# United States Patent [19]

**Sato**

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[54] **ELECTROPHOTOGRAPHIC BORDER APPARATUS**


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[51] **Int. Cl.** ............................................. **G03g 15/22**

[58] **Field of Search** ................. 355/3, 17, 126, 127, 355/74, 70, 7, 51


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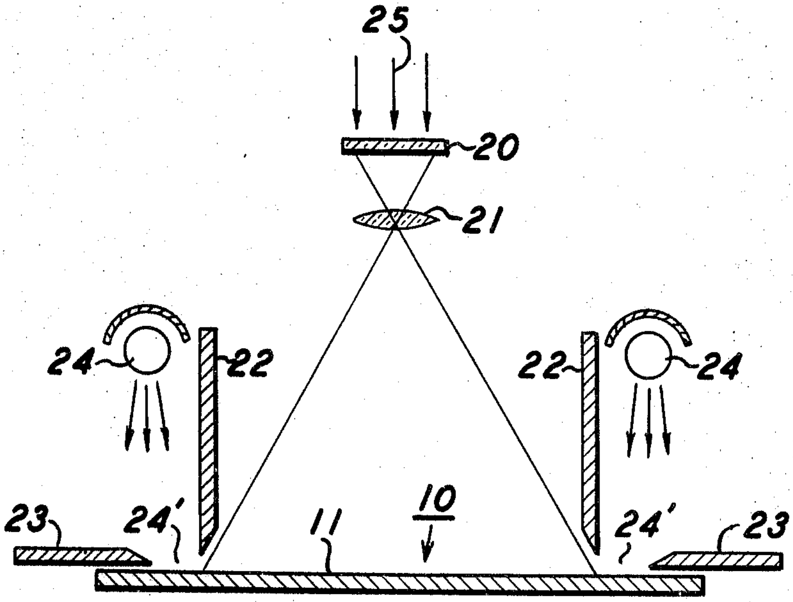
[57] **ABSTRACT**


Apparatus for producing a toner-free border surrounding an image region on a charged photoconductive insulating layer comprising imagewise exposure means, electromagnetic radiation means for uniformly exposing the border portions of the photoconductive insulating layer and an electromagnetic radiation intercepting shielding plate positioned perpendicularly adjacent to the photoconductive insulating layer and a covering plate parallel and adjacent to the photoconductive insulating layer arranged to provide uniform exposure only on the desired width of the toner-free border sought while maintaining a charged surface surrounding and external to the desired toner-free border. Use of the apparatus in electrophotographic imaging results in a photoconductive insulating layer having an image region thereon, a uniformly exposed region surrounding the image region and a charged region surrounding the uniformly exposed region. Toner is thus attracted away from the intermediate, uniformly exposed region, and towards the image and charged regions on either side thereof. Upon transfer of the developing toner to a substrate, the substrate bears a toner-free border around the image region and corresponds to the uniformly exposed intermediate region of the photoconductive insulating layer.


**5 Claims, 2 Drawing Figures**



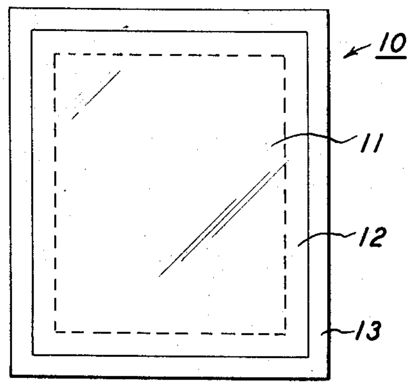



FIG. 1

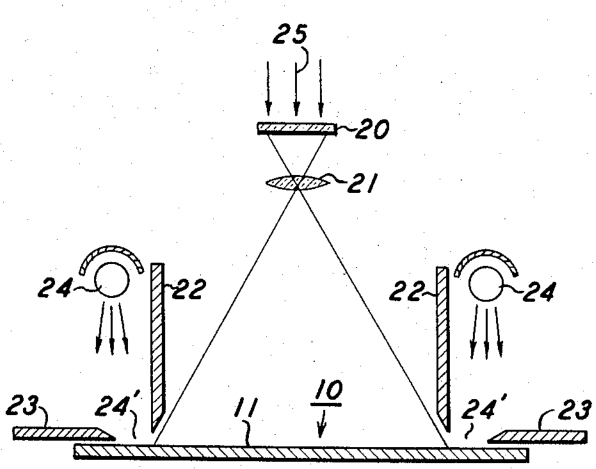



FIG. 2

# ELECTROPHOTOGRAPHIC BORDER APPARATUS

## BACKGROUND OF THE INVENTION

The present invention relates to electrophotography, and more particularly to a method for forming a toner-free border around an electrophotographically reproduced image. One form of electrophotography, xerography, will be used throughout to explain the invention. The term electrophotography is used herein to mean electrostatic electrophotography as defined by the "Standard Definitions of Terms for Electrostatographic Devices," published by the Institute of Electrical and Electronics Engineers, IEEE No. 224, dated November, 1965, which term includes both xerography and xeroradiography. The discussion with respect to xerography applies equally well to xeroradiography.

