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[54] **ELECTRODED DEVELOPMENT DEVICE**

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[52] **U.S. Cl.** **118/637,** 118/636, 117/17.5
[51] **Int. Cl.** **G03g 13/00**
[58] **Field of Search** 118/636, 637; 117/17.5

[56] **References Cited**

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[57] **ABSTRACT**

A development system is herein disclosed for making visible a latent electrostatic image supported on an image retaining member. The apparatus includes an elongated biased electrode positioned in close parallel relation to the image-retaining member to form an enclosed development zone in which a flow of two component developer material is maintained. A series of pins are mounted on the electrode and extend into the development zone to disperse the developer material while the material is under the influence of an electroded force field wherein the concentration of toner in the flow stream is controlled.

4 Claims, 2 Drawing Figures

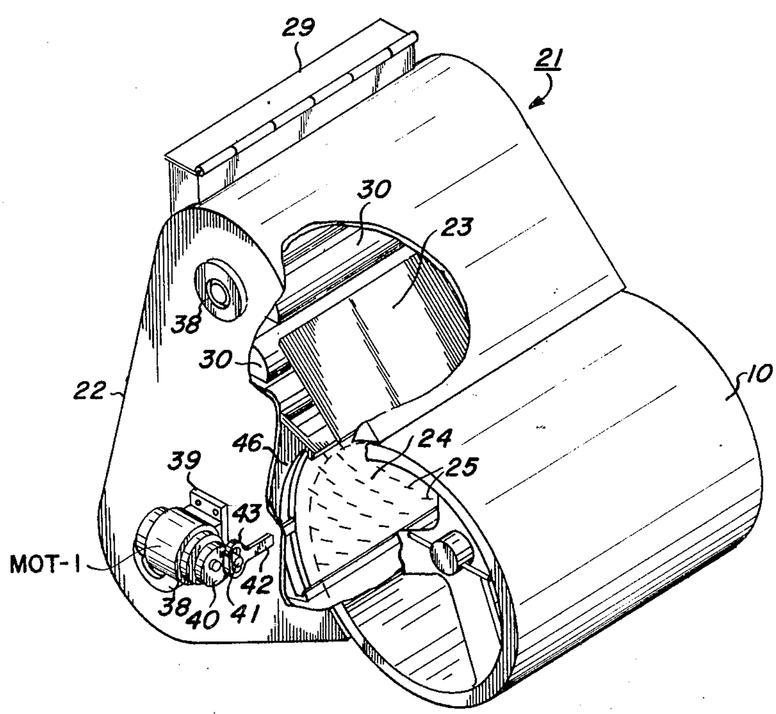


FIG. 1

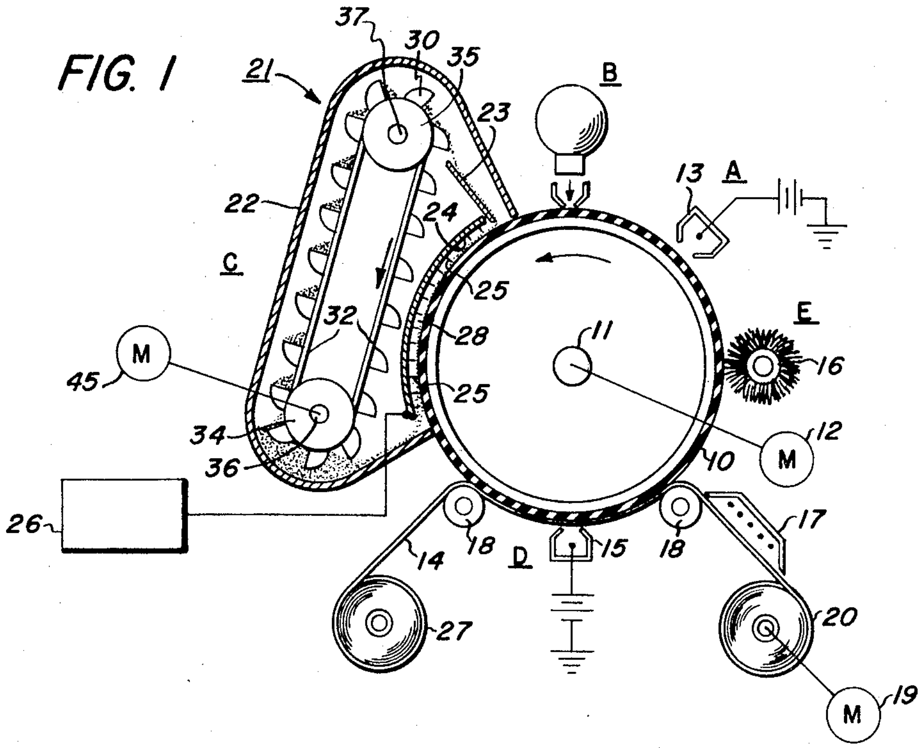
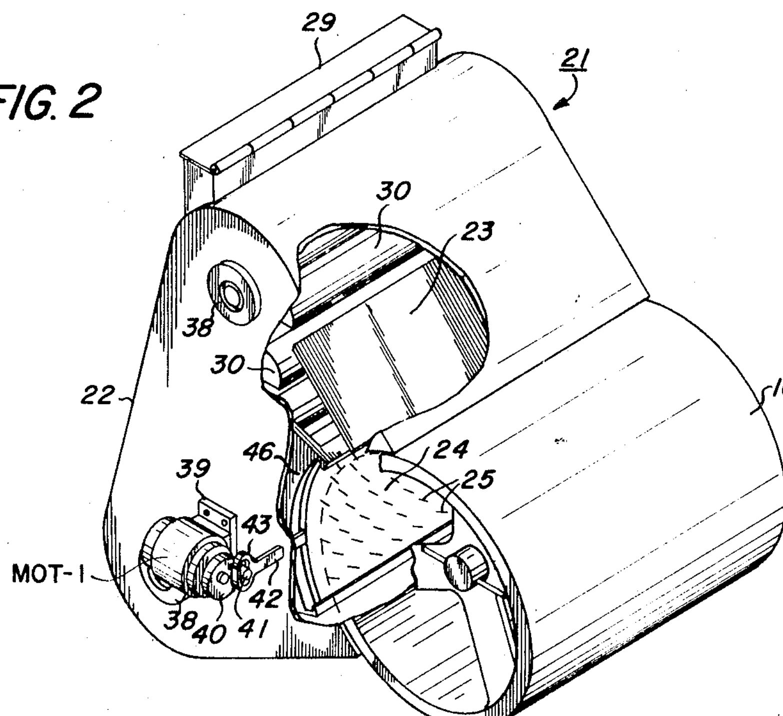


FIG. 2



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ELECTRODED DEVELOPMENT DEVICE

This invention relates to apparatus for developing a latent electrostatic image and, in particular, to an electroded development system for making visible a latent electrostatic image supported on an image-retaining member.

More specifically, this invention relates to a xerographic developing apparatus in which a sensitive control is afforded over the developer material during the image developing process. In the art of xerography, a xerographic plate, generally comprising a photoconductive surface placed over a conductive backing, is first charged uniformly and then exposed to a light image of an original to be reproduced. Under the influence of the light image, the photoconductive surface is selectively discharged to form what is known as a "latent electrostatic image." Conventionally, the latent image is developed by contacting the charged image areas with an oppositely charged toner material which has been specifically developed for this purpose. The oppositely charged toner particles are electrostatically attracted into the charged image areas thus making the latent image visible.

