

May 23, 1972

SUSUMU TANAKA
METHOD OF TRANSFERRING AN ELECTROSTATIC
IMAGE TO A DIELECTRIC SHEET

3,664,833

Filed June 10, 1970

2 Sheets-Sheet 1

FIG. 1A

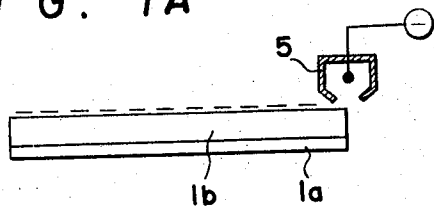


FIG. 1C

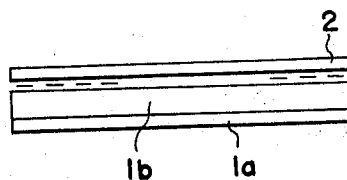


FIG. 1B

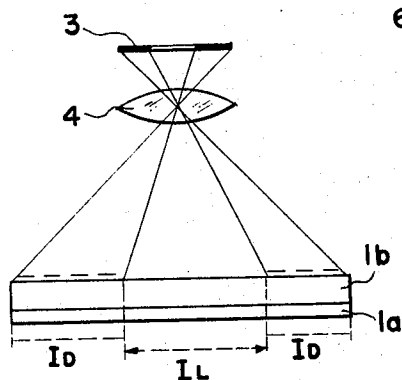


FIG. 1D

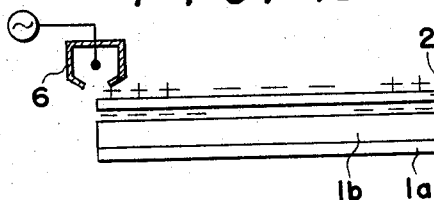


FIG. 1E

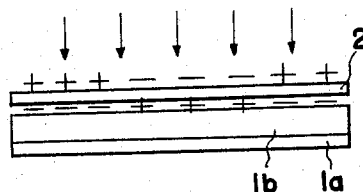
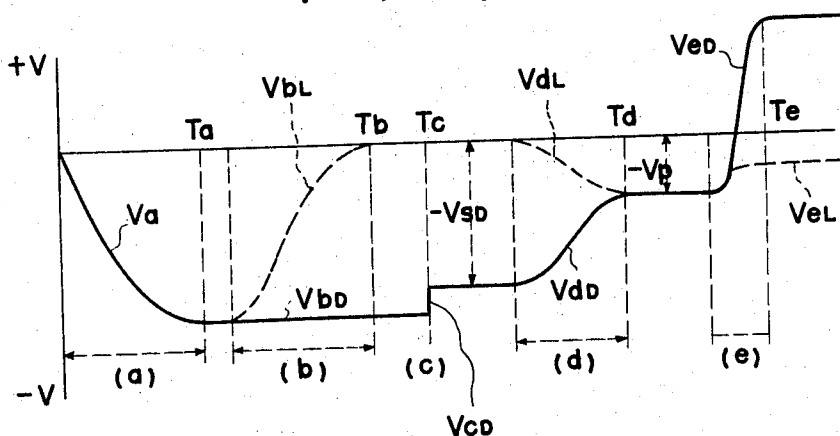


FIG. 2



INVENTOR

Susumu Tanaka

BY
Watson, Cal, Grindle & Watson
ATTORNEY

May 23, 1972

SUSUMU TANAKA
METHOD OF TRANSFERRING AN ELECTROSTATIC
IMAGE TO A DIELECTRIC SHEET

3,664,833

Filed June 10, 1970

2 Sheets-Sheet 2

FIG. 3A

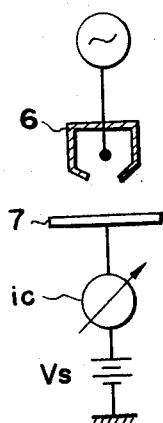


FIG. 3B

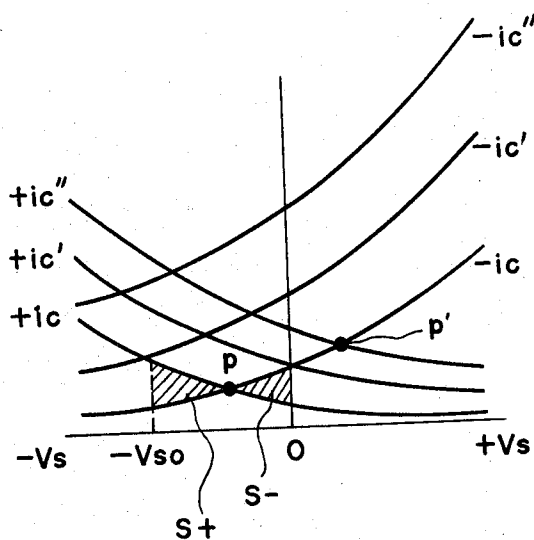


FIG. 4A

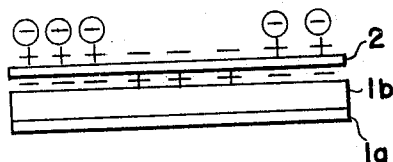
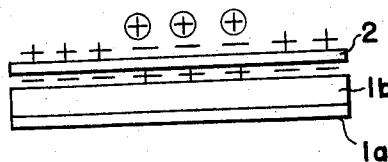


FIG. 4B



INVENTOR

Susumu Tanaka

BY

Watson, Cole, Grindley & Watson
ATTORNEY

1

3,664,833

METHOD OF TRANSFERRING AN ELECTRO- STATIC IMAGE TO A DIELECTRIC SHEET

Susumu Tanaka, Sakai, Japan, assignor to Minolta
Camera Kabushiki Kaisha, Osaka, Japan

Filed June 10, 1970, Ser. No. 45,124

Claims priority, application Japan, June 16, 1969,

44/47,491

Int. Cl. G03g 13/00, 13/15

U.S. Cl. 96—1

7 Claims

ABSTRACT OF THE DISCLOSURE

An electrostatic image is transferred from a photoconductive layer onto a dielectric sheet of 10μ to 200μ thickness by applying an AC corona discharge to the dielectric sheet and projecting a uniform light onto the dielectric sheet from an incandescent light source. The image on the dielectric sheet is developed with toner and the dielectric sheet is stripped from the photosensitive material.

BACKGROUND OF THE INVENTION

There are two types of transferring processes—a latent image transferring process and a visible image transferring process for electrostatic copiers.

In the former process, a transfer sheet is put upon a photosensitive plate on which an electrostatic image is formed and by applying thereto a bias electric field the electrostatic image is transferred from the photosensitive plate to the transfer sheet. The transfer sheet is stripped to obtain the electrostatic image on the surface thereof which has been in contact with the photoconductive plate. However, there are the following drawbacks in this process—it is difficult to set up the bias voltage for promoting the transfer of electrostatic image from the photosensitive plate to the transfer sheet; the electrostatic image transferred is deteriorated remarkably as compared with the electrostatic image on the photosensitive plate; and an electric discharge produced by stripping the transfer sheet results in unevenness on the electrostatic image on the transfer sheet.

Whereas, in the latter process after the electrostatic image on the photosensitive sheet is developed, the visible image thereof is transferred onto the transfer sheet, so that it is necessary to remove the remaining visible image on the photosensitive plate and this fact lowers the efficiency of the visible image transferring process.

The present invention is directed to a transferring process for electrostatic copiers which does not have the drawbacks described above in both prior art transferring processes.

SUMMARY OF THE INVENTION

The present invention forms an improved electrostatic image in accordance with an electrostatic latent image on a photosensitive body on the surface (not facing the photosensitive body) of a transfer sheet put upon the photosensitive body and develops the electrostatic image by applying an AC corona discharge onto the transfer sheet in a dark place and by applying an overall exposure onto the electrostatic image.

