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Jugle et al.

[11] **3,795,222**

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[54] **DEVELOPMENT ELECTRODE SYSTEM**

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

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[52] **U.S. Cl.** **118/637**

[51] **Int. Cl.** **G03g 13/08**

[58] **Field of Search** ..... 118/637, DIG. 24, DIG. 23; 346/74 ES; 355/3 DD

[56] **References Cited**

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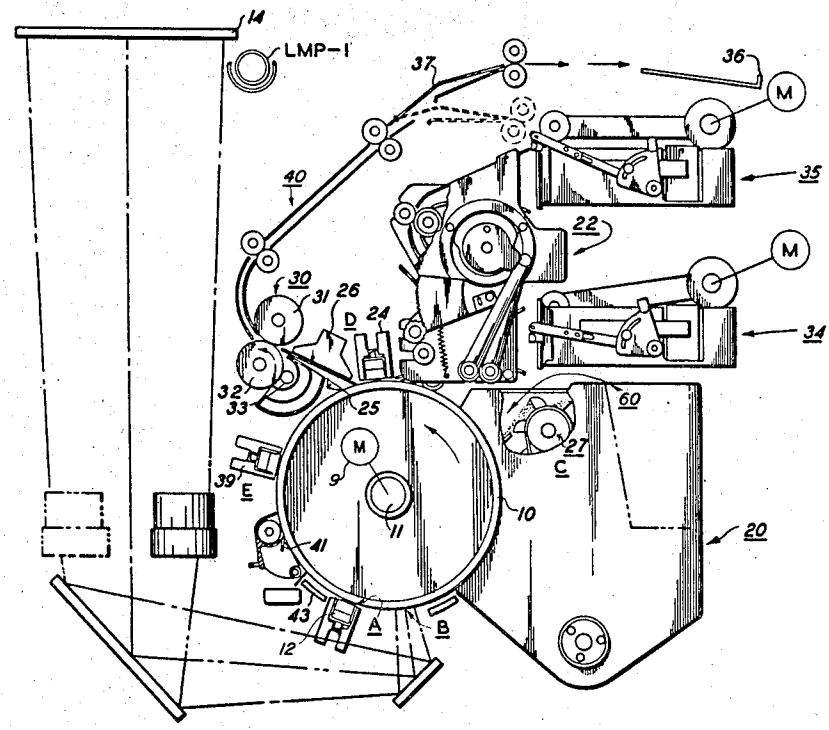
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Primary Examiner—Morris Kaplan

[57] **ABSTRACT**

A development apparatus of the type in which a latent electrostatic image is moved in an uphill direction for development by cascading multi-component developer materials over the image surface and in which an improved electrode is used to both clean the background of the image and effect a wider toner concentration latitude. The electrode is positioned in parallel relation to the moving image surface and is connected to a first source of electrical potential of a polarity similar to the polarity of the image and a second source of electrical potential of a polarity opposite of the polarity of the image by a switching device. The switching device applies the first and second potentials to the electrode in alternating fashion according to whether the image is being developed or not developed, respectively.

