoconductor.

In addition to the requirement of a toner layer of uniform thickness which is free of agglomerates, it has been found desirable to have the toner particles in the layer charged uniformly so that all that are needed, can be effectively transferred to the imaged areas of the photoconductor. Further, in the continuous process of development as described above, wherein a given point on the donor surface rotates through the toner reservoir to be loaded, is then brought adjacent the photoconductor to develop, and the back into the toner reservoir to be loaded, it is necessary to prepare the toner surface for reloading after development has taken place. This preparation is necessary so that an image history or ghost pattern is not retained in the toner layer after the donor surface has been reloaded with toner. If a ghost pattern is retained, it can interfere with accurate development of the imaged portion of the photoconductive surface.

The art of xerographic development would be significantly advanced if all of the foregoing problems and disadvantages could be eliminated.

Accordingly, it is an object of the invention to improve apparatus for developing latent electrostatic images.

It is a further object of the invention to improve apparatus for accomplishing transfer development of xerographic images.

It is a still further object of the invention to eliminate ghost images in the toner layer of a donor member in the development of xerographic images.

It is yet a further object of the invention to remove toner agglomerates from the toner layer on the donor member.

Another object of the invention is to improve transfer development apparatus so as to insure that the toner layer on the donor member is of uniform thickness prior to its presentation to the photoconductor.

Still another object of the invention is to improve upon known transfer development processes.

SUMMARY OF THE INVENTION

This invention is directed to a transfer development apparatus including a donor member capable of retaining toner particles along a transportable surface thereof and a means to continuously advance said surface past a plurality of treating stations. These treating stations include: a toner loading station at which toner particles are contacted and retained by the donor member, a toner agglomerate removal station at which agglomerates and loosely adhering toner particles are vacuumed from the surface of the donor member; and a developing station at which the toner layer is presented in developing relation to the latent image on the xerographic plate.

A charging station adapted to place a uniform charge on the toner particles retained by the donor member of a polarity opposite to that of the latent image may be located after the toner agglomerate removal station. Under certain circumstances, a cleanup station having a cleanup member located between the charging station and the developing station may be employed. This station is adapted to insure that the toner layer is of uniform thickness and to remove any agglomerates not removed at the agglomerate removal station. Further, a donor member cleaning station, adapted to remove at least the upper region of the residual toner layer may be located between the development station and the toner loading station.

The invention is also directed to a transfer development process comprising forming a latent electrostatic image on the surface of a xerographic plate, retaining a layer of toner particles on the surface of a donor member, vacuum-removing toner agglomerates and loosely adhering toner particles from said layer, and presenting the agglomerate-free layer to the latent, electrostatic image to effect development thereof.

BRIEF DESCRIPTION OF THE DRAWING

For a better understanding of the invention as well as other objects and further features thereof, reference is made to the accompanying drawing, wherein:

FIG. 1 is a sectional view of xerographic apparatus in accordance with the present invention; and

FIG. 2 is an isometric view of a cleanup roll in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is a transfer development system in which toner particles are applied to an electrostatic latent image on a photoconductive plate to develop the image. Although the system is described herein as part of a xerographic copier, it can be utilized in conjunction with any reproduction system wherein a latent image is to be developed by applying toner thereto.

Referring to FIG. 1, there is shown a xerographic reproduction system utilizing the concept of the present invention. In this apparatus the xerographic plate is in the form of a drum **10** which passes through stations A–E in the direction shown by the arrow. The drum has a suitable photosensitive surface, such as one including selenium, overlying a layer of conductive material, on which a latent electrostatic image can be formed. The various stations about the periphery of the drum which carry out the reproduction process are: charging station A, exposing station B, developing station C, transfer station D, and cleaning station E. Stations A, B, D and E represent more or less conventional means for carrying out their respective functions. Apart from their association with the novel arrangement to be described with respect to station C, they form no part of the present invention.

At station A, suitable charging means **12**, e.g., a corotron, places a uniform electrostatic charge on the photoconductive material. As the drum rotates, a light pattern, via a suitable exposing apparatus **14**, e.g., a projector, is exposed onto the charged surface of drum **10**. The latent image thereby formed on the surface of the drum is developed or made visible by the application of a finely divided, pigmented, resinous powder, called toner, at developing station C, which is described in described in greater detail below. After the drum is developed at station C, it passes through transfer station D, comprising copy sheet **16**, corona charging device **18** and fuser device **20**. Following transfer and fixing of the developed image to the copy sheet, the drum rotates through cleaning station E, comprising cleaning device **22**, e.g., a rotating brush.