In xerography, a special xerographic photoreceptor comprising a layer of photoconductive insulating material placed upon a conductive backing is used to support xerographic images. The photoreceptor may be formed in any shape. An image is formed by uniformly electrostatically charging the photoreceptive surface and then exposing it to an electromagnetic radiation pattern in the form of the image to be reproduced. This radiation selectively discharges, in proportion to exposure, areas of the photoreceptor forming an electrostatic charge pattern conforming to the radiation image. This radiation image is generally an original document or other object which is illuminated and imaged on the photoreceptor.

The latent image on the photoconductive layer is then developed by contacting it with a finely divided electrostatically attractable material such as a resinous powder hereinafter called a toner. The toner is held to the image areas by electrostatic charge fields on the layer. The toner is held proportionately to the charge field so that the greatest amount of material is deposited where the greatest charge field is located. Where there is a minimum charge there is little or no material deposited. Therefore, a toner image is produced to conform with the latent image previously placed on the photoreceptor. In reusable xerographic systems the toner is transferred to a sheet of paper or other suitable substrate and suitably fixed thereto to form a permanent print. This fixing may take place by heat or vapor which fuses the toner to the support material to which it has been transferred.

The toner used to develop the image is generally formed in a developer material consisting of the toner and a "carrier" of larger granular beads formed with glass, sand or steel cores coated with a material which is removed in the triboelectric series from the toner so that there is a triboelectric charge attraction between the toner and the carrier. The charge causes the toner to adhere to the carrier making it easily handled in a developer system which brings the developer into contact with the previously exposed xerographic surface. Because the charge pattern on the xerographic surface has a greater attraction for the toner than the triboelectric charge the toner has with the carrier, the toner is then attracted electrostatically to the image charge pattern on the surface forming a visible toner image thereon. Toning may conventionally be by cascade or brush development utilizing the above-mentioned two component developer, by liquid development, or by toner cloud developing utilizing only



toner. The aforementioned is well-established in the prior art and will not be further described.

Although radiation discharges the photoconductive insulating layer, complete discharge, which is required for a toner-free border around an image area, has been impossible to provide by conventional methods even if the region which is to be toner-free is exposed to electromagnetic radiation of extremely high intensity. That is to say, a residual charge remains after exposure of the layer to extremely high intensity radiation.

For some purposes, it is desirable to have a toner-free border around a xerographically reproduced image. For example, in xerographic reproductions of photographs it is desirable to have a white border corresponding to the white border found on photographic paper customarily provided in silver salt photography.

One prior art method for providing a white border and utilizing liquid development uniformly exposes a region around the imaged area of the photoconductive insulating layer to high intensity light. A residual charge remains, however, and a small amount of toner adheres to this region of the layer and transfers to the new substrate when transfer of the image is attempted. This small amount of toner produces a greyish appearance upon a white substrate and is hereinafter referred to as "fog."

## SUMMARY OF THE INVENTION

It is, therefore, an object of this invention to provide an imaging method overcoming the above deficiencies.

A further object of this invention is to provide a "fog-free" or clear border around an electrophotographically reproduced image.

Another object of this invention is to provide a toner-free border around an electrophotographically reproduced image.

These and other objects are attained in accordance with this invention wherein there is provided a method resulting in the creation of an electric field which attracts toner away from the border region and its relatively weak residual charges. A uniformly charged photoconductive insulating layer is imagewise exposed to an original while uniformly exposed about the imagewise exposure with radiation of intensity at least equal to that of the imagewise exposure and is provided with a charged surface of the same polarity surrounding the uniformly exposed region. Toning with toner bearing a charge polarity opposite to that of the photoconductive insulating layer results in the toner adhering only to the imagewise exposed region of the layer and to the charged surface, and not to the uniformly exposed region of the layer. Upon toned image transfer to a substrate, the region of the substrate corresponding to the uniformly exposed region of the layer is a clear border relative to the transferred image.

## DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic plan view of a photoconductive insulating layer that has been subjected to the method of my invention.