1 Claim, 2 Drawing Figures



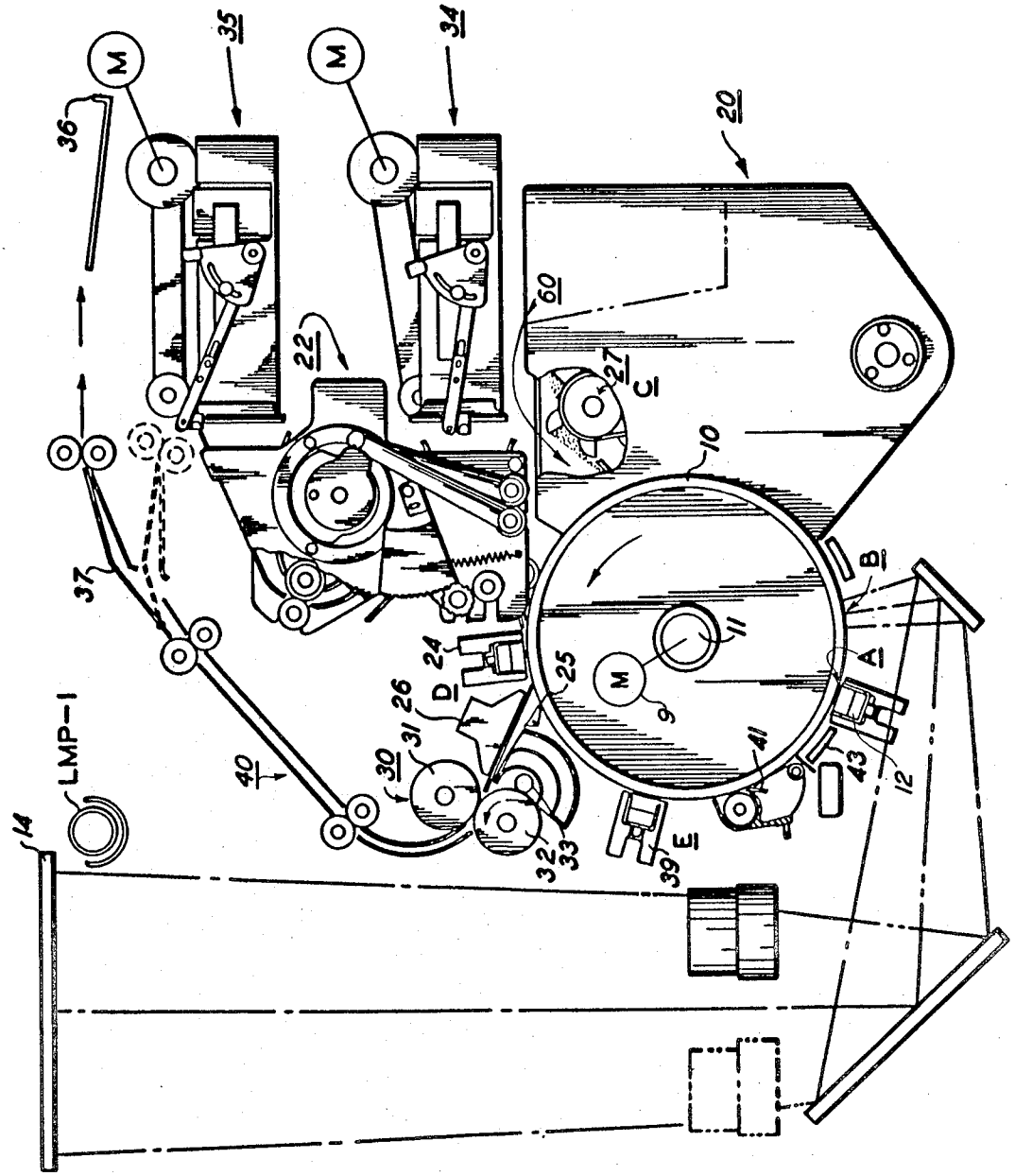

M
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M
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D
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40
LMP-1
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14
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39
E