Theoretically, areas of greater charge concentration should be developed as areas of high toner density while areas of lesser charge concentration should be proportionally less dense. However, in practice, this has not been found to be the case. Large, "solid," areas of charge concentration supported on a surface, such as a photoconductive plate, exhibit a nonuniformity of development when contacted with a toner material. It is believed that the flux density of the electrostatic force field associated with the solid areas varies with the stronger forces located along the fringes or edges of the images. The edge areas, therefore, develop at a faster rate than the interior areas although both are similarily charged. Because of the phenomena, solid areas which must be developed within a relatively short time period, as in automatic xerographic machines, appear washed out or underdeveloped.

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

A further object of this invention is to enhance the solid area developing a capability of a xerographic developing apparatus.

Yet a further object of this invention is to improve automatic xerography by providing a developing apparatus capable of providing a sensitive control over the developer material whereby images of varying sizes are developed at a constant rate.

These and other objects of the present invention are attained by means of a biased electrode which is positioned in close parallel relation to a latent image bearing member to form an extended, substantially enclosed, development zone therebetween which is capable of supporting a continuous flow of two component developer material, means to continually maintain a flow of developer material through the enclosed development zone whereby developer material is brought into contact with a latent image supported upon the member, and flow disrupting means positioned within the enclosed development zone to disperse the developer material moving between the member and the electrode wherein charged toner particles moving through the zone are readily positionable as they move through the electroded zone.

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 view of an automatic xerographic reproducing machine employing the developing apparatus of the present invention;

FIG. 2 is an enlarged partial perspective view showing the developing apparatus of the present invention illustrated in FIG. 1.

There is illustrated schematically in FIG. 1 a continuous xerographic apparatus for the purpose of showing a suitable environment for the xerographic developing system having mounted therein an electroded development zone in accordance with the present invention.

As illustrated in FIG. 1, the xerographic apparatus comprises a xerographic plate including a photoconductive layer or light receiving surface placed on a conductive backing and formed in the shape of a drum, generally designated by numeral **10**, which is mounted upon shaft **11** journaled in the frame (not shown) to rotate in the direction indicated by the arrow to cause the drum to pass sequentially through plurality of xerographic processing stations. Drum **10** is rotated at a constant rate through the drive action of a synchronous motor **12**.

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

A charging station A, at which a uniform electrostatic charge is deposited on the photoconductive layer of the drum surface by means of a corona discharge device **13** of the type disclosed by Walkup in U.S. Pat. No. 2,777,957;

an exposure station B, at which a light or radiation pattern of an original to be reproduced is projected onto the drum surface to dissipate the charge found thereon in the exposed areas thereby forming a latent electrostatic image thereon, the exposure station being positioned adjacent to the charging station in the direction of drum travel;

a development station C, at which a xerographic developing material including toner particles having an electrostatic charge opposite to the electrostatic latent image charge are brought into contact with the image-bearing drum surface whereby the toner particles adhere to the electrostatic latent image in configuration to the original to be reproduced thereby making the latent image visible;

a transfer station D, at which the xerographic powder image is electrostatically transferred from the drum surface to a final support material **14** by means of a second corona generating device **15** similar to that used in the charging station;

a drum cleaning and discharge station E, at which the drum surface is brushed by means of a rotating cylindrical brush **16** to remove residual toner particles remaining thereon after image transfer.

In the present embodiment, the final support material **14** is mounted on a supply spool **27** in a web configuration and is transported through heat fuser **17** wherein the developed and transferred powder image on the web surface is permanently affixed thereto. The web is guided by a set of idler rollers **18** and driven through the transfer station in synchronous moving relation with the drum surface by means of synchronous drive motor **19** acting through a takeup spool **20**.

Referring now to FIGS. **1** and **2**, there is shown a preferred embodiment of a electroded development system constructed in accordance with the present invention.

The term "two components developer material," as herein used, refers to a material employed to develop latent electrostatic image, the material comprising a relatively large "carrier" bead to which is bonded electrostatically a quantity of smaller "toner" particles. The carrier and toner materials are preselected from materials which are triboelectrically remote so that they interact when brought into rubbing contact to charge the materials to opposite potentials. Conventionally, the carrier will assume a positive charge while the toner assumes a negative charge. The toner is loaded on the carrier beads and the beads brought into contact with a latent electrostatic image supported upon a member, such as a xerographic plate, where the toner particles are electrostatically transferred from the bead surface to the more highly charged image areas.