At developing station C, the apparatus includes a donor member **24** rotatably mounted adjacent a toner reservoir **26** containing a supply of toner **28**. The donor roll **24** is positioned so that a portion of its periphery comes into contact with toner **28**. The donor roll is also located so as to provide a small gap between the surface of drum **10** and the outer surface of a toner layer carried by donor roll **24**. This gap can be approximately 1 mil.

While the donor roll **24** can be any device adapted to carry a layer of toner to the development region, a preferred type is that embodying the principles described in U.S. Pat. No. 3,203,394. In essence, a preferred donor can comprise, an electrically conductive support member in the form of a cylinder, a thin electrically insulating layer overlying the support member, and a continuous, electrically conductive screen pattern overlying the insulating layer. The screen pattern is provided with an electrical connection to a slip ring so that its potential may be controlled throughout the process. To effect toner loading a bias is applied to the screen pattern, e.g., −200 to −250 volts, via the slip ring connection. As the donor roll rotates in contact with the toner particles in the reservoir, toner particles are deposited on the surface in conformity with the field thereon. In this manner the donor roll will continuously pick up a thin layer of toner particles.

As indicated above, because of conditions difficult to control, some of the toner particles tend to agglomerate and be deposited on the surface of the roll and protrude well above the mean thickness of the toner. In addition, if some provision is not made for controlling the thickness of the toner layer carried by the donor roll, thicker regions of the toner layer will be compacted between the donor roll surface and the surface of the photoconductive layer in the development zone, also producing agglomerates.

In order to insure removal of agglomerates and also to control the thickness of the toner layer presented to the imaged photoconductive drum, a vacuum means **30** is positioned adjacent the periphery of the donor drum at a point between the toner reservoir and the development zone. The vacuum means can conveniently be a narrow slit of a length slightly wider than the width of the toner layer, in a vacuum manifold. The vacuum manifold is spaced a short distance from the toner layer surface and sufficient force is exerted via the vacuum so that toner agglomerates and loosely adhering toner will be pulled from the toner layer. The force can be carefully adjusted so that only an even layer of particulate toner needed for development remains on the donor surface.

Located between vacuum means **30** and the development zone is a charging means **32**, such as a corona charging device, which is adapted to place a uniform charge on the toner particles having a polarity opposite to the polarity of the latent image on the photoconductive drum.

After being rendered agglomerate-free and of comparatively uniform thickness, the uniformity charged toner layer is presented to the imaged regions of the photoconductor and touchdown development as described above, takes place. Because the toner layer is of uniform thickness no toner compaction is experienced. This coupled with an absence of agglomerates results in copy of excellent quality.

Following development, the donor roll is prepared for reloading by exposing residual toner thereon to a neutralizing charging means **40**, to make easier the removal of the residual toner by way of a suitable cleaning means, e.g., a rotating brush **42**, equipped with a vacuum means **44**. The donor roll is thus freed of any image history or ghost image from the developed region and is prepared to pick up fresh toner.

It is sometimes found that the vacuum means **30** does not completely remove all agglomerates nor result in the desired degree of evenness in the toner layer. This may be the result of employing a particular type of tonor, or a particular donor roll and loading technique. When such a condition exists, agglomerate removal and toner layer evenness can be assured by employing a cleanup member **34** positioned between the charging means **32** and the development region. The cleanup member is of the type described in U.S. Pat. application Ser. No. 99,443 filed of even date.

The cleanup roll **34** may be either one of two types: it may be a roll or cylinder, at ground potential, which removes agglomerates and smooths the surface of the toner layer by a purely mechanical action or it may be an electrically biased roll which removes agglomerates and loosely adhering toner by electrostatic attraction. When removing any remaining agglomerates by strictly mechanical force, the cleanup roll can be of a design having micro appendages on the surface thereof. By micro appendages is meant small individual extensions from the surface of the roll or ridgelike extensions extending along the length of the roll. FIG. 2 of the drawing shows a cleanup roll **46** of this type having ridgelike extensions **48** disposed on the surface thereof.

When this type of roll is brought into contact with the upper region of the toner layer and rotated at a faster rate than the rotation of the donor roll, the appendages will strike any remaining agglomerates, free them or break them up and, at the same time, reduce the overall level of the toner layer to a comparatively uniform thickness. For example, a roll of trihelicoid design, having a rotation rate of from 50 to 75 times that of the rate of rotation of the donor drum has been found satisfactory. It has been found desirable to rotate the cleanup roll in a direction counter to the direction of rotation of the donor roll.

