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SEIJI MATSUMOTO

3,799,774

MULTICOLOR ELECTROPHOTOGRAPHIC MASKING PROCESS

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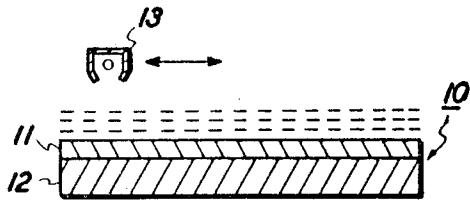


FIG. 1

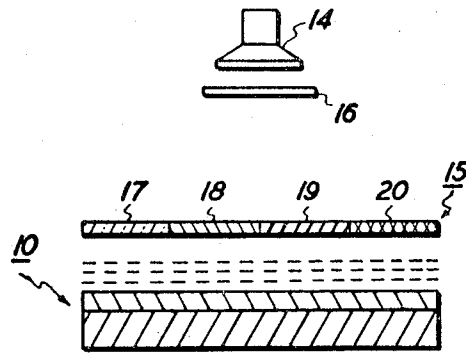


FIG. 2

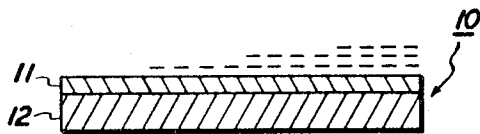


FIG. 3

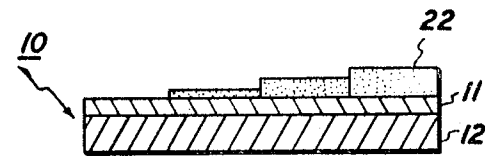


FIG. 4

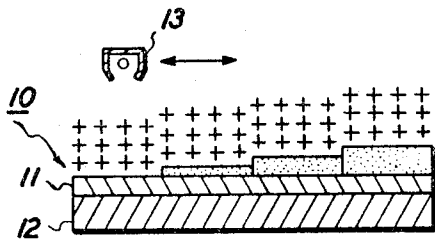


FIG. 5

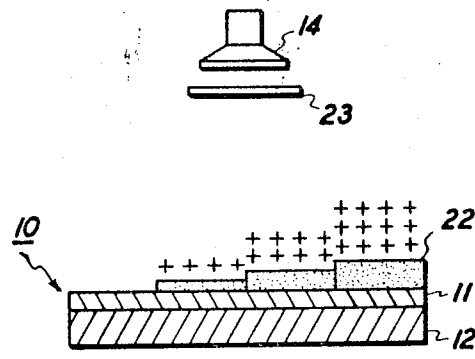


FIG. 6

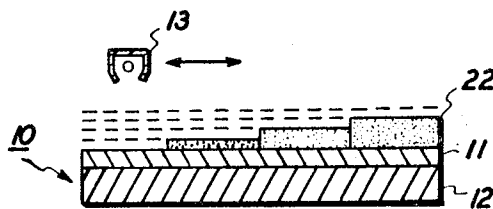


FIG. 7

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MULTICOLOR ELECTROPHOTOGRAPHIC MASKING PROCESS

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Continuation-in-part of abandoned application Ser. No. 86,499, Nov. 3, 1970. This application Nov. 13, 1972, Ser. No. 305,748

Claims priority, application Japan, Nov. 28, 1969, 44/95,988

Int. Cl. G03g 13/00, 13/22

U.S. Cl. 96—1.2

4 Claims

ABSTRACT OF THE DISCLOSURE

A color masking technique suitable for use in a xerographic subtractive color process. A first subtractive toner image, developed upon a photosensitive plate, is utilized to optically mask the plate in a manner whereby the latent electrostatic image representative of the next subtractive toner to be applied to the plate is electrically corrected to compensate for the unwanted characteristic of the first toner to absorb light energy within the absorptive domain of the second toner.

This application is a continuation-in-part of application Ser. No. 86,499 filed Nov. 3, 1970, now abandoned.

This invention relates to color xerography and, in particular, to a color masking technique suitable for use in the xerographic process.

In the art of color copying, a full color rendition of a color original is created upon a single support surface by laying down the subtractive colorants of cyan, magenta and yellow in controlled amounts to faithfully reproduce the original colors. Ideally, the density of each colorant applied to the support should be inversely proportional to the intensity or brightness of the color complement found in the original. However, the light absorptive characteristics of most colorants found in nature are less than ideal in that one colorant will exhibit the unwanted ability to absorb light energy within the absorptive domain of of some other colorant. In photography, such techniques as the dye transfer process and the like have been developed to mask the undesirable absorptive properties found in most colorants. These techniques, however, do not lend themselves to use in most copying machine environments, as for example, the xerographic process.

Typically, in the xerographic color process, the color original is broken down optically into three primary color components and each component used to produce a developed toner image which is the subtractive complement of the original color. The three developed images are then transferred in superimposed registration upon a final support sheet. Other methods of producing a color copy have been devised wherein each color complement is developed on the plate over those images previously developed and the final rendition transferred in a single step to the support sheet. This latter process is disclosed by Hayford et al., in U.S. Pat. 3,057,720 and constitutes the color process in which the present invention is most suited for use.

In both the photographic and xerographic process disclosed by Hayford, it is extremely difficult to produce a color print of high quality because of the inherent limitations found in most known cyan, magenta and yellow colorants. Ideally, a cyan colorant should absorb light only in the red region, while similiary magenta colorants should absorb light only in the green region and yellow colorants in the blue region. In practice, however, it is found that while most available yellow colorants are reasonably close to the ideal, cyan colorants generally absorb

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heavily in the green regions and, to a lesser extent, somewhat in the blue regions. By the same token, magenta colorants absorb heavily in thhe blue regions. If left uncorrected, the use of defective colorants would result in the production of relatively poor quality copies.

To overcome these colorant deficiencies, various "masking" techniques, have been devised in which the density of each colorant is made to depend not only on the intensity of the primary colors found in the original but also to a degree on the manner in which the colorants interact with each other to produce a final color rendition. Bickmore, in U.S. Pat. 3,043,686 discloses one such masking technique. Although masking techniques are known and used in the printing art, few of these processes lend themselves readily to xerographic color printing. In accordance with the present invention, a color masking technique is disclosed which is uniquely suited for use in the xerographic process and which greatly simplifies the production of color prnts.

It is therefore an object of this invention to improve color masking techniques siutable for use in the xerographic process.

A further object of this invention is to provide an electrophotographic process which allows for extremely simple color masking to produce a high quality multicolor reproduction.

These and other objects of the present invention are attained by means of a multicolor electrophotographic process in which a color original is separated into a plurality of primary color components. A first color component separation is utilized to create an electrostatic image upon a xerographic plate and the latent image then made visible by applying toner containing the subtractive complement of the primary color. The plate is then charged uniformly and exposed to colored light in the absorptive domain of the next colorant to be applied thus causing the charge to be selectively dissipated in response to the first developed colorant ability to absorb light in the domain of the next to be applied colorant. A second uniformly distributed charge of an opposite polarity is then applied over the plate whereby the second charge is selectively reduced in those areas on the plate having a higher residual charge, i.e. in those regions wherein the first colorant absorbs light in the domain of the next applied colorant. The second image is then developed and the electrostatic correction repeated for the following colorants to be developed to produce a corrected rendition of the original upon the plate.

For a better understanding of the present 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 drawing wherein FIGS. 1-6 represent a series of simplified schematic views graphically illustrating the steps involved in carrying out the teachings of the present invention.

As illustrated in FIG. 1, a xerographic plate 10, which includes a photoconductive insulating layer 11 placed over a conductive backing 12, is initially charged to a uniform negative potential. Charging of the plate surface is accomplished by means of a corona discharge device similar to that disclosed by Vyverberg in U.S. 2,836,725. For illustrative purposes, the initially applied negative charge is represented as a series of negative signs (—) pictorially positioned above the photoconductive surface 11. Although a negative charge is herein utilized, it should be noted that the charge is so described for explanatory purposes only and that all charges recited herein are used to describe a relationship and are not limiting as long as the relationship involved between charges is maintained. The charge plate surface is next exposed to a light image

of the original to be reproduced to form a latent electrostatic image thereon.

Although the original input scene information can take almost any form, for explanatory purposes, the original herein employed is a multi-color transparency 15 such as a color slide or the like. As illustrated in FIG. 2, a light image of the color transparency is created by passing white light from an illumination source 14 through the color slide 15 containing the original input scene information and recording the original input scene information upon the plate surface by exposing the sensitized plate to the light image. In this particular embodiment, the original input scene information is color separated by placing a color filter between the light source 14 and color slide 15. The light images can be processed in any sequence desired, however, it is preferred that a red color component be first processed followed by a green color component and a blue color component. In this sequence, the latent images created on the plate surface are developed by applying cyan, magenta and yellow toners, in that order.

In carrying out the process of the present invention, it is desirable to develop the first electrostatic image created from the red separated image with a toner containing a cyan colorant. As will be explained in greater detail below, by applying the cyan colorant first, the material's ability to absorb in both the blue and green region can be effectively masked during subsequent development steps. To this end, the first exposure is made utilizing a red filter 16 as shown in FIG. 2. The original input scene information shown in FIG. 2 is schematically illustrated as being composed of a number of discrete regions 17-20, with each region exhibiting a different optical density. The regions vary from a region of relatively low optical density, designated 17, through a region of relatively high optical density, designated 20.

After exposure of the charged plate to a light image containing the red component, that is, an image created using a red filter, a latent electrostatic image having a charge density proportional to the input scene density created on the plate. Basically, the charge density of the latent image will substantially correspond to the optical density of the original when viewed under red light. As shown in FIG. 3, the regions of high optical density are recorded on the plate as areas of relatively high charge density while regions of low optical density are recorded as areas of low charge density. Although the charge density of the latent image is shown corresponding closely to the optical density of the original, it should be clear that this relationship, in practice, will not be as precise as shown and will vary in accordance with the characteristic of the particular system involved.

Following the creation of the first latent image recording the red component, the image is made visible by developing the plate with a toner containing a cyan colorant. Development can be accomplished by any conventional means known and used in the art that is responsive to charge density of the latent image, as for example, electroded magnetic brush development. The density of the developed toner image should correspond to the charge density of the latent image. As illustrated in FIG. 4, the density of cyan image 22, represented by the height of the bars, closely follows the charge density of the latent image. It should be clear, however, that the image pile height is herein used as a convenient pictorial means of representing image density and in practice, such a discernible difference in densities does not generally occur.

Subsequent to the development of the cyan toner image, the image bearing photoconductor is again subjected to corona treatment similar to that used in the first charging step, however, the polarity of the induced charge is reversed. For example, if the original charge placed on the plate was negative, as herein disclosed, the second charge would be positive in relation thereto. The positive

charge is laid down directly over the first developed image and the next image developed directly over the previously developed image.

In order to understand the overdevelopment technique herein employed, it should be made clear that resensitization of the xerographic plate, in the manner herein utilized, is not necessarily dependent upon the characteristics of the toner material involved. The force fields that are created upon the plate surface by this overcharging step exist between the corona that is laid down both over the plate and the toner material and the grounded plate substrate 12 upon which the photoconductor 11 is coated. The introduction of a thin layer of insulating material between the corona and the grounded substrate does not prevent the plate from accepting charge in a conventional manner. The mechanics by which a xerographic plate is sensitized through an insulating material is disclosed by Hall in U.S. Pat. 3,234,019. In Hall, a photoconductive plate that is overcoated with an insulating layer, such as a resin or plastic material is corona charged in a conventional manner. The corona is applied upon the insulating coating and a force field established between the corona and the grounded plate substrate by means of capacitance coupling. When the insulating material is relatively thin, that is, less than three times the thickness of the photoconductive coating, and no other grounded or charged surfaces are in close proximity with the plate, the insulating material interposed therebetween will have little effect on the performance characteristics of the system.

Assuming that the next colorant to be applied is to be magenta, the uniformly charged plate is next exposed to green light, or, more specifically, light energy that is within the absorption spectrum of the magenta colorant. To accomplish this task, a green filter 23 (FIG. 6) is substituted for the red filter and the charged plate illuminated with light from the illumination source 14 in the absence of the slide 15. As previously noted, most cyan colorants have the unwanted ability to absorb in the green regions. Therefore, the previously developed cyan image will, depending on the toner density of the image involved, prevent some of the green light from reaching the charged plate.

This, in effect, regulates to what extent the plate is discharged in these particular regions. A "masking electrostatic image" is thus created with the image potential strongest in those regions where the cyan toner absorbs most heavily in the absorptive domain of the magenta toner. This masking image is shown graphically in FIG. 6. To insure that the masking charge is distributed selectively in the manner herein described, it is preferred that the toner material exhibit sufficient insulating properties to prevent a lateral distribution or leakage of the selectively distributed charge from a zone of high charge into a zone of lesser charge. Generally most resin based toners employed in the xerographic process are capable of acting as insulators and will lend themselves to use in the practice of the present invention.

The next step in the instant process is to charge the plate negatively in a conventional manner directly over the masking electrostatic image. Charging is achieved in the manner described above in reference to FIG. 7. The effect of applying the charge over the masking image is to reduce the negative charge in accordance with the strength or density of the positive masking charge so that the negative charge is modulated by the masking charge. Less negative charge therefore is deposited in those regions where the previously developed images absorb light energy in the absorptive domain of the next-to-be applied magenta colorant. Diagrammatically this effect is shown in FIG. 7.

While the photoreceptor is in the negatively charged state as shown in FIG. 7, an image wise exposure of the original input scene is achieved employing a green filter to record a latent electrostatic image containing magenta

development information. This latent image is then developed using conventional xerographic techniques with a magenta pigmented or dyed toner. As can be seen, the amount of the magenta toner deposited in the cyan developed areas is controlled in accordance with the amount of cyan toner present thus making the unwanted characteristic of cyan to absorb in the green regions. Stated differently, those regions on the photoconductive surface having a larger amount of cyan toner accept a relatively smaller electrostatic charge during the second negative charging step and therefore a lesser amount of toner is deposited therein during development. Thus the unwanted absorption of green light by the cyan toner is compensated for by appropriately reducing the density of the magenta toner image to restore the proper color balance to the system.

Likewise, yellow toner images are obtained in a manner similar to that herein described in reference to the magenta toner. That is, a uniform positive electrostatic charge is first placed over the magenta and cyan toner images and the plate uniformly illuminated by blue light to create a masking latent electrostatic image corresponding to the ability of both the cyan and magenta toner images to absorb light in the absorptive domain of the yellow colorant. A negative electrostatic charge is then placed over the masking charge and an imagewise exposure of the original input scene information is produced using a blue filter. It should be clear, however, that this description of the specification in regard to the nature of the charges involved is not intended to limit the present invention. For instance, it would be possible to utilize a toner material having a different charge which, of course, would call for a similar change in the relationship of all charges involved. Therefore, all reference to positive or negatives charges used in this specification is considered as merely defining a relationship and it should be clear that the teachings of the present invention can be practiced as long as these relationships are maintained.

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

What is claimed is:

1. In a xerographic color reproducing process wherein a multi-color original is first color separated to provide a plurality of inputs, each of which contains color information relating to a primary color contained in the original, recording each of said inputs in the form of a latent electrostatic image upon a photosensitive surface and developing, in sequence, each recorded image on the photosensitive surface with a complementary colorant of the

primary color recorded thereon, the improvement comprising:

charging the photosensitive surface after each interim development step to a potential of a first polarity, uniformly irradiating the charged photosensitive surface with radiation which is in the absorptive domain of the next subsequent colorant to be developed whereby the charge within the previously developed regions on said surface is selectively dissipated in accordance with the previously developed colorant's ability to absorb radiation within the absorptive domain of said next developed substrative colorant, recharging the photosensitive surface to a potential of a second polarity opposite to that of said first polarity whereby said potential of a second polarity is reduced in accordance with the amount of charge potential of a first polarity retained on said photosensitive surface in the previously developed regions, recording a light image of the next primary color to be developed upon the recharged photosensitive surface to create a latent electrostatic image relating to the next primary color to be developed thereon.

2. The method of claim 1 including the further step of developing the recorded image with a developer material containing a colorant adapted to absorb radiation within the absorptive domain of said uniform illumination.

3. The method of claim 1 wherein the steps of charging and recharging the image bearing plate surface are accomplished by means of a corona generator.

4. The method of claim 3 wherein the photosensitive surface is initially charged with corona of a negative potential.

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