FIG. 1

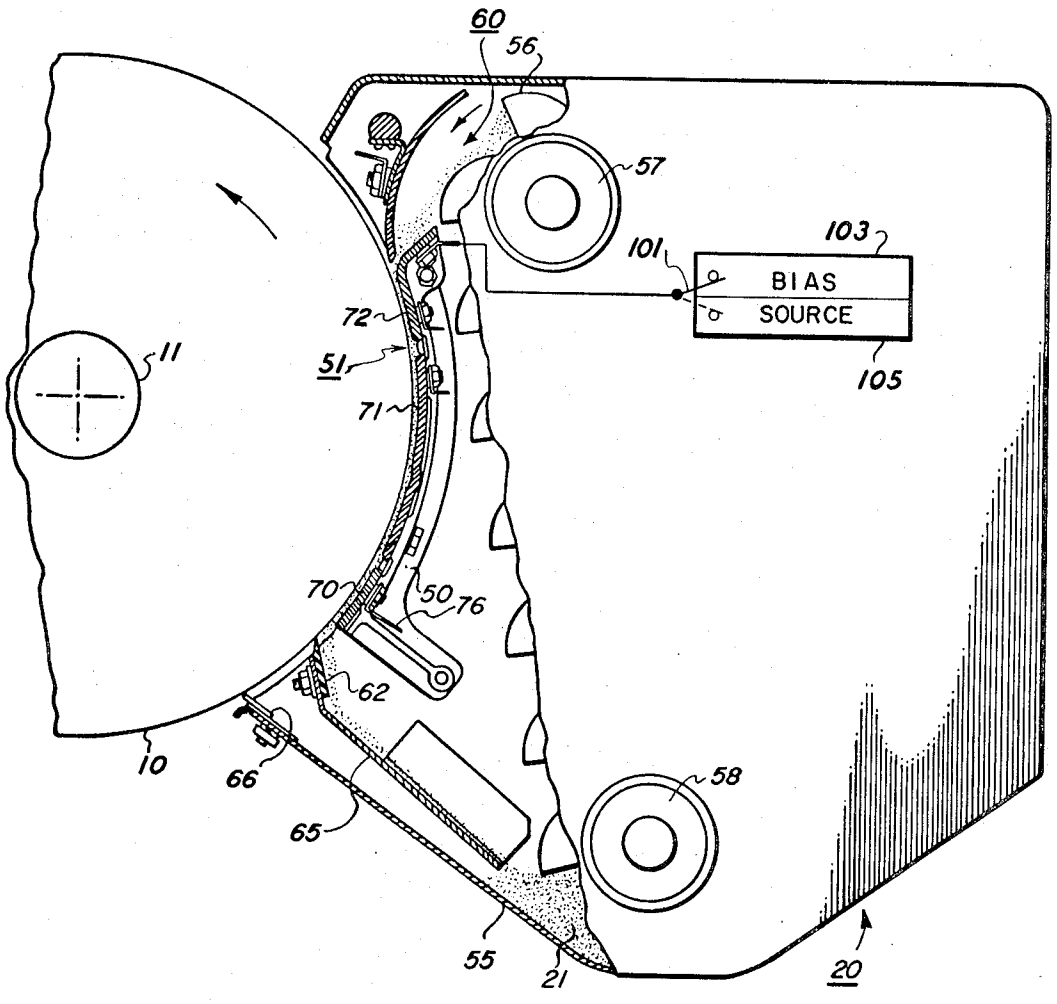

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FIG. 2

DEVELOPMENT ELECTRODE SYSTEM

This invention relates to xerographic development and in particular to improving the quality of xerographic prints and enhancing the toner concentration latitude of the developer material.

More specifically, this invention relates to a cascade development system in which fully loaded, and thus, electrically neutral, multi-component developer material is used to mechanically scrub unwanted background from a fully developed xerographic image on an upwardly moving photoconductive surface.

In the art of xerography, as originally disclosed by Carlson in U. S. Pat. No. 2,887,691, a plate comprising a conductive backing upon which is placed a photoconductive insulating material is charged uniformly and the charged surface exposed to a light image of an original document to be reproduced. The photoconductive coating is caused to become conductive under the influence of the light image so as to selectively dissipate the electrostatic charge found thereon producing what is known as an electrostatic latent image. This latent image is developed by means of a variety of pigmented resins which have been specifically developed for this purpose. The pigmented resin material, or toner, is electrostatically attracted to the latent image on the photoconductive surface in proportion to the amount of charge found thereon. That is, area of small charge concentration become areas of low toner density while areas of greater charge concentration become proportionally more dense. The fully developed image is generally transferred to a final support material, as for example, paper, and the image fixed thereto to form a permanent record of the original document.