When using an electrically biased roll, the roll **34** can be smooth-surfaced, as shown in FIG. 1 of the drawing, and need not rotate at a rate faster than the rate of rotation of the donor roll. A bias of −50 to +50 volts (often used at 0 volts) has been found satisfactory to remove any remaining agglomerates and loosely adhering toner and yield a toner layer of more or less uniform thickness. When using a biased cleanup roll the spac-

ing of this roll from the donor member must be such as to only remove agglomerates and loosely adhering toner from the toner layer.

With either type of roll, a cleaning mechanism is positioned adjacent the surface of the cleanup roll and is designed to remove the toner particles and agglomerates which are dislodged or electrostatically attracted from the toner layer of the donor roll. This cleaning mechanism can be a brush **36**, employed in association with a vacuum system **38**, which draws the removed toner particles from the cleaning brush.

It is to be understood that while for purposes of illustration the donor member has been described basically as a cylinder, it may be an endless belt or other planar surface adapted to deliver toner from the toner source to the development region, after subjecting the toner layer to the conditioning region, after subjecting the toner layer to the conditioning apparatus described herein. A vibrating means may be used in conjunction with the toner reservoir to keep the toner particles loose and to assist in loading the donor roll.

While the present invention has thus far been described with respect to a transfer development technique wherein the donor member and toner layer are spaced from the imaged surface, and toner particles must traverse an airgap to reach the imaged regions of the photoconductor, this has been only by way of illustration. It is to be understood that the present invention can be employed in association with other transfer development techniques where a toner laden donor actually contacts the imaged photoreceptor and no airgap is involved. In one such technique the toner-laden donor is rolled in a non-slip relationship into and out of contact with an electrostatic latent image to develop the image in a single rapid step. In another such technique, the toner-laden donor is skidded across the xerographic surface. Skidding the donor by as much as the width of the thinnest line will double the amount of toner available for development of a line which is perpendicular to the skid direction, and the amount of skidding can be increased to achieve greater density or greater area coverage.

It is to be noted, therefore, that the term "transfer development" is generic to development techniques where (1) the toner layer is out of contact with the imaged photoconductor and the toner particles must traverse an airgap to effect development, (2) the toner layer is brought into rolling contact with the imaged photoconductor to effect development, and (3) the toner layer is brought into contact with the imaged photoconductor and skidded across the imaged surface to effect development. Transfer development has also come to be known as "touchdown" development and includes the three techniques described above.

Conventional drive means, e.g., motors and belts, are employed to drive the several movable members all in a manner well within the skill of the art.

Since many changes can be made in the above construction and many apparently widely different embodiments of this invention can be made without departing from the scope thereof, it is intended that all matter contained in the drawing and specification should be interpreted illustratively and not in a limited sense.

What is claimed is:

1. In an apparatus for developing an electrostatic latent image formed on the surface of a xerographic plate, means for developing said latent image, said developing means including

a. a donor member capable of retaining toner particles along a transportable surface thereof,

b. means to continuously advance said donor member past a plurality of treating stations, said treating stations comprising:

1. a toner loading station at which toner particles are contacted and a layer of toner particles is retained by said donor member,

2. a toner agglomerate removal station operative to vacuum remove toner agglomerates and loosely adhering toner particles from said retained layer of toner particles; and

3. a developing station at which the agglomerate-free toner layer is presented in developing relation to said latent image on said xerographic plate.

2. In an apparatus for developing an electrostatic latent image formed on the surface of a xerographic plate, means for developing said latent image, said means including

a. an endless donor member capable of retaining a layer of toner particles along a transportable surface thereof;

means to continuously advance said donor member past a plurality of treating stations, said treating stations comprising:

1. a toner loading station at which toner particles are contacted and a layer of toner particles is retained by said donor member;

2. a toner agglomerate removal station having a vacuum manifold means located adjacent said donor member so that a force from said vacuum means can be exerted on the outermost region of said toner layer to remove toner agglomerates and loosely adhering toner particles therefrom; and

3. a developing station at which the agglomerate-free toner layer is presented in developing relation to said latent image on said xerographic plate.

3. The apparatus of claim **2** wherein said vacuum manifold means has a slit opening of a length at least as wide as said toner layer positioned across the width of said toner layer, said vacuum means being adapted to exert a force sufficient only to remove toner-agglomerates and loosely adhering toner particles.

4. The apparatus of claim **3** wherein said donor member is located adjacent said xerographic plate so that said agglomerate-free toner layer of uniform thickness is presentable in closely spaced developing relation to said latent image.

