United States Patent [19]

Weiler

[11] **3,790,397**

[45] **Feb. 5, 1974**

[54] **RETONING CARRIER BEADS IN THE DEVELOPMENT ZONE**

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[22] Filed: **Aug. 5, 1971**

[21] Appl. No.: **169,400**

Related U.S. Application Data

[62] Division of Ser. No. 858,040, Sept. 15, 1969, Pat. No. 3,648,658.

[52] **U.S. Cl.** ..... **117/17.5,** 96/1 R, 118/637, 355/3 R, 355/17

[51] **Int. Cl.** **C03g 13/08,** C03g 15/08

[58] **Field of Search** ..... 117/17.5; 118/637; 96/1 R; 355/3, 17

[56] **References Cited**

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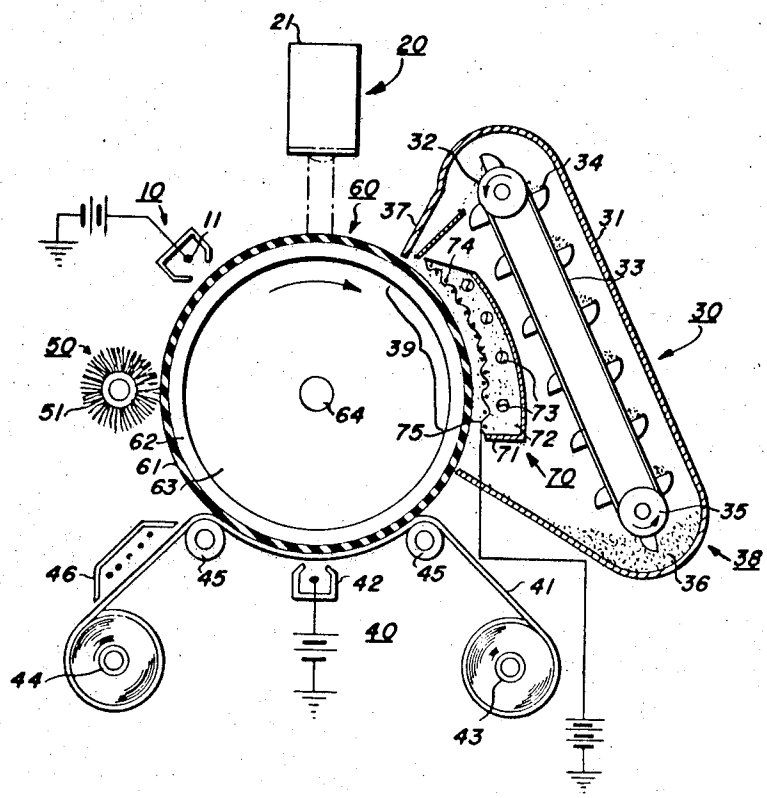
[57] **ABSTRACT**

A development method wherein developer, comprising a mixture of toner particles and carrier beads, is lifted from a trough or sump and is cascaded over the surface of an insulating plate bearing a latent electrostatic image and the toner is attracted from the carrier to the plate to develop the latent image thereon. The carrier beads are retoned with toner particles from a container located in the development zone as the beads give up toner particles to the plate during the development process. The carrier beads and residual toner particles are directed to the trough where additional toner particles are then added to the mixture, whereupon the returned carrier beads are again lifted from the trough and cascaded over the insulating plate to start the same cycle over again.