One of the most widely used methods for developing a latent electrostatic image is the cascade developing technique which is primarily grounded on the principal of triboelectrification. This phenomenon occurs when two dissimilar materials having unique properties are brought into rubbing contact with each other causing the materials to become electrostatically charged to opposite polarities. In the art of xerography, triboelectrification is utilized to generate a charge on the toner material. When fine toner material is mixed with a relatively coarser carrier material, as for example specially coated glass beads, the toner material becomes electrostatically charged and is attracted to the oppositely charged surface of the relatively larger carrier material. Development of the latent electrostatic image is effected by cascading the multi-component developer material over an image bearing photoconductive surface. As the toner ladened beads contact and flow over the photoconductive surface, the toner material is dislodged from the bead surface and attracted electrostatically into the image areas. The toner starved or denuded carrier, still maintaining its triboelectric charge acts to attract or scavenge unwanted residual toner from background or non-image areas so as to produce a relatively sharp, clear, clean image of the original document. This two-step method of developing a latent image and removal of unwanted background is sometimes referred to as the classical development-scavenging technique.

The development-scavenging technique, as attested to by its wide commercial acceptance, is particularly suited for use in a downhill cascade system wherein the developer material is cascaded over a downwardly moving photoconductive surface. The development process begins at the time that the developer material initially contacts the downwardly moving photoconductive surface and continues as long as the developer and photoconductor move the same direction or until the image is fully developed. A preponderence of the total image development is found to take place at or shortly after the cascading developer makes initial contact with the plate surface. The remaining period of developer plate contact is used primarily in scavenging unwanted background from the plate surface.

Because of design and space considerations, it has been found advantageous in many new xerographic reproducing machines to cascade developed latent images on an upwardly moving xerographic plate. This technique is generally referred to as uphill cascade development. In an uphill cascade system, as in the downhill system, multi-component developer is caused to flow over a moving photoconductive surface, however, in the uphill system developer material is introduced into the development zone at the point where the developed image is leaving the system. Development of the latent electrostatic image on the other hand, begins at the point where the latent image enters the development system which is also the point where the denuded or toner starved developer material leaves the system.

It is therefore a primary object of this invention to improve xerographic development.

A still further object of this invention is to improve xerographic development in an uphill cascade development system.

A further object of this invention is to improve the print quality of an uphill cascade development system.

Another object of this invention is to provide apparatus for removing unwanted background in an uphill cascade development system without detracting from its effective charge characteristics.

A still further object of this invention is to improve uphill cascade development for use in automatic xerographic reproducing machines.

Another object of this invention is to enhance the toner concentration latitude of developer material in an uphill cascade development system.

These and other objects are attained in accordance with the present invention by alternately applying an electrical charge to the electrode of a polarity similar to the polarity of the electrostatic image and an electrical charge to the electrode of a polarity similar to the polarity of the electrostatic image and an electrical charge to the electrode of a polarity opposite to the polarity of the electrostatic image at predetermined intervals.

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 read in connection with the accompanying drawings, wherein:

FIG. 1 is a schematic side elevation of an automatic xerographic machine utilizing the instant invention; and

FIG. 2 is an enlarged side elevation of the developing apparatus used in the xerographic reproducing machine shown in FIG. 1 with parts broken away to better illustrate the invention.

The general apparatus of the instant invention is shown herein embodied in an automatic xerographic apparatus. As shown schematically in FIG. 1, the auto-

matic xerographic reproducing apparatus comprises a xerographic plate **10** including a photoconductive layer or light receiving surface which is placed on a conductive backing and formed in the shape of a drum. The drum is mounted on a shaft **11** and journaled in the machine frame (not shown) to rotate in the direction indicated by the arrow thus causing the drum surface to sequentially pass a plurality of xerographic processing stations.