5. In an apparatus for developing an electrostatic latent image formed on the surface of a xerographic plate, means for developing said latent image, said means including

a. an endless donor member capable of retaining a layer of toner particles along a transportable surface thereof;

b. means to continuously advance said donor member past a plurality of treating stations, said treating stations comprising:

1. a toner loading station at which toner particles are contacted and a layer of toner particles is retained by said donor member;

2. a toner agglomerate removal station having a vacuum means located adjacent said donor member so that a force from said vacuum means can be exerted on the outermost region of said toner layer to remove toner agglomerates and loosely adhering toner particles therefrom;

3. a cleanup station having a rotatable, cylindrical cleanup member located adjacent said donor member so as to contact the outermost region of said layer of toner particles, said cleanup member being so constructed and designed to convert the layer of retained toner particles to one of comparatively uniform thickness and to remove any toner agglomerates not removed by said vacuum means; and

4. a developing station at which the agglomerate-free toner layer of uniform thickness is presented in developing relation to said latent image on said xerographic plate.

6. The apparatus of claim **5** wherein said cleanup member has microappendages on the curved surface thereof and said cleanup member is adapted to rotate at a rate in excess of the rate of transport of said donor member.

7. The apparatus of claim **6** wherein said cleanup member is adapted to operate at ground potential.

8. The apparatus of claim **7** wherein said cleanup member is adapted to rotate in a direction counter to the direction of transport of the surface of said donor member.

9. The apparatus of claim **8** having a toner removal means in association with said cleanup member adapted to remove toner particles from the surface of said cleanup member.

10. The apparatus of claim 5 wherein said cleanup member is an electrically biased, comparatively smooth-surfaced cylindrical member and is adapted to rotate at a rate substantially equal to the rate of transport of the toner layer.

11. The apparatus of claim 10 wherein said cleanup member is adapted to rotate in a direction counter to the direction of transport of the toner layer.

12. The apparatus of claim 11 having a toner removal means in association with said cleanup member adapted to remove toner particles from the surface of said cleanup member.

13. The apparatus of claim 5 wherein a charging station is located between said toner agglomerate removal station and said cleanup station and is adapted to place a uniform charge on said toner particles retained by said donor member of a polarity opposite to that of said latent image.

14. The apparatus of claim 13 having a cleaning means located between said developing station and said toner loading station and adapted to remove at least the outermost region of said toner layer.

15. The xerographic developing method comprising forming a latent electrostatic image on the surface of a xerographic plate, retaining a layer of toner particles on the surface of a donor member, vacuum removing toner agglomerates and loosely adhering toner particles from said layer and presenting the agglomerate-free layer to the latent electrostatic image to effect development thereof.

16. The xerographic developing method comprising forming a latent electrostatic image on the surface of a xerographic plate, retaining a layer of toner particles on the surface of an endless donor member, vacuum removing toner agglomerates and loosely adhering toner particles by applying a force from a vacuum means to the outermost region of said layer of toner particles, and presenting the agglomerate-free layer to the latent image to effect development thereof.

17. The xerographic developing method comprising forming a latent electrostatic image on the surface of a xerographic plate, retaining a layer of toner particles on the surface of an endless donor member, vacuum removing toner agglomerates and loosely adhering toner particles by applying a force from a vacuum means to the outermost region of said layer of toner particles, removing any toner agglomerates not removed by said vacuum means and converting said layer to a comparatively uniform thickness by bringing a rotating, cylindrical cleanup member into contact with the outermost region of said toner layer, and presenting the agglomerate-free layer of uniform thickness to the latent electrostatic image to effect development thereof.

18. The method of claim 17 wherein said cylindrical member has microappendages on the curved surface thereof and said member is rotating at a rate in excess of the rate of transport of the toner layer.

19. The method of claim 18 wherein said cleanup member is at ground potential and rotating counter to the direction of transport of said toner layer.

20. The method of claim 17 wherein said cylindrical cleanup member has a comparatively smooth surface, is electrically biased and is rotating at a rate substantially equal to the rate of transport of said toner layer.

* * * * *

PO-1050
(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,645,618 Dated February 29, 1972

Inventor(s) Fredrick W. Hudson

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Claim 2, column 6, line 9, insert

--b.-- before "means".

Signed and sealed this 21st day of November 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

PO-1050
(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,645,618 Dated February 29, 1972

Inventor(s) Fredrick W. Hudson

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Claim 2, column 6, line 9, insert

--b.-- before "means".

Signed and sealed this 21st day of November 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents