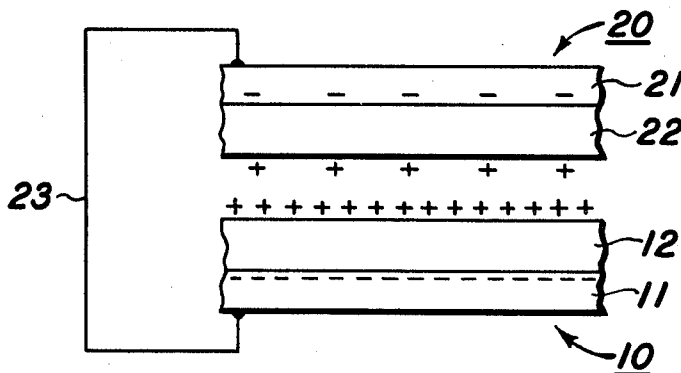


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|------|-----------|---|
| [72] | Inventors | Masamichi Sato;
Yasuo Tamai; Seiji Matsumoto, all of
Saitama, Japan |
| [21] | Appl. No. | 748,518 |
| [22] | Filed | July 29, 1968 |
| [45] | Patented | June 1, 1971 |
| [73] | Assignee | Xerox Corporation
Rochester, N.Y. |

- [56] **References Cited**
- UNITED STATES PATENTS
- 2,892,973 6/1959 Straughan 317/262
- OTHER REFERENCES**
- Shaffert, " Electrophotography," The Focal Press, 1965,
pages 332,333 Patent Office Se. Library TR 470 S 3
- Primary Examiner*—Lee T. Hix
- Attorneys*—Paul M. Enlow, James J. Ralabate, Norman E.
Schrader, Ronald Zibelli and David C. Petre

- [54] CHARGING SYSTEM**
18 Claims, 5 Drawing Figs.
- [52] U.S. Cl.**..... **317/262**
[51] Int. Cl...... **G03g 13/00,**
H05f
[50] Field of Search..... **317/262,**
262 ESF; 250/49.5

ABSTRACT: A charge bearing member comprising a free surface first electrically insulating layer which is electrically charged and which is backed by an electrically conductive substrate, is positioned, contiguous a second electrically insulating layer to be charged on an electrically conductive substrate. The insulating layers face each other during the transfer of charge to said second electrically insulating layer. The above steps are repeated at least a second time to transfer more charge to said second electrically insulating layer.