For the purpose of the present disclosure, the several xerographic processing stations in the path of movement of the drum surface may be described functionally as follows:

a charging station A, at which is positioned a corona generating device **12** for placing a uniform positive electrostatic charge on the photoconductive layer of the xerographic drum;

an exposure station B, at which a light or radiation pattern of an original document supported on platen **14** is projected onto the drum surface thereby dissipating the charge found thereon in the areas exposed so as to form a latent electrostatic image of the original document;

a developing station C, having a housing, generally designated **20,** in which a multi-component xerographic developing material having negatively charged toner particles is cascaded over the upwardly moving drum surface by means of bucket conveyor **27** enabling the toner particles to contact and adhere to the electrostatic image thereon to form a xerographic powder image in the configuration of the original document to be reproduced;

a transfer station D, at which the xerographic powder image is electrostatically transferred from the drum surface to a sheet of final support material by means of transfer corotron **24**;

a drum cleaning and discharge station E, at which the drum surface is exposed to a cleaning corotron **39** and then wiped by a doctor blade **41** to remove residual toner particles which may remain thereon after the transfer operation and at which the drum surface is exposed to a source of illumination **43** to effect substantially complete discharge of any residual electrostatic charge remaining thereon.

Subsequent to the transfer station is positioned a polarity of mechanical stripper fingers **25** arranged to contact the lower leading edge of the support material and being adapted to strip the leading edge of the material from the drum surface. The stripper fingers are shaped so as to direct the sheet of support material in contact with stationary vacuum transport **26.** The support material, a portion of which is still electrostatically adhered to the drum surface, is moved along the vacuum transport towards fuser assembly **30** as the drum rotates in the direction indicated.

Under the influence positioned the rotating drum, the support material is moved along the stationary vacuum transport **26** into the nip between upper fuser roll **31** and lower fuser roll **32.** The fuser rolls are arranged to coact and deliver pressure driving force to a sheet of support material postioned therebetween. A radiant source of energy **33** extends transverse to the lower roll and transfers heat energy to the lower roll surface. The heat energy is brought into thermal contact with the image bearing support material as the lower roll is rotated in the direction indicated. Image fixing is accomplished by a combination of pressure and heat energy transferred to the powder image as the support material moves through the roll fuser assembly.

The fixed copy is transported through a circular paper path, generally referred to as **40,** where it is either discharged from the apparatus into catch tray **36** positioned at any suitable point for collection, or fed into a secondary feed tray **35** from which the support material can be refed through the xerographic processing stations to form a second image thereon.

It is believed that the foregoing description is sufficient for purposes of this application to show the general arrangement of a xerographic reproducing apparatus. However, for further details concerning the specific construction of the xerographic apparatus shown herein, reference is made to U. S. Pat. No. 3,611,992.

Referring now specifically to FIG. **2,** the apparatus of the development system basically comprises a series of conductive control members separated by insulating blocks which are supported in close parallel relation to a moving xerographic drum surface so as to form a continuous enclosed flow path therebetween. This flow path is herein referred to as the development zone and is numerically designated **51.** Positioned at the upper entrance to the enclosed development zone is an entrance chute, generally referenced **60,** through which a continuous flow of multi-component developer material is introduced into the development zone. A series of conductive control members form the backwall of the development zone **51** and, as will be explained in greater detail below, function to control the distribution of developer material in the flow stream during development. The front wall of the development zone is described by the upwardly moving drum surface. It should be noted that in this particular development apparatus, the drum surface is moving upwardly in opposition to the downwardly moving developer flow stream. This particular flow relationship between developer and plate is directly opposite that utilized in most conventional cascade development as disclosed by Walkup in U. S. Pat. No. 2,618,551 in that therefore, the carrier beads do not operate in the classical sense to first give up toner during the development process and then, when partial denuded, scavenge the weakly held background development from the non-imaged areas.