FIG. 2 is a schematic side sectional view illustrating the method of my invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

FIG. 1 schematically shows the principles of this invention. Member **10** is an electrophotographic material. The surface of the electrophotographic material **10,** treated to have a photoconductive insulating layer thereon, is electrically charged uniformly in a dark place, then an image zone **11** is imagewise exposed to radiation and a surrounding border region **12** is uniformly exposed to radiation. The radiation is, of course, one to which material **10** is sensitive. An unexposed region of small width **13** is formed externally of and surrounding the border region **12** and in accordance with the above noted principles, retains a charge of greater magnitude than exposed region **12.**

An electrostatic latent image is formed in the image region **11** which has been exposed to the optical image. If the image is toned or developed in this state, a purely clear border can be provided because no toner adheres to the border region **12.** The reason for this is believed to be as follows: the unexposed region **13** carries an electric charge of the same polarity as the electric charge carried by the latent image and of greater magnitude than the residual charge in border region **12** so that an electric field which is directed such that a toner is dispelled thereby is present on opposite sides in the vicinity of unexposed region **13.** This electric field is thought to cancel out the electric field effect formed by the residual charge present in the border region **12,** so that no toner adheres to the border region **12.**

The width of unexposed region **13** may be similar to or smaller than the width of border region **12.** For example, if the width or border region **12** is 3 to 5 millimeters, 1 to 5 millimeters will be satisfactory for the width of unexposed region **13.** There is, of course, no upper limit to the width of unexposed region **13.** However, if the unexposed region **13** has a large width, the electrophotographic material and toner will be wasted in greater quantities and thus the large width is not preferred for practical purposes. It is difficult to determine the lower limit of the width of unexposed region **13** because it varies depending on the quantity of electric charge carried by such region. If the density of the electric charge carried by the unexposed region **13** is substantially the same as that carried by unexposed portions of the image region **11,** the lower limit of the width of unexposed region **13** can be from 0.1 to 1 millimeter.

The unexposed region **13** need not be formed of a photoconductive insulating layer but may be formed of a highly insulating material. If this is the case, the quantity of an electric charge carried thereby can be increased. It is also thereby possible to further reduce the width of unexposed region **13,** and to dispense with maintaining region **13** in an unexposed state. The term "charged surface" is used throughout to describe both the charged unexposed photoconductive insulating surface and the charged non-photoconductive insulating material surface. Although the description proceeds in terms of an unexposed region **13** of the photoconductive insulating layer it is understood that non-photoconductive insulating material may be used in which case exposure thereof is of no concern.

FIG. 2 schematically shows an embodiment of the method of my invention in concrete form for forming the unexposed region **13** and the border region **12.** Visible light is used illustratively. Transparent original **20** is projected through projection lens **21** by light **25.** Intercepting plates **22** divide the image region **11** from the border region **12,** and cover plates **23** prevent light from reaching the unexposed region **13.** Both **22** and **23** comprise materials which are impenetrable by the radiation used. Such materials are well-known and will not be further described. Preferably, the forward end portions of plates **22** and **23** are as sharp edged as possible and disposed near the surface of the photoconductive layer. Light source **24** uniformly exposes the border region **12** to radiation of an intensity at least equal to the maximum projected through lens **21** and impinging upon region **11.**

The image region **11** and border region **12** can be exposed to different sources of radiation and may be so exposed either simultaneously, or sequentially. Also, the light source **24** for providing the border **12** may be dispensed with and a light source (not shown) for illuminating both the original image and border **12** may be used instead. The region **12** is formed by exposure through slits **24'** between the plates **22** and **23.**

It is to be understood that this invention may be used with a liquid developing method, magnetic brushing method, cascading method and other developing methods for electrophotography; that the photoconductive insulating layer has a conductive backing and may be charged either positively or negatively; that the electromagnetic radiation may be of any frequency from the electromagnetic spectrum to which the photoconductive insulating materials used are responsive; that the image original may be either a positive or a negative image and either transparent or opaque with suitable prior art methods used to project the image onto the photoconductive insulating layer; and that the developed latent electrostatic image may be transferred to any suitable substrate, including white or colored paper.

It will be understood that various changes in the details, materials, steps and arrangements of parts, which have been herein described and illustrated in order to explain the nature of the invention will occur to those skilled in the art upon the reading of the disclosure. It may be that other substances exists or may be discovered that have some or enough of the properties of the particular materials described to be used in their place. Other modifications and ramifications of the present invention will occur to those skilled in the art upon reading of the present disclosure. These are intended to be included within the scope of this invention.

