United States Patent

Sato et al.

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[54] APPARATUS FOR DEVELOPING A LATENT ELECTROSTATIC IMAGE

[72] Inventors: **Masamichi Sato; Isoji Takahashi,** both of Kanagawa, Japan

[73] Assignee: **Fuji Photo Film Co., Ltd.,** Kanagawa, Japan

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Related U.S. Application Data

[63] Continuation of Ser. No. 694,467, Dec. 29, 1967, abandoned.

[30] **Foreign Application Priority Data**

Dec. 29, 1966 Japan.....42/437

[52] **U.S. Cl.**.....**118/637,** 101/DIG. 13, 117/17.5

[51] **Int. Cl.**.....**G03g 13/00**

[58] **Field of Search**.....118/637; 117/17.5

[56] **References Cited**

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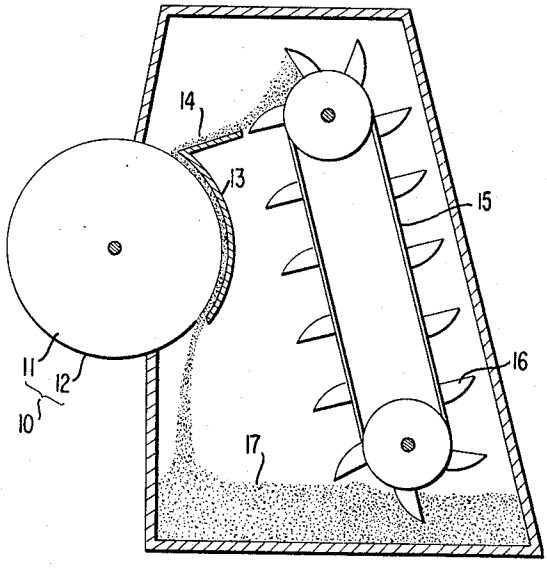
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Primary Examiner—Mervin Stein
Assistant Examiner—Leo Millstein
Attorney—Sughrue, Rothwell, Zinn & Macpeak

[57] **ABSTRACT**

A cascade apparatus for developing a latent electrostatic image which comprises flowing a cascade developer between the upper surface of a photoconductive insulating layer containing a latent electrostatic image and a flexible developing electrode positioned so as to cover said layer by gravity and developing the latent electrostatic image while maintaining a constant and small space between said developing electrode and latent electrostatic image surface of the photoconductive insulating layer.