One of the most prevalent methods of bringing the developer material into contact with an image-bearing member is to pour or cascade the developer material over the member and permitting the material to gravity flow downwardly in contact with member for a sufficient period of time to affect development. In the cascade system, the carrier beads which have given up their toner material in the development process still retain a charge thereon and act to scavenge or clean unwanted toner particles from the nonimaged or background areas on the plate surface. Thus, in a cascade development system, the developer material is used to both develop and clean the image-bearing plate surface.

As previously noted, however, solid area development of a latent electrostatic image by simply contacting the image with a developer material has long been a problem in the xerographic art. The nonuniformity found in the electrostatic force field density associated with the image causes the image to be developed at different rates. By the use of a biased development electrode, it is possible to increase the electrostatic force field above the image to produce a more uniform field acting on the toner particles. It should be made clear at this point that the term "biased electrode" as herein used is broad enough to include either a positively or negatively charged electrode, a grounded electrode, or even a free floating electrode. Nevertheless, it was generally recognized that an electrode, when brought into close proximity with an image-retaining member changes the images electrostatic field configuration so that the developability of the system is enhanced. However, little has heretofore known of the effect biased electrode had upon the developer material contained within a flow stream as it moved through an electroded force field.

It has been shown that a two component developer material moving through an enclosed development zone, such as between a development electrode and a photoconductive plate as herein disclosed, after passing through the introductory region tends to become compacted. That is, the particulate material moves in a unitized mass with the particles in contact with each other when flowing through an extended, enclosed, region. As the mass of developer moves through an electroded development zone, the electrode force field not only enhances the image force field but also acts upon the fine toner particles tending to force or move the particles, depending upon the charge relationship involved, to one side or the other of the development zone. However, if the developer mass is highly compacted, the toner particles are afforded little or no room to gravitate from one side of the development zone towards the other.

As will be explained in greater detail below, the apparatus of the present invention provides a developing system having means to disperse developer material moving in a restricted flow zone between an electrode and a plate wherein the fine toner particles moving in the electroded zone have sufficient room to move within the flow. By controlling the electrode potential and bias magnitude, a toner gradient can be established in the flow stream to concentrate the toner on one side or the other of the development zone.

In order to effect development of the electrostatic latent image on the cylindrical xerographic plate, the developing system shown includes a developer apparatus, generally referred to numerically as **21**, which coacts with a cylindrical xerographic drum **10** to form a development area wherein the charged and exposed surface of the drum is capable of being developed to form a visible powder image of the original to be copied.

For this purpose, a developer housing **22** is mounted adjacent to the xerographic drum as illustrated in FIG. **1**. Mounted within the developer housing is a driven bucket-type conveyor used to transport two component developer material, previously supplied to the developer housing, to the upper portion of the housing where the material is guided through an introductory region into the active development zone **28** by means of an entrance chute **23**. A shaped electrode **24** is mounted within the developer housing in spaced parallel relation to the cylindrical drum surface and extends transversely across the drum to form an elongated development zone **28** therebetween. As the developer material is introduced into the upper part of the development zone, the material is caused to flow downwardly through the development zone wherein toner particles on the developer material adhere electrostatically to the previously formed latent images on the drum surface and the remaining developer material passes through the bottom opening of the development zone back into the sump or supply area of the developer housing. Toner particles, consumed during the developing operation to form the visible powder images, are replenished by means of a toner dispenser **29** mounted on the top portion of the developer housing as shown in FIG. **2**.