The primary object of the present invention is to provide an improved transferring process for electrostatic copying for transferring the electrostatic image onto the face of a transfer sheet opposite to the face facing the photosensitive body.

The second object of the present invention is to provide a transferring process for electrostatic copying in which the stripping of a transfer sheet from the photosensitive

2

body is not necessary to obtain latent images and the development thereof.

The third object of the present invention is to provide a transferring process for electrostatic copying in which the transferring of electrostatic images has high sensitivity and high contrast.

The fourth object of the present invention is to provide a transferring process for electrostatic copying in which both positive-positive and negative-positive transfers which are free of fog can be effected.

The fifth object of the present invention is to provide a transferring process for electrostatic copying in which a half-tone can be formed correctly.

The other objects of the present invention will be understood from the detailed description disclosed hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A the uniform charging process of a photosensitive body which is a step in the process of electrostatic copying; FIG. 1B shows the electrostatic image forming process on a photosensitive body which is also a step in the process of electrostatic copying; FIG. 1C shows the transfer sheet in place upon the photosensitive body in accordance with the process of the present invention; FIG. 1D shows the application of an AC corona discharge onto the transfer sheet in a dark place in accordance with the present invention; and FIG. 1E shows the overall exposure process in accordance with the present invention.

FIG. 2 is a plot showing the time-voltage relationship of the surface potential between a photosensitive body and a transfer sheet.

FIG. 3A shows the relative arrangement of an AC corona discharge device and an electrode; FIG. 3B shows the characteristics of the output current in FIG. 3A.

FIG. 4A shows positive-positive development and FIG. 4B shows negative-positive development.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Reference numeral 1 denotes a photosensitive body composed of photoconductive layer 1b provided with conductive layer 1a on the back thereof for use in the conventional xerography process. A photosensitive substance for forming an electrostatic image at low potential, such as a resin dispersoid mainly composed of, for example, ZnO or a CdS resin dispersoid which is a high potential substance, which fogs readily, may be used in the process of the invention.

The process for forming an electrostatic image on a photosensitive body is about the same as the prior xerography process. As shown in FIG. 1A a discharge is made onto the face of photoconductive layer 1b of photosensitive body 1 by means of DC corona discharge device 5 in a dark place, and by moving it relative to the photosensitive body it is possible to charge it uniformly negative (—). In this manner, the surface potential of photoconductive layer 1b of photosensitive body 1 increases along curve V_a as shown by (a) in FIG. 2 and is saturated to a maximum value at time T_a .

Next, in FIG. 1B the exposure of a picture image is applied onto photoconductive layer 1b charged uniformly to a negative (—) potential as described above. That is, the image of original copy 3 is projected onto the charged face of photoconductive layer 1b by means of lens 4.

And thus, the negative charge of light image I_L on photoconductive layer 1b is damped and the surface potential thereof is decreased as shown by curve V_{bL} in FIG. 2b to a minimum value, namely, zero at time T_b .

Whereas, the negative charge on light image shadow I_D is held as it is and the surface potential thereof is not varied as shown by curve V_{BD} .

In this manner, on the face of photoconductive layer 1b of photosensitive body 1 an electrostatic latent image is formed corresponding to the light and darkness of an image.

The transferring process in accordance with the present invention is carried out in the processes shown in FIGS. 1C, D and E, however, in order to clarify the charging, the development of the surface potential, and the transfer thereof on the transfer sheet in FIGS. 1A and B in the processes shown in FIG. 1C, D and E, the explanation has been made in accordance with FIGS. 1A and B.