The conductive control members, and the insulating blocks separating these members, are mounted on a non-conductive rigid support frame **50** and the frame affixed to the sidewalls of the developer housing **20.** An opening is provided in one end wall of the housing through which the rotating drum surface is allowed to pass in close proximity to the conductive control members supported therein. The control members and the insulating blocks both extend horizontally across the drum surface and have end seals (not shown) provided which ride in contact with the extreme ends of the drum surface to enclose the development zone **51.**

Multi-component developer material is transported from a storage and mixing area in the sump **55** of the developer housing into an entrance chute **60** by means of a conveyor. The conveyor is made-up of a series of horizontally extended elongated buckets **56** affixed to an endless belt which passes over pulley assemblies **57** and **58.** As the buckets are transported in the direction indicated through the developer sump area, the buckets become loaded with developer material. The continuous movement of the buckets through the devel-

oper mix sufficiently agitates the developer mix to produce triboelectric charging of the materials. The loaded bucket, upon leaving the sump area, are raised to the top of the developer housing where they are discharged into entrance chute **60** thus supplying a continuous flow of material to the development zone.

The developer material delivered into the entrance chute is introduced into the development zone **51** where it is allowed to flow downwardly under the influence of gravity in opposition to the upwardly moving photoconductive plate surface. The behavior of the developer material, as it passes through the development zone, is closely and automatically controlled by the control member to develop the plate surface and clean unwanted background which results in the development of extremely clear, clean, xerographic images. Because of the unique sensitivity of the present system, a wide variety of images such as line copy, solid area, half toned images or any combination thereof can be processed without changing the electrical or mechanical parameters of the present system. As the developer material leaves the development zone, it is intercepted by a pickoff baffle **62** which is mounted in close proximity to the drum surface in the lower portion of the developer housing. The intercepted developer material is redirected down an incline chute **65** back into sump area **55** where it is stored and recharged preparatory to being reused in the xerographic developing process. Also positioned immediately below the pickoff baffle is a developer housing seal **66** adapted to coact with the moving drum surface to prevent any developer material which might migrate into this area from escaping from the developer housing.

After the plate is charged and exposed, the latent image is transported upwardly on the drum surface through the bottom opening provided into development zone **51.** It should be noted that in this embodiment, the point of entry of the latent electrostatic image is also the point at which developer material is leaving the development zone. However, as will become apparent from the discussion below, the developer material in this start of developing region is, because of the systems unique characteristics, properly charged and in condition to produce complete image development in a short period of time. In fact, a slightly overdeveloped condition is produced in this start of development region. More toner than is normally required for image development is present at the drum surface at this time which results in some background being developed. However, excessive background development is not harmful in the present apparatus because the background is efficiently and effectively cleaned from the plate surface as the plate moves through the development zone.

A latent electrostatic image produced on a photoconductive surface, such as a selenium drum, characteristically has an electrostatic field charge pattern which is extremely strong and dense along the edges or outer fringes. However, the density and strength of the force field components, particularly the components perpendicular to the plate surface, progressively diminish as you move away from the edge areas. During development the stronger and more dense filed components associated with the fringe areas reach out and pull oppositely charged toner particles. However, the weaker and less dense components associated with the large interior solid areas cannot effectively or rapidly capture toner particles and therefore these areas generally appear washed out due to underdevelopment. A low potential development electrode **70** is placed in close proximity to the moving plate surface in the start of development region. Electrode **70** is connected to a suitable biasing source. The electrode is placed at a potential below the potential found in the non-imaged, or exposed areas on the drum surface. A force field is established in this inverted portion of the development zone which acts to force the toner in the flow stream upwardly against the drum surface. The electrode, because it is biased below the background potential, not only strengthens the force fields associated with the solid image areas but also strengthens the force fields associated with the exposed non-imaged areas so that a relatively strong field exists across the entire drum surface in this electroded region.