A suitable bucket-type conveyor is used to convey the developer material from the reservoir portion of the developer housing to the upper portion of the developer housing from where the material is gravity fed through the development zone. In this embodiment, the bucket-type conveyor consists of a series of parallel spaced buckets **30** secured by rivets or the like to a pair of conveyor belts **32** which are wrapped about conveyor drive pulleys **34** and conveyor idler pulleys **35** secured to drive and idler shafts **36** and **37**, respectively. The two shafts **36** and **37** are rotatably supported in parallel relation in bearing blocks **38** (FIG. **2**) provided in the parallel opposed sidewalls of the developer housing **22**. The drive shaft **36**, which is securely journaled for rotation within the bearing blocks **38** passes exterior the developer housing and is operatively connected to motor **45** wherein the bucket conveyor moves in predetermined timed relation with the xerographic drum surface in the direction indicated.

To properly introduce the developer material into the development zone, and to spread this material is longitudinally across the face of the drum surface as the material is emptied out of the conveyor buckets by gravity, an input chute **23** is secured as by welding the end flanges (not shown) of the chute to the sidewalls of the developer housing.

In the present invention, an arcuate-shaped electrode **24**, extending longitudinally across the drum surface, is slideably supported in close parallel relation to the drum surface **10** to establish therebetween an elongated development zone **28** capable of supporting a flow of two component developer material. The development zone extends from the upper portion of drum down into the inverted drum region such that the developer material is caused to move in contact with the drum surface for relatively long period of time. The developer to drum access time afforded by this system is considerably longer than that provided by a conventional cascade development system. A developer material introduced into the development zone moves downwardly in contact with the moving drum surface through the development zone and is eventually discharged back into the reservoir of the developer housing where it once again reused in a development process.

The electrode, as illustrated in FIG. **2**, is supported in a slide member **46** formed of an insulating material and secured to the sidewalls of the developer housing. The electrode is capable of being moved in a lateral direction substantially perpendicular to the developer flow and is electrostatically isolated from the developer housing. A biasing means **26** is electrically connected to the electrode and electrically biases the electrode to a predetermined potential and magnitude to control the positioning and concentration of toner within the flow stream.

Mounted upon the electrode and extending substantially perpendicular from the electrode into the development zone are a series of pinlike members **25**. The pins are positioned to contact the developer material moving through the development zone to disperse and scatter the particulate material within a flow stream. The pins impact or collide with the carrier beads to scatter the beads throughout the development zone. At the same time toner material is dislodged from the beads surface to form an airborne toner cloud. It should be noted, that while carrier beads are scattered throughout the development zone, and the toner dislodged from the beads, the entire developer mass is flowing in a stream downwardly through the development zone. However, because the developer material is now dispersed, the electroded force field more readily act upon the charged toner particles to control the concentration of toner within the flow stream. In this preferred embodiment, the toner particles are triboelectrically charged to a negative potential and a highly negative charge is placed upon the electrode to establish a force field in the development zone to place a high percentage of the available toner in contact with the image-bearing drum surface where it is readily available for use in a development process. Because the solid area force fields are also enhanced by the electrode, the toner made available at the plate surface is rapidly attracted to the charged image areas thus rapidly and efficiently developing the image regardless of the image surface area.

Preferably, the pins are mounted equally spaced in parallel rows with the pins in each successive row being offset so that the developer material is caused to follow a relatively torturous path through the development zone. In this manner, the maximum number of bead impacts possible are maintained as the material moves through the development zone.

The pins can be constructed of either a conductive material or an insulating material. Conductive pins act much in the same manner as small individual point source electrodes to produce strong force fields about the pin capable of affecting image development. In practice, it has been found that the conductive pins cause the imaged drum surface to experience a history of unidirectional toning causing a discernible series of dark lines or streaks to be produced thereon due to the pins bringing a localized force field close to the plate surface. By oscillating the electrode substantially perpendicular to the developer flow so that the individual pins effect overlapping areas of development on the plate surface, is possible to eliminate the streaking effect while at the same time in effect bringing the electrode close to the plate surface while maintaining a flow zone capable of supporting a relatively large volume rate of flow.