7 Claims, 3 Drawing Figures



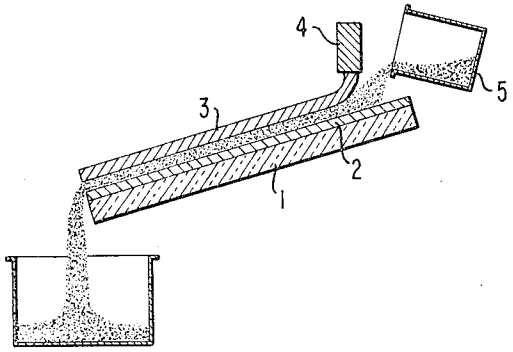


FIG. 1

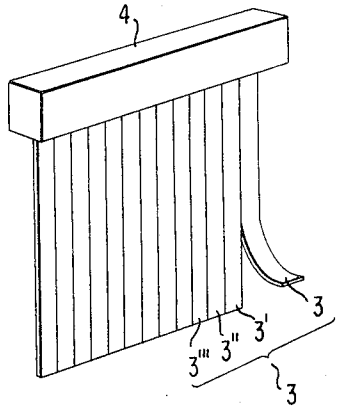


FIG. 2

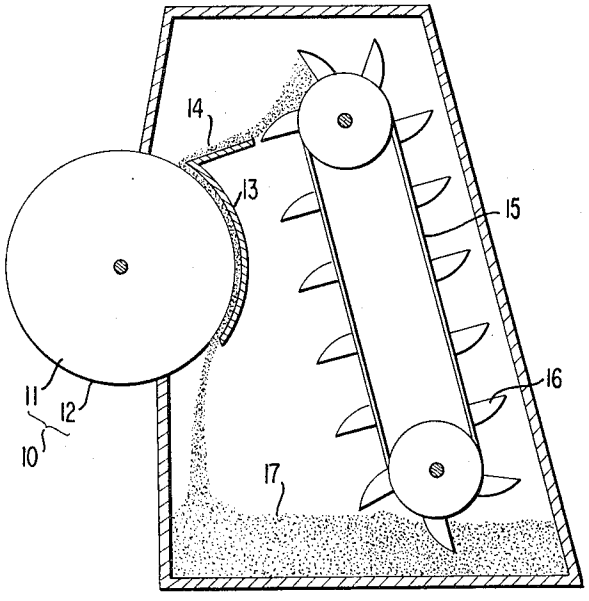


FIG. 3

INVENTORS
MASAMICHI SATO
ISOJI TAKAHASHI

BY Sughrue, Rothwell, Mion, Zinn & Macpeak

ATTORNEYS

APPARATUS FOR DEVELOPING A LATENT ELECTROSTATIC IMAGE

RELATED APPLICATION

This is a continuation of application, Ser. No. 694,467, filed Dec. 29, 1971, which is now abandoned.

BACKGROUND OF THE INVENTION

The present invention relates to a cascade apparatus for developing a latent electrostatic image whereby the edge effect is eliminated.

In conventional xerography as is disclosed in U.S. Pat. Nos. 2,297,691 or 2,357,809, for example, a xerographic plate composed of an electrically conductive base plate and photoconductive insulating layer thereon is uniformly charged electrostatically and exposed according to an original to be reproduced by the projection method. This exposure discharges the uniform charges on the photoconductive insulating layer according to the intensity of the light to form a latent electrostatic image. The latent electrostatic image is developed by applying a cascade developer consisting of a granular material called carrier and a pigmented powder called toner clinging to the carrier surface, whereby the toner is brought into surface contact with the photoconductive insulating layer and electrostatically held thereon according to the latent electrostatic image on the photoconductive insulating layer. Conventionally, it has been the practice to transfer the developed image to a support or transfer material and to fix the image in a suitable manner. Surface contact of the toner with a photoconductive insulating layer has been carried out by the process known as cascade method wherein toner-carrying granules which will hereinafter be referred to as cascade developer is cascaded on the photoconductive insulating layer. This developing method gives particularly good results in forming linear images on white backgrounds.

In attempting to reproduce an original image having a large area, however, there occurs the so-called edge effect, i.e., the state of the electric field in the zone of a latent electrostatic image does not agree with the charge density forming the latent electrostatic image to such an extent that a charge-compacted area is not developed uniformly. The use of a developing electrode (adjacent electrode) has been proposed in order to eliminate the edge effect and to develop a latent electrostatic image with complete fidelity. This is particularly essential in the reproduction of continuous tone images. However, the provision of developing electrodes near the upper surfaces of photoconductive insulating layers in an automatic continuous apparatus often results in marked interruptions of the flow of the cascade developer and lowering of the efficiency of said apparatus.

It is the principle object of the invention to eliminate the edge effect by the use of a developing electrode while maintaining the simplicity of the ordinary cascade developing apparatus.

BRIEF DESCRIPTION OF THE INVENTION

In accordance with the invention, there is provided a cascade apparatus for developing a latent electrostatic image which comprises flowing a cascade developer between the upper surface of a photoconductive insulating layer and a flexible developing electrode acting so as to cover said layer by gravity and developing the latent electrostatic image while maintaining a small and constant interval between said developing electrode and latent electrostatic image surface of the photoconductive insulating layer.

DESCRIPTION OF THE DRAWINGS

Further objects and features of the invention will become apparent while reading the following description in connection with the accompanying drawings wherein:

FIG. 1 is a side view in class section showing a typical embodiment of the apparatus, for practising the invention.

FIG. 2 is a perspective view showing a developing electrode used for the apparatus of the invention.

FIG. 3 is a cross-sectional view of one embodiment of the apparatus suitable for practising the invention.