FIG. 1C shows the process in which transfer sheet 2 is placed, in a dark place, upon the face of photoconductive layer 1b of photosensitive body 1 on which the electrostatic latent image is formed, and transfer sheet 2 is made of an insulating material, for example, a film of polyester, polyethylene, vinyl chloride, or the like can be used. And, provided transfer sheet 2 is put upon the face of photoconductive layer 1b at time T_0 , the production of straight line V_{BD} of the light image shadow on photoconductive layer 1b of photosensitive body 1 decreases suddenly as shown by straight line V_{CD} and the surface potential on the shadow on transfer sheet 2 assumes the value $(-)$ V_{SD} .

In this state, if transfer sheet 2 is developed with toner having a positive $(+)$ electric charge it is developed only temporarily, however, this is realized only if transfer sheet 2 is thin—in the order of several microns—and the potential difference corresponding to the light and darkness of the electrostatic image on photosensitive plate 1 is large. But such a thin transfer sheet is of no practical use. And, a CdS photosensitive plate which has a large potential difference corresponding to light and dark areas, potential remains on the light areas, resulting in ground contamination, so that it is very difficult to reproduce a clear image on the transfer sheet and it is of no practical use. However, in the present invention, by applying the following processes the use of transfer sheets having a thickness of several hundreds μ is possible and the practical use also is turned into a possibility.

That is, in the process shown in FIG. 1D, onto transfer sheet 2 placed upon photosensitive body 1 an AC corona discharge is applied in a dark place, and simultaneously discharging AC corona discharge device 5 and transfer sheet 2 are moved relative to one another. In this manner, on a portion corresponding to the light image shadow on transfer sheet 2 a positive $(+)$ electric charge is generated and the surface potential thereof is decreased as shown by curve V_{dD} in FIG. 2D. And on the other side, on a portion corresponding to the light image a negative $(-)$ electric charge is generated and the surface potential thereof is increased from zero potential as shown by curve V_{dL} , and at time T_d the surface potentials of the light and the shadow are at the same potential $(-)$ V_p and a balanced state is attained. And accordingly, even though AC corona discharge is continued to be applied the charging does not proceed and the surface potential remains at a constant value $(-)$ V_p .

Such a phenomenon, namely, that on transfer sheet 2 corresponding to an image shadow a positive $(+)$ electric charge is generated and on transfer sheet 2 corresponding to the light image a negative $(-)$ electric charge is generated is caused by the characteristics of the output current of AC corona discharge device 6. As to this fact, in FIG. 3A the output current i_c of AC corona discharge device 6 undergoes a change in accordance with the polarity and amplitude of potential on electrode 7. That is, the positive $(+)$ ions from AC corona discharge device 6 increase by being attracted

by a negative $(-)$ electric field when electrode 7 is at a negative $(-)$ potential and conversely decreases by repulsion when electrode 7 is at a positive $(+)$ potential and curve $+ i_c$ undergoes a change as shown in FIG. 3B. Whereas, negative $(-)$ ions from AC corona discharge device 6 decrease by repulsion when electrode 7 is at a negative $(-)$ potential and increase by being attracted by a positive $(+)$ electric field when electrode 7 is at a positive $(+)$ potential and curve $(-) i_c$ undergoes a change as shown in FIG. 3B.

These curves $(+) i_c$ and $(-) i_c$ intersect at point P, however, the fact that point P is at a negative potential is because there is a difference of mobility between positive $(+)$ ions and negative $(-)$ ions and at zero potential of electrode 7 the mobility of negative $(-)$ ions is larger considerably than that of positive $(+)$ ions. And in general, the higher the AC corona discharge voltage is, the larger the slope of the curve of the output current becomes as shown by curve i'_c and curve i''_c or curve $(-) i'_c$ and curve $(-) i''_c$.

In the AC corona discharge process in accordance with the present invention, the potential on electrode 7 corresponds to the surface potential on transfer sheet 2, and the potential of point P is $(-)$ V_p and on the shadow, positive $(+)$ electric charge on S $(+)$ portion is generated and on the light, negative $(-)$ electric charge on S $(-)$ portion is generated.