1 Claim, 2 Drawing Figures



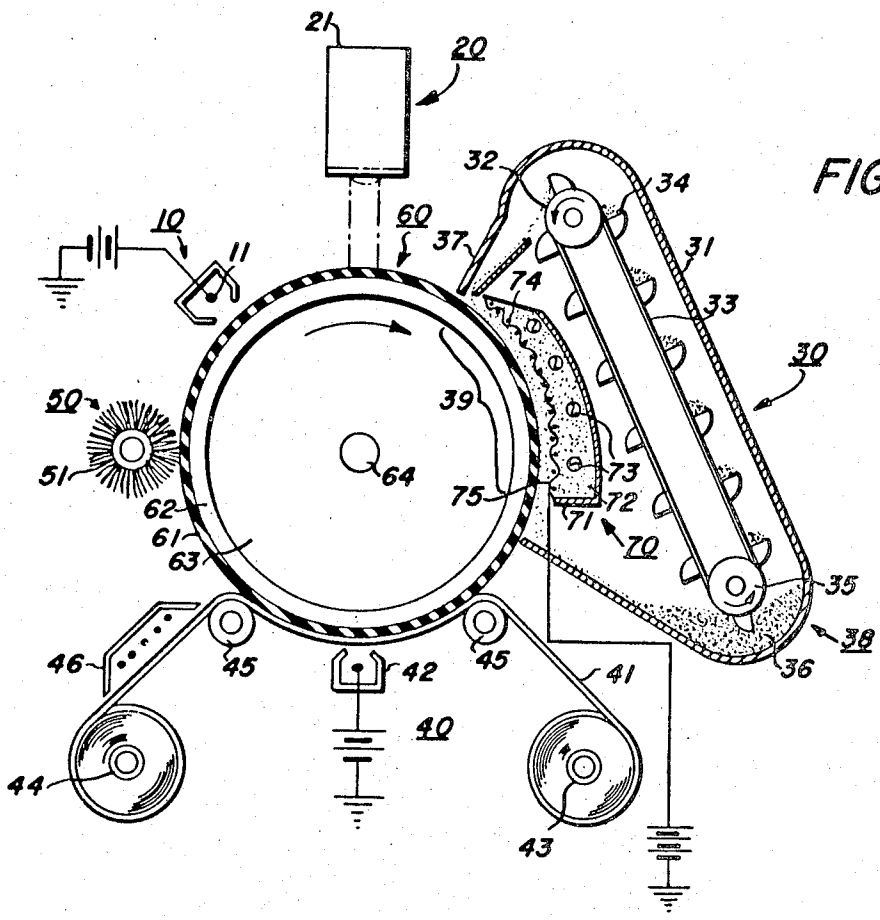


FIG. 1

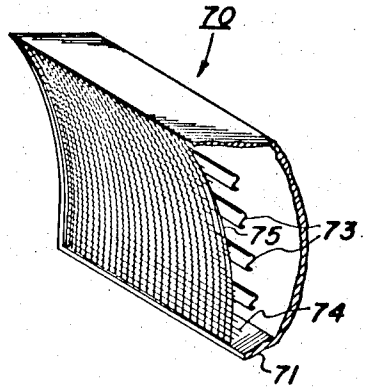


FIG. 2

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RETONING CARRIER BEADS IN THE DEVELOPMENT ZONE

This is a division of application, Ser. No. 858,040, filed Sept. 15, 1969, now U. S. Pat. 3,648,658.

BACKGROUND OF THE INVENTION

This invention relates to cascade development, and more particularly to a development electrode device which places toner particles adjacent to the flow of developer in the development zone which are attracted to under-toned carrier beads.

In reproduction processes where a latent image is first formed on an insulating plate and then made visible, or developed, with a colored powderous material, such as in the process of xerography, it is desirable to deposit the powderous material on the plate so that it adheres only to the image areas of the latent image to form a clear, well defined, visible image. One method of depositing toner on the plate is by cascade development techniques. In cascade development a developer mixture, comprising a finely-divided, pigmented, electroscopic powder referred to as toner and a coarse, granular material referred to as carrier beads, is cascaded from an elevated position over the surface of the plate bearing the latent image. The carrier beads are made or are coated with a material which is removed from the toner material in the triboelectric series so that when the two are mixed together to form the developer mixture, the toner particles are triboelectrically attracted to the carrier beads. The toner particles are small relative to the carrier beads and many toner particles are "carried" throughout the development system by each carrier bead. AS the developer flows across the plate bearing the latent image in the development zone, the electrostatic charges on the plate attract toner particles from their respective carrier beads onto the plate surface where they are deposited in imagewise configuration. It is common practice to use a development electrode in the development zone when depositing toner on the plate through cascade development techniques to improve solid area coverage. The effect of such an electrode is to change the field configuration of the electrostatic image and increase the field in the space above solid areas of charge.

As a result of giving up toner particles to the plate during cascade development, the carrier beads, become under-toned while still in the development zone; that is, a given carrier bead becomes under-toned when it has less toner attracted to it through triboelectric action than if an unlimited quantity of toner particles were available to it. The presence of under-toned carrier beads in the development zone is undesirable since less toner particles are available to be deposited on the plate than there would be if each carrier bead maintained in a fully-toned condition throughout the development zone; that is, when a carrier bead has attracted to it all the toner particles that it can through triboelectric action when it has an unlimited supply of toner particles available to it. The under-toned condition is a common occurrence in cascade development systems, particularly in the lower regions of the development zone since more toner has had a chance to transfer from the carrier beads to the plate.