Referring to FIG. 1, the apparatus comprises electrically conductive base plate 1, photoconductive insulating layer 2, flexible sheet-like developing electrode 3 one edge of which is fixed to fixture 4 and cascade developer feeder. Developing electrode 3 is light and drooped from fixture 4 naturally by its dead weight to cover uniformly the upper surface of photoconductive insulating layer 2. A light-sensitive material consisting of electrically conductive base plate 1 and photoconductive insulating layer 2 is slantly arranged as shown in FIG. 1, and cascade developer 5 comprising a toner and granular carrier is poured at a constant rate between fixture 4 and photoconductive insulating layer 2 so as to be uniform in the direction of width of electrically conductive base plate 1.

Cascade developer 5 falls down between developing electrode 3 and insulating layer 2 by its dead weight. During the same time, cascade developer 5 yields the toner to the latent electrostatic image of insulating layer 2, whereby developing is accomplished.

Developing electrode 3 may be composed of an assembly of flexible, electrically conductive ribbons electrically shortcircuited to each other as shown in FIG. 2 in addition to the form of sheet. As a material for forming developing electrode 3 it is preferred to use a screen made from plastic wires plated chemically or a screen of thin metal wires. The better developing can be accomplished, if the lower surface of the developing electrode is coated with a thin insulating layer so as to prevent fogging and dissipating of charges forming a latent electrostatic image, said dissipating being due to direct contact of developing electrode 3 with the latent electrostatic image of photoconductive insulating layer 2.

FIG. 3 shows a main part of the automatic continuous xerographic apparatus utilizing the method of the invention (cascade developing unit), comprising xerographic drum 10 consisting of electrically conductive drum 11 and amorphous selenium vapor-deposited layer 12 thereon, flexible developing electrode 13 fixed to the lower end of fixed slant plate 14 and endless conveyor belt 15 having a plurality of buckets 16 running in the direction of the arrow. 17 is the cascade developer. This apparatus is further provided with means for electrically charging, exposing, transferring, cleaning, etc., (not shown). In the operation of this apparatus, cascade developer is scooped up by bucket 16, caused to fall down on fixed slant plate 14 continuously and uniformly in the direction of width thereof and, passing thereon, cascades on selenium vapor-deposited layer 12 having a latent electrostatic image on xerographic drum 10. Then, cascade developer 17 falls down through a gap between selenium vapor-deposited layer 12 and fixed slant plate 14 and rolls down between layer 12 and flexible electrode 13 widening the gap therebetween somewhat, the gap between layer 12 and electrode 13 remaining substantially constant over the length thereof. The latent electrostatic image is thus developed. In this apparatus, it is desirable that the length of flexible developing electrode 13 extends from fixed slant plate 14 at least to a position where developer 17 leaves the surface of xerographic drum 10 by gravity and xerographic drum is covered thereby throughout the width.

The following examples are given in order to illustrate the invention.

EXAMPLE 1

Using the so-called selenium flat plate as a light sensitive material for electrophotography, being obtained by the vacuum vapor deposition of amorphous selenium on an aluminum plate, it was positively charged uniformly in the dark and then exposed according to an original to be reproduced to obtain a latent electrostatic image. Cascade developing

thereof was then carried out by arranging a developing electrode as shown in FIG. 1, said developing electrode consisting of a 200 mesh nylon screen made from nylon wires of about 50 microns in diameter and plated chemically with silver to give a surface conductivity and feeding a cascade developer used widely for Xerox-914 (an electrostatical copying machine manufactured by Xerox Corporation) thoroughly to the whole surface of the selenium flat plate. After all the cascade developer fell down, the developing electrode was removed. The original image was developed with fidelity and without occurrence of the edge effect even in a large area, toner compacted part. If the surface potential of the selenium flat plate is too large when charged uniformly, a spark appears between a high potential area of the latent electrostatic image and the developing electrode when they are made adjacent in development, resulting in a breakage of the image. In order to prevent this, it was effective to insert a sheet of insulating film in between the latent electrostatic image and developing electrode, and feed cascade developer to between the latent electrostatic image and said insulating film.