SHEET 1 OF 2

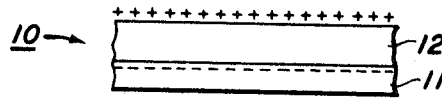


FIG. 1

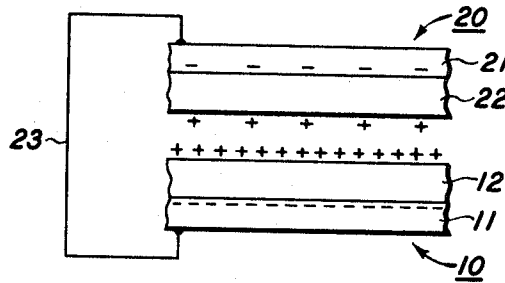


FIG. 2

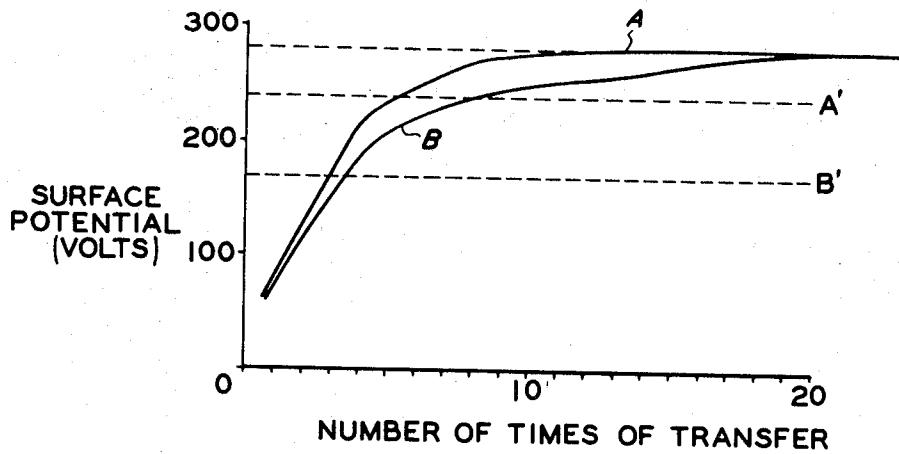


FIG. 3

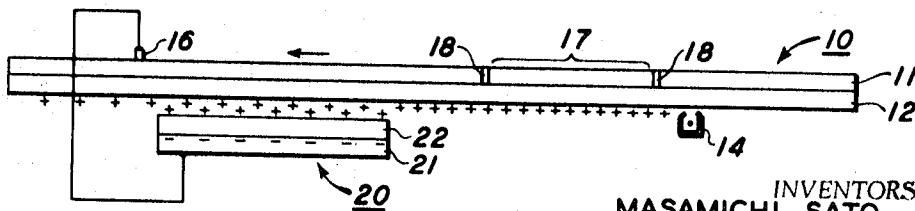


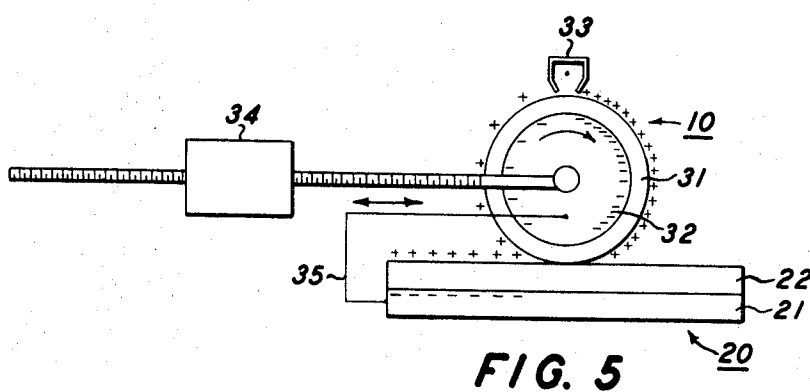
FIG. 4

INVENTORS
MASAMICHI SATO
YASUO TAMAI
SEIJI MATSUMOTO

BY

David C. Petre

ATTORNEY



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CHARGING SYSTEM

BACKGROUND OF THE INVENTION

The present invention relates to a method of charging an insulating layer and, in particular, to a method of charging a photoconductive insulating layer.

In the xerographic imaging process, for example, as described in U.S. Pat. No. 2,297,691 to Carlson a friction charging method is described for the charging of the photoconductive insulating layer. Later the convenient corona charging method came to be utilized and has found wide commercial acceptance. In the friction charging method it was practically quite difficult to achieve the high, uniform surface potentials desired in the xerographic process. On the other hand, while corona charging conveniently provides high, uniform surface potential charging, a dangerously high voltage, for example from 6,000–12,000 volts on the corona wires is necessary. Such high voltages also require special transformer and other equipment, adding to machine complexity.

Thus, there is a need for a new charging process which does not directly involve friction charging or corona charging and which overcomes the disadvantages attendant thereto.

SUMMARY OF THE INVENTION

Now, therefore, in accordance with the present invention a charge bearing member comprising a free surface first electrically insulating layer which is electrically charged and which is backed by an electrically conductive substrate, is positioned, contiguous a second electrically insulating layer to be charged on an electrically conductive substrate. The above steps are repeated at least a second time to transfer more charge to said second electrically insulating layer.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention as well as other objects and further features thereof, reference is made to the following detailed disclosure of this invention taken in conjunction with the accompanying drawings wherein:

FIG. 1 is a sectional view of an electrostatic charge bearing member as employed according to the present invention.