As described above, after electric charges are generated on transfer sheet 2 and the surface potential thereof reaches $(-)$ V_p , an overall irradiation is applied onto transfer sheet 2 to give an overall exposure, as shown in FIG. 1E.

The overall exposure is applied from the side of transfer sheet 2 when sheet 2 is transparent, and when photosensitive body 1 is transparent (especially when photoconductive layer 1a thereof is transparent) the overall exposure can be applied from the photoconductive layer side and in this case transfer sheet 2 may be opaque.

Upon applying the overall exposure photoconductive layer 1b has increased conductivity, and on the shadow thereof, except the negative $(-)$ electric charge seized by the internal field of positive $(+)$ electric charge on transfer sheet 2, negative $(-)$ electric charge is discharged to photoconductive layer 1a, and the positive $(+)$ electric charge acts as the external field. And the surface potential on transfer sheet 2 increases suddenly from negative $(-)$ potential to positive $(+)$ potential to obtain a maximum value at time T_0 and then is constant as shown by curve V_{eD} in FIG. 2E. Whereas, on the light image, positive $(+)$ electric charge is attracted from photoconductive layer 1a by the negative $(-)$ electric charge on transfer sheet 2 and moves to the interface between transfer sheet 2 and photoconductive layer 1b, and the surface potential on transfer sheet 2 decreases a little as shown by curve V_{dL} .

Upon applying the overall exposure process as described above, the surface potential on the light image is changed very little but the surface potential on the shadow image portion reverses its polarity and increases its surface potential difference.

At time T_e when the process is finished, on the light image on transfer sheet 2 an electrostatic image of high contrast which is quite free of fog can be obtained.

The electrostatic image on transfer sheet 2 has different characteristics in accordance with its thickness, and if it is thick the surface potential on the shadow image portion becomes higher than if it is thin and the contrast thereof has a tendency to be lighter, and a transfer sheet having a thickness of as much as several hundred microns can be put to use.

Next, the electrostatic image formed on transfer sheet 2 in the manner described above can be developed without stripping and in the known developing method making use of toner having electrically charged colored particles as the main constituents, as shown in FIGS. 4A

5

and B. FIG. 4A shows positive-positive development carried out with toner charged to a negative (—) electric charge and FIG. 4B shows negative-positive development carried out with toner charged to a positive (+) electric charge, however, in either case, the surface electric charge and the surface potential on the portion to be white are of the same polarity as the electric charge of the toner, so that there is no ground contamination.

And, after development it is possible to strip the transfer sheet and fix it directly, and it is also possible to transfer it onto transfer paper and reproduce additional copies. On the other side, on the surface of photosensitive body 1 there is no toner which is adhered thereto, so that cleaning and/or washing are not required.

As described above, the present invention has been explained for the case wherein the potential on the electrostatic image on photosensitive plate 1 is zero on the light image and negative (—) potential on the shadow image portion, however, even if the remaining potential (—) V_p is the light image of an electrostatic image on photosensitive body 1, in the case where $V_p < V_p$ and the value is small point P is between both potentials and as seen clearly in FIG. 3B the light image is not charged to a positive (+) electric charge by the AC corona discharge process (FIG. 1D) so that no fog results.

And, in the case that on photosensitive plate 1 an electrostatic image charged to a positive (+) electric charge is formed as S_0 , by setting a point of intersection for the output current of the AC corona discharge device to be on the positive (+) potential side, for example, as point P' in FIG. 3, it is possible to carry out the process in the same way as in for the negative (—) electric charge. The setting of point P' can be attained by applying positive (+) voltage to the secondary coil side of the AC corona discharge device. That is, for example, by applying a positive (+) voltage to AC corona discharge device 6 of 6000 v., the positive (+) discharge becomes 6500 v. and the negative (—) discharge becomes (—) 5500 v.