EXAMPLE 2

This example is similar to Example 1 except that a polyester film having a thickness of 75 microns, vapor deposited with aluminum in vacuum, was used as a developing electrode. The developing electrode was so kept that its polyester surface came near the surface of a latent electrostatic image, and the developing was similarly carried out with good results.

In this developing electrode, there appeared no spark even though the potential difference between the surface potential of the selenium flat plate and developing electrode was too large, since the latent electrostatic image surface was separated from the electrically conductive surface of the developing electrode through the polyester film.

EXAMPLE 3

Cascade developing was carried out by the use of an electrophotographic light sensitive drum (xerographic drum) consisting of an aluminum drum and amorphous selenium vapor deposited film on the outer surface thereof in a system as shown in FIG. 3. The same developer was used as in Example 1 and a polyester film having a thickness of 75 microns on one surface of which aluminum had been vapor deposited in vacuum was used as a developing electrode. The developing electrode was fixed to the lower end of a slant plate and covered the surface of drum so as to face the non-aluminum vapor deposited surface (insulating surface) throughout the width and to a position somewhat lower than where the developer being off, through its weight and flexibility when there was fed no developer. The electrically conductive surface of the developing electrode was grounded. The cascade developer was lifted by buckets, cascaded on the surface of drum via the slant plate and thus fed to between the surface of drum and developing electrode, whereby the developing electrode was pushed up to form a clearance therebetween. Although the electrostatic attraction between a latent electrostatic image on the drum and developing electrode acts so that the passage of the cascade developer is interrupted, this does no harm, that is, there occurs no choking phenomenon and good development can be effected, since the developing electrode is pushed away by the weight of the cascade developer falling down.

EXAMPLE 4

A polyester film having a thickness of 75 microns on one surface of which aluminum had been vapor deposited in vacuum was cut in the form of a ribbon and used as a developing electrode. The developing electrode was arranged in the apparatus of Example 3 in such a manner that one end of each ribbon was fixed as shown in FIG. 2 and electrically shortcircuited. Choking was prevented and good development was accomplished by the use of this developing electrode.

In all of the foregoing examples, edge-affect free images are obtained. In accordance with the method of the invention, therefore, the ability of a developing electrode is effectively utilized, a cascade developer is fully supplied and a latent electrostatic image is developed with high fidelity, while preventing the choking phenomenon and maintaining the simplicity of the cascade developing apparatus and method.

Moreover, the present invention is available for developing latent electrostatic images on a paper coated with photoconductive zinc oxide and resin dispersion and other light sensitive materials for electrophotography, of course, although selenium is used in all of the foregoing examples.

What is claimed is:

1. Apparatus for developing an electrostatic image on a photoconductive insulating layer comprising

means for supporting said insulating layer so that at least a portion thereof is downwardly slanting;

a flexible developing electrode;

means for supporting said electrode so that the upper portion of said electrode is fixedly disposed with respect to and removed from said insulating layer and substantially the remainder of said electrode including the lower portion thereof lies upon at least part of said downwardly slanting portion of said photoconductive insulating layer;

means for cascading a developer between said flexible developing electrode and said downwardly slanting portion of said photoconductive insulating layer so that all portions of said developing electrode are capable of being pushed away from the photoconductive insulating layer by the weight of said developer falling down said downwardly slanting portion whereby the flow of the developer is substantially continuous and smooth to effect said developing.

2. Apparatus according to claim 1 where said flexible developing electrode comprises a flexible sheet.

3. Apparatus according to claim 1 where said flexible developing electrode comprises a screen composed of multiple wires.

4. Apparatus according to claim 1 where said developing electrode comprises a plurality of ribbons.

5. Apparatus according to claim 1 including an insulating layer interposed between said photoconductive layer and said electrode.

6. Apparatus as in claim 1 where said developing electrode comprises a nylon screen plated with silver.

7. Apparatus as in claim 1 where said developing electrode comprises a flexible electric insulating sheet having disposed thereon an electric conducting layer, said insulating sheet being disposed adjacent said downwardly slanting portion of said photoconductive insulating layer.

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