FIG. 2 is a sectional view illustrating a preferred mode of how the electrostatic charges are transferred from the charge bearing member of FIG. 1 to a separate insulating or photoconductive insulating layer 22;

FIG. 3 is a graph indicating the relation between the number of times of transfer and the surface potential in two examples of the present invention where a zinc oxide-resinous binder photoconductor layer is being charged; and

FIG. 4 is an embodiment of automatic apparatus for practicing the present invention, and

FIG. 5 is another embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The principle of the system of the present invention is that of electrostatic charge transfer as described in Schaffert, Electrophotography 317–361 London Focal Press, Ltd. 1965. As described therein, and in reference to FIG. 1, illustratively positive charges are uniformly distributed over the surface of electrically insulating layer 12 of charge bearing member 10 also comprising an electrically conductive support 11. FIG. 2 illustrates how the charges on the charge bearing member 10 are transferred onto a separate member 20 comprising insulating layer 22 (which may be photoconductive) on an electrically conductive support 21. Insulating layers 12 and 22 are preferably of a resistivity exceeding about 10^{10} ohm-cm. The charge bearing surface 12 of member 10 is caused to approach member 20 to be charged with the conductive substrates of each member in direct electrical connection i.e., shorted by means of a conductor 23. When the space between approaching layers 12 and 22 is reduced to a certain value, which, as Schaffert points out may vary from several thousand

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microns to 2 or 3 microns when the two surfaces are lightly pressed together in virtual contact, depending on the thickness, the dielectric constant as well as the quantity of surface charges of both insulating layers 12 and 22, discharge is produced in the space or gap between the two layers 12 and 22 and part of the charges on insulating layer 12 is transferred to the insulating layer 22. If both insulating layers are further caused to approach, further discharge occurs each time the gap is narrowed until the surface potential difference between the two layers 12 and 22 falls below a certain value whereupon no more discharge takes place even if the distance between both layers is further decreased. If the gap is reduced completely to zero, free direct movement of charges takes place until the potentials on the surfaces of both insulating layers equalizes whereupon the transfer of charges finally ceases. However, in practice, such a perfect contact condition in which the gap is reduced completely to zero is hard to realize and even in the case where both member 10 and 20 are flexible, perfect contact cannot be achieved unless, for instance, high pressures i.e., of some 20kg./cm.² are applied. Accordingly, free direct transfer of charges can be disregarded in a condition under which both insulating layers are contiguous each other which means spaced apart from each other by a maximum distance of several thousand microns or are at a minimum distance being lightly pressed against each other in virtual contact. Another mechanism of charge transfer consists in the field emission, that is, if the electric field in the gap reaches some 10^6 volts/cm., field emission of electrons takes place from the surface of insulating layer 12 whereby the transfer of charges to layer 20 is also accomplished.

However, if one actually conducts experiments on the electrostatic charge transfer technique, one finds that the experiments do not proceed according to the theory. For instance, where member 10 comprises a layer of polyethylene terephthalate, available under the designation Mylar from DuPont, on an aluminum substrate and member 20, a xerographic plate comprising a layer of amorphous selenium on an aluminum backing, or Electrofax paper, one finds that the quantity of charge actually transferred is smaller than the theoretically taught quantity of transfer. As known to those skilled in the art, Electrofax paper comprises a photoconductor layer on a paper substrate, the photoconductor layer generally comprising zinc oxide or other photoconductive pigment in a resin binder for example see U.S. Pat. No. 3,121,006 to Middleton et al.

Specifically, according to this invention, about 75 micron Mylar layers were used for both layers 12 and 22 and a charge carrying member 10 was corona-charged to a surface potential of about 3,000 volts. Member 10 was then moved toward and brought into virtual contact (although spacings up to about 7 microns give similar results and the invention applies for spacing up to several thousand microns, virtual contact is used in the examples herein of the invention because of the ease of obtaining such a spacing) with the member 20 with substrates 11 and 21 in shorted electrical contact. The resultant surface potentials of a member 20 due to charges transferred onto members 20 were about 700–900 volts. The theoretically expectable value is about 1000 to 1100 volts.