Besides, in the present invention by setting properly the characteristics of the output current of the AC corona discharge device, for example, by increasing or decreasing the corona discharge voltage or by changing the value of positive (+) discharge voltage and negative (—) discharge voltage, it is possible to move point P to increase the quantity of electric charge on transfer sheet 2 and also increase the sensitivity easily.

And, it is also possible to make the electric charge on the light image portion to be zero to bring out the half tone by making the potential of point P zero.

The embodiments of the transferring process for an electrostatic image in accordance with the present invention are shown as follows:

THE FIRST EMBODIMENT

As the photosensitive plate, a ZnO-resin dispersed photosensitive plate is put to use, and after a polyester film having a thickness of 50μ is put upon an electrostatic image composed of a light image of 0 v. and a shadow image of (—)500 v., an AC corona discharge of 6000 v. is applied onto the film surface, and an electrostatic image of (—)250 v. on the light image and (+)250 v. on the shadow image can be obtained on the film surface.

THE SECOND EMBODIMENT

As the photosensitive plate, a CdS-resin dispersed photosensitive plate is put to use, and after an electrostatic image composed of a light image of (—)100 v. and a shadow image of (—)1000 v. is formed and the same transfer film as in the first embodiment is put upon the

6

electrostatic image, an AC corona discharge of 6000 v. is applied, and an electrostatic image of (—)400 v. on the light image and (+)450 v. on the shadow image can be obtained on the film surface.

What I claim is:

1. A transferring process for electrostatic image copying, comprising the steps of:

- (1) forming an electrostatic latent image on a photoconductive layer of a photosensitive material according to a picture image by means of a charging means and a picture image exposure means;
- (2) placing a sheet composed of a dielectric of 10μ to 200μ thickness upon the photosensitive material;
- (3) applying an AC corona discharge to the dielectric sheet;
- (4) projecting a uniform light onto the dielectric sheet by means of an incandescent light source;
- (5) developing the dielectric sheet with toner; and
- (6) stripping the dielectric sheet from the photosensitive material.

2. A process as set forth in claim 1, wherein the electrostatic latent image formed in said first step has light and shadow portions and the surface potential of both portions is of the same polarity with the surface potential of the light portions smaller than the negative surface potential of the shadow portions, and the AC corona discharge device and an electrode are disposed so that the point of intersection of the discharge current of the positive ions of the AC corona discharge device and the discharge current of the negative ions lies between the negative surface potential of shadow portions and the potential of the light image portions; and in the process for projecting a uniform light onto the dielectric sheet a negative electric charge is placed thereon in accordance with the light image portions on the dielectric sheet.

3. A process as set forth in claim 2, wherein the toner used in developing the image is given a negative charge to prevent it from adhering to the dielectric sheet.

4. A process as set forth in claim 2, wherein the toner used in developing the image is given a positive charge to prevent it from adhering to the dielectric sheet.

5. A process as set forth in claim 2, wherein the positive discharge and negative discharge voltage of the AC corona discharge device is adjusted in accordance with the surface potential of the discharge electrode.

6. A process as set forth in claim 2, wherein a DC bias voltage is applied to the AC corona discharge device and the discharge electrode.

7. A process as set forth in claim 2, wherein a variable DC bias voltage is applied to the AC corona discharge device and the discharge electrode by means of a variable resistor and a rectifier connected to the AC electric power source.

References Cited

UNITED STATES PATENTS

3,551,146	12/1970	Gundlach	96—1.4 X
3,084,061	4/1963	Hall	96—1 X
3,147,679	9/1964	Schaffert	96—1 X
3,438,706	4/1969	Tanaka et al.	96—1.4 X
3,281,857	10/1966	Kaiser	96—1 X
2,833,648	5/1958	Walkup	96—1
2,937,943	5/1960	Walkup	96—1
3,545,969	12/1970	Herrick et al.	96—1

GEORGE F. LESMES, Primary Examiner

J. R. MILLER, Assistant Examiner

U.S. Cl. X.R.

96—1.4