To provide more toner particles throughout the development zone of a cascade system, the development zone is usually made long enough to assure that enough

toner is cascaded over all parts of the plate to fully develop the latent image thereon.

In reproduction systems such as those using a reusable insulating plate in the shape of a drum which is rotated continuously through several processing stations arranged about its periphery, the area available for the development zone is necessarily limited to only a portion of the drum's periphery. Because the development zone is limited in length and because a relatively large amount of toner is necessary to be cascaded through such a development zone to adequately develop the latent image, the speed at which the drum rotates is restricted to lower values which, in turn, restricts the speed of the entire reproduction process. On the other hand, if additional particles could be added to the developer mixture throughout the development zone to maintain the carrier beads in a more nearly fully-toned condition in all areas of the development zone, more toner would be available for deposit on the plate and the development zone could be shortened and the plate in such a continuous system could rotate at a much faster speed than known heretofor. It is obvious that this would make a much faster reproduction system.

The present invention is an apparatus for supplying additional toner particles, as needed, to carrier beads in a developer mixture while the developer is being cascaded through the development zone of a reproduction system. The apparatus includes an apertured development electrode placed adjacent the development zone having a container of toner particles attached thereto. The device places additional toner particles in the apertures of the electrode and a under-toned carrier beads passes adjacent to and/or strikes the electrode, additional toner particles at the electrode are attracted to the carrier beads until they become fully-toned again. This acquisition of toner particles by the under-toned carrier beads occurs throughout the development zone thereby minimizing the effects of the toner particles on the carrier beads being used upon the plate to result in excessvely under-toned carrier beads in the lower region of the development zone.

Accordingly, it is an object of the invention to improve the development of latent electrostatic images.

It is a further object of the invention to improve apparatus for cascade development of latent electrostatic images.

It is a further object of the invention to improve apparatus for cascade development by supplying additional toner particles to the carrier beads in the development zone as needed during the development process.

It is a further object of the invention to improve cascade development by supplying additional toner particles to carrier beads through an apertured development electrode containing a reservoir of toner particles while the carrier beads flow through the development zone.

SUMMARY

The present invention includes an apertured development electrode spaced at a gap from the plate being developed and a toner container adjacent the electrode which supplies the apertures with toner particles. The toner reservoir preferably contains at least one agitator means which maintains the toner in a loose consistency so that it can flow from the container into the apertures in the electrode. As developer flows between the devel-

opment electrode and electrostatic plate, as in conventional cascade development, toner particles are attracted away from the carrier beads and adhere to the surface of the electrostatic plate in imagewise configuration, a process which is aided by the action of the development electrode. The carrier beads giving up toner particles are retoned as they flow adjacent to and in contact with the development electrode by the additional toner particles which are attracted from the apertures of the electrode to the under-toned carrier beads. The carrier beads, after being retoned, continue to participate in the developing process until they leave the development zone.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention as well as other objects and further features thereof, reference is had to the following detailed description of the invention to be used in conjunction with the accompanying drawings wherein:

FIG. 1 is a schematic illustration of the invention.

FIG. 2 is a detailed view of the development electrode.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention can be adapted to any reproduction apparatus which uses electroscopic pigmented powders, or toner, to develop an electrostatic latent image. For the purpose of this disclosure, however, the invention will be described within the environment of a xerographic reproduction apparatus.

Referring to FIG. 1 there is shown a continuous xerographic copier, having a photosensitive plate **60** on which a latent electrostatic image of the information to be reproduced is formed. The plate is in the shape of a rotatable drum **63** which is driven by shaft **64.** The peripheral surface of the drum is covered with layer **62,** an electrically conductive material, which, in turn, is covered on its outer surface with layer **61,** a photosensitive insulating material such as vitreous selenium. The drum has five processing stations located about its periphery which carry out the steps of the xerographic process. These stations include charging station **10,** exposing station **20,** developing station **30,** transfer station **40,** and cleaning station **50.**

A latent electrostatic image is formed on the drum by passing its surface through charging station **10** and exposing station **20.** The charging station consists of any suitable means for placing a uniform charge on layer **61** such as the corona charging device **11** shown in the drawing. Exposing station **20** comprises projector **21** which projects and focuses a light pattern on the drum conforming to the image to be reproduced by the xerographic system. The image projected onto the photosensitive layer of the drum which, synchronized with the movement of the photosensitive layer of the drum, causes selective charge dissipation on elemental areas of layer **61** to form a latent electrostatic image thereon. Other means for forming electrostatic images including means for forming on ordinary insulating surfaces are known in the art and may be used instead of the one shown.