I claim:

**1.** Apparatus for producing a toner-free border surrounding an imagewise exposed region on a charged photoconductive insulating layer comprising:

a. imagewise exposure means including first electromagnetic radiation means for imagewise exposing a photoconductive insulating layer;

b. second electromagnetic radiation means for uniformly exposing a border surrounding the imagewise exposed region of the photoconductive insulating layer at a radiation intensity at least equal to the maximum radiation intensity within the imagewise exposed region so that the border, upon uniform exposure, is discharged to a residual charge level no greater than the lowest charge level within the imagewise exposed region;

c. an electromagnetic radiation intercepting shielding plate, impenetrable by electromagnetic radiation from said second electromagnetic radiation means positioned perpendicularly adjacent to, but out of contact with, the surface of the photoconductive insulating layer such that the imagewise exposed region is shielded thereby from electromagnetic radiation from said second electromagnetic radiation means; and

d. a covering plate, impenetrable by electromagnetic radiation from said second electromagnetic radiation means positioned parallel and adjacent to, but out of contact with, the photoconductive insulating layer surface surrounding the imagewise exposed region and at a distance from said electromagnetic radiation intercepting shielding plate equaling the desired width of the border sought to be free of toner so as to allow uniform exposure of the charged photoconductive insulating layer surface surrounding the imagewise exposed region to radiation from said second electromagnetic radiation means along the desired width of the toner-free border sought while maintaining a charged photoconductive insulating layer surface, which charged surface surrounds and is external to the tonerfree border and is of a charge lever greater than the residual charge level of the toner-free border.

2. The apparatus of claim 1, wherein the perpendicular end portions of said electromagnetic radiation intercepting shielding plate and the parallel portions of said covering plate nearest the surface of the photoconductive insulating layer are sharp.

3. Apparatus for producing a toner-free border surrounding an imagewise exposed region on a charged photoconductive insulating layer comprising:

a. imagewise exposure means including first electromagnetic radiation means for imagewise exposing a photoconductive insulating layer for uniformly exposing a border surrounding the imagewise exposed region of the photoconductive insulating layer at a radiation intensity at least equal to the maximum radiation intensity within the imagewise exposed region so that the border, upon uniform exposure, is discharged to a residual charge level no greater than the lowest charge level eithin the imagewise exposed region;

b. an electromagnetic radiation intercepting shielding plate, impenetrable by electromagnetic radiation from said electromagnetic radiation means positioned perpendicularly adjacent to, but out of contact with, the surface of the photoconductive insulating layer such that the imagewise exposed region is shielded thereby from electromagnetic radiation from said second electromagnetic radiation means; and

c. a covering plate, impenetrable by electromagnetic radiation from said electromagnetic radiation means positioned parallel and adjacent to, but out of contact with, the photoconductive insulating layer surface surrounding the imagewise exposed region and at a distance from said electromagnetic radiation intercepting shielding plate equaling the desired width of the border sought to be free of toner so as to allow uniform exposure of the charged photoconductive insulating layer surface surrounding the imagewise exposed region to radiation from said electromagnetic radiation means along the desired width of the toner-free border sought while maintaining a charged photoconductive insulating layer surface, which charged surface surrounds and is external to the toner-free border and is of a charge level greater than the residual charge level of the toner-free border.

4. Apparatus for producing a toner-free border surrounding an imagewise exposed region on a charged photoconductive insulating layer comprising:

a. imagewise exposure means including first electromagnetic radiation means for imagewise exposing a photoconductive insulating layer;

b. second electromagnetic radiation means which may be the same as the electromagnetic radiation means recited in part (a) above or a separate electromagnetic radiation means for uniformly exposing a border surrounding the imagewise exposed region of the photoconductive insulating layer at a radiation intensity at least equal to the maximum radiation intensity within the imagewise exposed region so that the border, upon uniform exposure, is discharged to a residual charge level no greater than the lowest charge level within the imagewise exposed region;

c. an electromagnetic radiation intercepting shielding plate, impenetrable by electromagnetic radiation from said second electromagnetic radiation means positioned perpendicularly adjacent to, but out of contact with, the surface of the photoconductive insulating layer such that the imagewise exposed region is shielded thereby from electromagnetic radiation from said second electromagnetic radiation means; and

d. an insulating surface insensitive to electromagnetic radiation from said second electromagnetic radiation means lying substantially in the same plane as the surface of the photoconductive insulating layer, surrounding the photoconductive insulating layer and in contact therewith.

5. The apparatus of claim 4, wherein the end portions of said electromagnetic radiation intercepting shielding plate near the surface of the photoconductive insulating layer are sharp.

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