Also, where charges were transferred from Mylar on an aluminum substrate to Electrofax paper, where the two were brought into virtual contact, the values ranging from about 70 to about 80 volts were obtained as against the theoretical values of about 100 to about 110 volts. Such discrepancies may be due to dust or surface irregularities. If Electrofax paper is charged by this method, insufficient surface potential may be encountered in some cases. For instance, if Electrofax paper is charged by this method and developed, after image exposure, by means of a liquid developing process, a 70 or 80 volt initial potential may be sufficient to render quality prints, but when carrying out cascade or magnetic brush development, the low initial surface potential may produce inferior copy exhibiting, low image contrast, low density and low resolution.

It has been discovered, in accordance with the present invention, that the electrostatic charge transfer method may be used to create higher surface potentials by applying said method a plurality of times to the same member 20 until its surface potential is raised up to a desired value. For example, where Electrofax paper was charged, about 75 micron thick Mylar on an aluminum substrate was charged to a potential of about 3,000 volts by corona charging, which was transferred onto a sheet of noncharged Electrofax paper by the above-mentioned process as a result of which the Electrofax paper surface potential reached about 80 volts. Depending on the type of Electrofax paper employed, the surface potential may be lower or may reach as high as several hundred volts. Next, the Mylar was recharged to a potential of about 3,000 volts by corona charging and again transferred to the sheet of Electrofax paper already possessing a surface potential of about 80 volts, as a result of which the surface potential of the Electrofax paper increased to about 120—140 volts. If this process is carried out repeatedly, the surface potential of Electrofax paper increases steadily and saturates at last.

Surprisingly in connection with the charging method of the present invention is that the above-mentioned saturation value often surpasses by far the saturation value obtained by means of corona charging. For example, for the Electrofax paper employed in the above example, the saturation value was about 240 volts in the case of positive charging by corona discharge where the corona wire voltage was not less than about 3,000 volts, whereas the saturation value reached about 280 volts employing the method of the present invention. On the other hand, in the case of negative charging, the saturation value was about 170 volts under corona charging whereas it reached about 280 volts under the present method.

FIG. 3 shows the number of times of charging and the charged potential under the present invention. Curve A represents a particular Electrofax paper charged positively by the method of the present invention and the dashed line A' the same paper charged positively by means of corona charging. Curve B represents the same Electrofax paper charged negatively by the method of the present invention and the dashed line B' the same paper charged negatively by means of corona charging. It can be seen from FIG. 3 that the saturation values obtained by the method of this invention are higher than the ones obtained as a result of corona charging.

Any suitable electrically insulating material may be used as layer 12. Typical such materials include plastics, for example, polystyrene, tetrafluorethylene, polyvinylidene chloride.

One of the great advantages of the present invention, in addition to higher saturation values, is that charge carrying members 10 can hold a charge over long periods of time. Specifically, Mylar, about 75 microns thick on an aluminum substrate and wound in the form of a roll is found to substantially retain a surface charge even when stored for over a year. Also the present invention offers a mode for increasing the surface potential of an insulating layer by relatively small controlled increments. Controlling the surface potential by means of corona charging is difficult with respect to small surface potential increments such as below about 30 or 40 volt increments and even then the distribution of charges by corona charging is often uneven. Carefully charging to a precise surface potential is especially advantageous in the case of rendering good tone gradation by the liquid developing process, where tone gradation rendering is achieved more satisfactorily at a surface potential of about 100 volts than in the case of higher voltages.

While charge bearing member 10 has been described as an insulating layer on a conductive substrate, the conductive layer may be dispensed with and an electrically insulating film employed by itself, in the case where the insulating film 12 is backed by an electrode, preferably in shorted electrical contact with the conductive substrate of member 20, at the time of charge transfer. For example, a relatively conductive roller such as a rubber covered roller may be used in this regard.