After the formation of the latent electrostatic image by passing the drum through stations **10** and **20,** the drum carries the latent image to developing station **30.** At the developing station a developer mixture comprising toner powder and carrier material is cascaded over the drum surface and the toner particles are attracted to and deposited on the drum surface in imagewise configuration. The toner particles are comprised of pigmented, resinous, electroscopic powder while the carrier material, commonly referred to as carrier beads, is a coarse, granular material which is removed from the toner in the triboelectric series or is coated with a material which is removed from the toner in the triboelectric series. When the toner and carrier beads are mixed, several toner particles are attracted to each grossly larger carrier bead through triboelectric attraction. Then, when the developer mixture is cascaded over the surface of the drum, toner particles are attraced from their respective carrier beads and deposited on the surface of the drum by electrostatic charge pattern on the drum.

The cascade development assembly comprises housing **31** containing a quantity of developer. The mixture is lifted to an elevated position over the drum by buckets **34** which are supported on conveyor **33** which, in turn, is supported and driven by pulleys **35.** The developer mixture lifted to the elevated position over the drum surface is dumped onto the drum surface in the vicinity of deflector plate **37.** The deflector plate directs the developer mixture onto the surface of the drum where it flows across the surface through the development zone **30** and then into the trough **38** of housing **31.** The development zone includes a development electrode shown in greater detail in FIG. **2,** which is spaced at a gap from the surface of the drum. Attached to the development electrode is toner reservoir **70** including a container **71** which contains a quantity of toner particles. Also within the container **71** is at least one and preferably a plurality of toner agitators **73** which keep the toner particles in a loose, free-flowing consistency. Development electrode **74** contains a plurality of apertures through which toner particles within housing **71** can be placed on and/or adjacent the development electrode. During the development process developer flows across the surface of drum **60** between the drum surface and development electrode and carrier beads in the developer mixture give up toner particles which are deposited on the drum surface. The carrier beads are then retoned with additional toner particles as they flow adjacent and/or in contact with the development electrode. This retoning process will be described in more detail below.

Following the development step, the drum carries the developed image through transfer station **40** where the toner imge is transferred from the drum surface to support material **41.** Transfer of the developed image onto the support material is aided by corona device **41** which applies an electrostatic charge to the support material having a polarity opposite that of the triboelectric charge on the toner particles. Transfer takes place between guide rollers **45** which act to position the support material against the photosensitive drum at the transfer station. Support material **41** is fed from reel **43** before transfer and is rewound on reel **44** after transfer takes place. If the support material is the permanent substrate upon which the developed image is to be fixed, fusing device **46** is desirable and should be placed along the path of this support material between the point where the developed image is transferred to the support material and the point where the support material is rewound on reel **44.** The fusing device is po-

sitioned to heat the toner particles thereby permanently fixing them to the support material.

The final station shown in the drawing is cleaning station **50** comprising a cylindrical fur brush **51** which contacts the photosensitive surface of the drum. The cleaning station is utilized to remove any residue toner particles from this photosensitive surface after transfer occurs and before a new imaging cycle is begun. It is intended that various moving elements by driven by any suitable means. For instance, the motor that drives drum **63** can also through appropriate gearing drive all the other moving elements in the copier.

It is within the confines of the development station, station **30,** that the present invention is utilized. Toner particles **72** are placed in container **71** and are supported by the container adjacent the apertures **75** in development electrode **74.** During the developing process developer is elevated to a position over the drum by the buckets **34** and then released so that it flows through the development zone between the drum surface and development electrode **74.** As developer flows across the drum surface toner particles are attracted away from the carrier beads and adhere to the plate in imagewise configuration. The carrier beads are fully-toned or nearly fully-toned when entering the development zone and, as they give up toner particles to the drum surface, during the cascade process, they become under-toned. For the purpose of this disclosure, a fully-toned carrier bead is one which has all the toner particles attracted to it due to triboelectric action that it can when an unlimited supply of toner particles is available and the developer mixture is thoroughly mixed and an under-toned carrier bead is one which has less toner on it than when fully-toned, particularly when toner particles have been attracted from the carrier beads to the drum surface in the development zone. A carrier bead, after becoming undertoned, continues to flow through the development zone and in so doing moves adjacent and/or in contact with the development electrode. The under-toned carrier bead, in so doing, attracts toner particles from the apertures in the development electrode and becomes retoned; that is, it becomes more nearly fully-toned. This process can continue until the carrier beads finally exit the development zone and enters the trough **38** of housing **31.** After entering the trough, the carrier beads are mixed with additional toner particles before being elevated again.