As illustrated in FIG. 2, electrode **24** is slideably mounted in a nonconductive supporting member **46** and adapted to oscillate longitudinally across the drum surface transverse to the direction of developer flow. A motor MOT–1 is mounted in a support housing **39** and the support housing secured to the side wall of the developer housing by means of screws or the like. An eccentric disc **40** is keyed to the motor shaft and has a drive pin **41** staked therein. The drive pin extends perpendicular to the disc and passes through an elongated aperture **43** formed in one end of drive arm **42**. Arm **42**, which is also formed of an insulating material, passes through an opening provided in the developer housing wall and is secured at the opposite end to the electrode. As the motor turns the eccentric disc, the arm moves the electrode back and forth within the slide member, a distance at least equal to the lateral spacing between pins. It should be clear that the frequency of oscillation is related to the development speed and the pin positioning within the development zone and that the optimum frequency will change as the system parameters change. A suitable seal encloses the opening in the developer housing through which arm **43** passes and acts to prevent developer material from escaping from the developer housing.

The apparatus of the present invention now makes it possible to fully utilize a development electrode in a manner heretofore unknown in the art. By scattering the developer material moving through a restricted electroded development zone, in the manner herein disclosed, compacting of the developer material is prevented while at the same time toner is freed from the carrier beads. The developer material is thus placed in a condition such that the fine toner particles are freely moved by the electroded force field wherein the toner is concentrated on one side of the developer flow stream. In this preferred embodiment, the electrode is placed at a potential similar to the toner charge potential and having a magnitude sufficient to force a heavy concentration of toner into contact with the latent image-bearing member. Because the electrode also strengthens the image force components, the total effect of the electrode on the developability of the system is such that image areas of various sizes are rapidly and efficiently developed.

While this invention has been described in reference to the structure disclosed herein, it is not confined to the details as set forth, and this application is intended to cover modifications or changes as may come within the scope of the following claims.

We claim:

1. Apparatus to develop a latent electrostatic image supported upon an image retaining member including:

a biased electrode positioned in spaced parallel relation to the image-retaining member to form an extended, substantially enclosed, development zone being capable of supporting a flow of developer material,

means to produce a flow of developer material through the development zone, said developer material having charged particles being capable of developing a latent electrostatic image support upon the image-retaining member, and

means positioned within the development zone to disperse the developer material moving in the flow wherein the charged toner particles are freely moved by the electroded force field and concentrated on one side of the flow stream, said last-mentioned means comprising a series of pins supported by said electrode and extending into the development zone substantially perpendicular to said electrode wherein the pins impact the developer material in the flow stream, said pins being equally spaced in parallel rows with each successive row being laterally offset from the previous row, and

means to oscillate said electrode perpendicular to the direction of developer flow.

2. Apparatus to develop a latent electrostatic image supported upon a image-retaining member including:

a rotatably supported drum for retaining a latent electrostatic image mounted upon a horizontal axis,

an electrically isolated electrode placed in spaced parallel relation with the drum surface and extending downwardly to form an elongated enclosed development zone capable of supporting a flow of two component developer material,

means to move said drum through the development zone,

means to introduce a continuous flow of two component developer material at the upper end of the development zone wherein the material flows downwardly through said development zone to develop an image supported by said drum,

a series of pins supported on said electrode and extending substantially perpendicular to said electrode into said development zone in a position to impact and disperse the developer material moving through the development zone,

electrical biasing means operatively connected to said electrode to place said electrode at a predetermined potential, and

means to oscillate said electrode parallel to the drum surface in a direction substantially perpendicular to the flow of the developer material.

3. The apparatus set forth in claim **2** wherein said pins supported on said electrode are comprised of a conductive material.

4. The apparatus of claim **3** wherein the electrode is oscillated so that the force field associated with each conductive pin is moved into a region that was previously electrically effected by an adjacent pin.

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