The next subsequent conductive member positioned in relation to the direction of drum rotation is main development electrode **71.** As previously noted, the main development electrode is electrically isolated from the low potential electrode by means of a dielectric block. A suitable biasing source is connected to the main development electrode. The two adjacent electrodes **70, 71** are of substantially equal thickness. However, the dielectric block is constructed to be of lesser thickness so that a pocket or void is created on the backside of the system in the inverted zone.

The next subsequent electrode in relation to the direction of drum travel is a cleanup electrode **72.** The cleanup electrode is postitoned in the upper part of the development zone adjacent to the opening through which fresh developer material is first introduced into the development zone. The cleanup electrode is physically positioned adjacent to the main development electrode and electrically isolated there from by means of a dielectric block. The cleanup electrode functions primarily to establish an extremely high directional force field capable of attracting toner material to the electroded side of the system to control the movement of free or weakly held toner particles through the upper part of the development zone. The cleanup electrode further functions to condition the carrier beads moving in contact with the plate in this region to clean unwanted background from the plate surface.

In the past toner has collected on the cleanup electrode creating a large negative potential countering the effectiveness of the applied cleanup potential. It has been found that in standby or shutdown condition this toner may lose its charge and hence part of its adhesion force to the electrode and be released with the first cascading developer causing an excess toner concentration in the developer zone.

In accordance with the present invention the amount of toner collected on the cleanup electrode may be substantially reduced by applying a negative bias to the electrode during the passage of the interdocument zone, i.e., the area between images on the xerographic drum. Moreover, maintaining a lower level of toner deposit on the cleanup electrode enables a lower positive bias during image development to obtain high quality copies.

Usually the xerographic machine of the type described herein utilizes only about two-thirds of its cycle time developing images. The other one-third is occupied with the passage of the two interdocument portions of the drum through the development zone. In ac-

cordance with the invention, for positive latent electrostatic images, a switched mode of operation is used in which a positive bias potential of about 300 to 500 volts is applied to the electrode during image development and a negative bias potential of about −600 to −1000 volts is used during electrode cleanup. In operation a switch **101** is alternately coupled to positive potential source **103** and negative potential source **105.** Any suitable means can be used for switching the electrode, as for example, a camming device with the dwell time less than the time required for passage of the interdocument zones past the cleanup electrode **72.** It has been found that a positive potential of 400 volts and a negative ptoential of 800 volts works well with a positive latent electrostatic image.

With the above invention a lower level of toner deposits on the cleanup electrode enabling a lower positive bias during image development to obtain higher quality prints. At the same time, a wider toner concentration range for acceptable copies can be accomplished.

While this invention has been disclosed with references to the structure described herein, it is not to be confined to the details as set forth, and this application is to cover all modifications and changes which may come with the scope of the following claims.

What is claimed is:

1. In a xerographic developing apparatus of the type wherein a latent electrostatic image formed on a photoconductive surface rotated past processing stations in an uphill direction is developed and cleaned by cascading multi-component developer material including toner particles over the image bearing surface, an improved cleanup electrode member apparatus including

electrode means including a development member and a cleanup member positioned in spaced parallel relation to said moving surface and said cleanup member being arranged adjacent to the upwardly moving developed image on said surface at the top of the development zone,

a first source of electrical potential ranging from about 400 volts to about 600 volts coupled to said cleanup member of a polarity similar to the polarity of the latent image to attract developed material dislodged fron the developed surface by the flow of cascading developer material,

a second source of electrical potential ranging from about 600 to about 1000 volts coupled to said cleanup member of a polarity opposite to the polarity of the latent image to repel developer material covering the cleanup member, and

switching means for applying said first potential synchronous with development of image areas and said second potential synchronous with development of interdocument areas whereby accumulated toner particles on said cleanup member develop interdocument areas enabling high quality development of the image areas.

* * * * *