The development electrode, in addition to adding toner particles to the cascading developer mixture as needed, improves the deposition of toner on the plate, especially in solid areas. The development electrode causes the lines of force from the image areas to be directed in generally parallel relationship towards the development electrode and in perpendicular relationship to the image surface and to the development electrode. This results in a uniform adherence of the toner over the image area and produces a uniformly dark or concentrated image with lines that are not diffused, as contrasted with developing procedures in which there is no development electrode. In the absence of a development electrode the lines of force from the edges or outer portions of an image area are consequently directed in curved paths to the adjacent discharged or background areas, resulting in the lines of force being dissipated from the image areas and producing black or dark effects around the edges and light or white effects at the central portions. Due to the action of the development electrode, solid area toner coverage is improved greatly.

The principle upon which the instant invention in based is as follows. A carrier bead exhibits an attractive force on toner particles due to the relative locations of the carrier bead and toner particle on the triboelectric scale. As carrier attracts toner to its surface it electrostatic attraction for additional toner decreases in proportion to the amount of toner already being held on its surface. Once the carrier can electrostatically accept no more toner it is said to be fully-toned. During the developing process, toner particles are attracted away from the carrier and adhere to the drum surface. This migration of the toner particles is possible since the attractive force of the image areas of the drum is stronger than the attractive force of the carrier on the particles. A carrier bead which gives up toner to the drum surface is said to be under-toned and has capacity to attract more toner particles until it again reaches its fully-toned condition. As an under-toned carrier bead continues to flow through the development zone, it moves adjacent to and/or contacts the development electrode. When this happens, toner particles located in the vicinity of the apertures in the development electrode are drawn through the apertures by the attractive force of the carrier beads to retone the carrier beads. The toner particles in the toner container **71** remain in the vicinity of the development electrode and do not fall into the development zone due to the attractive forces between the toner and development electrode. As the carrier attracts additional toner, its force for attracting toner particles decreases until the force of the development electrode for the toner particles is approximately equal to the force of the carrier beads on the toner particles. At this time the carrier beads are retoned for further development and do not accept additional toner. The carrier then can move into contact with the latent image and continue to fully participate in the development process.

It is preferable in practicing this invention that the development electrode be made of a suitable conducting material and that many apertures be placed in it to enable a flow of toner to pass to the carrier beads from the toner reservoir. For instance, the development electrode can be made of a conducting mesh material having a coating of material which is similar to that of the carrier bead so that the toner particles gain a triboelectric charge which makes them attractive to the carrier as they are placed in the apertures. In this case the development electrode aids in triboelectrically charging the toner while maintaining its primary function of controlling the deposition of toner particles on the plate in imagewise configuration. In the alternative, carrier beads can be mixed with the additional toner in container **71** to triboelectrically charge the toner and to keep the toner in a loose consistency. The toner particles would then lie attracted from fully-toned carrier beads in container **71** through the apertures to undertoned carrier beads in the development zone.

In addition to the apparatus outline above, many other modifications and/or additions to the invention will be readily apparent to those skilled in the art upon reading this disclosure and these are intended to be encompassed within the invention disclosed and claimed herein.

What is claimed is:

1. A method for developing a latent electrostatic image on a photosensitive surface with toner particles comprising:

a. cascading carrier beads having toner particles triboelectrically attracted thereto across the photosensitive surface in a development zone whereby the electrostatic charges on the photosensitive surface attract the toner particles from the carrier beads to the surface thereof causing the carrier beads to become undertoned while still in the development zone,

b. retoning the under-toned carrier beads in the development zone by attracting additional toner particles thereto from an apertured container of toner particles as the carrier beads cascade past said container,

c. directing the carrier beads and the residual toner particles into a trough,

d. adding additional toner particles to the carrier beads in the trough, and

e. removing carrier beads and toner particles from the trough and cascading the same over the photosensitive repeat steps *a*, *b*, *c* and *d*.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,790,397 Dated February 5, 1974

Inventor(s) Ernest A. H. Weiler

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

Claim 1, Column 8, Line 11, after the word "sensitive", insert --surface to--.

Signed and sealed this 17th day of September 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334.

UNITED STATES PATENT OFFICE
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