Also, while member 10 has been described to be a flat member it may be in any other suitable form such as a Mylar covered aluminum core roller. See, for example, FIG. 5 where a roller member 10 having an electrically insulating layer 31 and a conductive support 32 is passed over the member to be charged 20. The roller member surface 31 is charged electrostatically by a corona discharge unit such as a corotron 33 and is repeatedly rolled over the surface of the member to be charged in either direction in accordance with the invention. Any suitable mechanism such as a reversible motor 34, or even hand rolling, can cause the roller to traverse the surface of the member to be charged. The electrically conductive substrates of each member are directly electrically connected by a conductor 35. Also, while the invention hereof has been described as a step and repeat process, it may be automated for example as illustrated in FIG. 4 by employing a web member 10, which may be an endless belt advancing in a direction substantially parallel to the surface of member 20 to be charged. Web 10 is charged by corona transfer device 14, for example of the type disclosed in U.S. Pat. No. 2,588,699 to Carlson or U.S. Pat. No. 2,836,725 to Vyverberg. Brush 16 makes electrical contact with the moving substrate 11 of web member 10. Electrical backing 11 may be a continuous strip or member 10 may comprise separate electrically independent portions by breaking the backing layer 11 into separate discrete elements 17, for example, by interposing transverse electrically insulating strips 18 along the length of strip 11.

Although specific components and proportions have been stated in the above description of examples of the charging system of this invention, suitable materials may be used with similar results. In addition, other variations may be made in the various processing steps to synergize, enhance or otherwise modify the character of the invention.

Another such process variation is that the two substrates may be electrically shorted after the charge carrying member and the member to be charged are placed in their contiguous charge exchanging relation.

Also, while electrical shorting of the substrates is preferred herein for more efficient transfer of charge, some transfer of charge, according to the invention, takes place even without this shorting.

It will be understood that various other 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 and may be made by those skilled in the art upon a reading of this disclosure, and such changes are intended to be included within the principle and scope of this invention.

We claim:

1. A charging method comprising the steps of:

- a. providing a charge bearing member comprising a free surface first electrically insulating layer backed by an electrically conductive substrate;
- b. electrostatically charging said first electrically insulating layer;
- c. providing a second electrically insulating layer on an electrically conductive substrate;
- d. bringing the electrostatically charged first electrically insulating layer to the second electrically insulating layer;
- e. positioning said electrically insulating layers contiguous to and facing each other to transfer charge from said first insulating layer to said second insulating layer; and
- f. repeating steps (a)—(e) at least a second time for the same electrically insulating layer to transfer more charge to said second electrically insulating layer.

2. A charging method comprising the steps of:

- a. providing a charge bearing member comprising a free surface first electrically insulating layer backed by an electrically conductive substrate;
- b. electrically charging said first electrically insulating layer;
- c. providing a second electrically insulating layer on an electrically conductive substrate;

- d. positioning said electrically insulating layers contiguous to and facing each other to transfer charge from said first insulating layer to said second insulating layer;
 - e. repeating steps (a)—(d) at least a second time for the same second electrically insulating layer to transfer more charge to said second electrically insulating layer; and
 - f. electrically shorting the substrates at least during a part of the time when the first and second insulating layers are in contiguous relation.
3. The method of claim 2 wherein the substrates are placed in electrically shorted contact after step (d) is accomplished.
4. A charging method according to claim 1 wherein said second electrically insulating layer is a photoconductive insulating layer.
5. A charging method according to claim 2 wherein said second electrically insulating layer is a photoconductive insulating layer.
6. A charging method according to claim 4 wherein said photoconductive insulating layer comprises a zinc oxide resinous binder layer.
7. A charging method according to claim 5 wherein said photoconductive insulating layer comprises a zinc oxide resinous binder layer.
8. A charging method according to claim 1 wherein steps (a)—(e) are repeated a sufficient number of times for the same second electrically insulating layer to charge it substantially to its charge acceptance saturation point.
9. A charging method according to claim 2 wherein steps (a)—(d) are repeated a sufficient number of times for the same second electrically insulating layer to charge it substantially to its charge acceptance saturation point.

10. A charging method according to claim 1 wherein said first electrically insulating layer is repeatedly electrically charged to the same polarity as initially.
11. A charging method according to claim 1 wherein said charge bearing member is in roller form.
12. A charging method according to claim 2 wherein said charge bearing member is in roller form.
13. A charging method according to claim 1 wherein at least one of said electrically conductive substrates is in roller form and is caused to effectively back the insulating layer by rolling it across said layer.
14. A charging method according to claim 2 wherein at least one of said electrically conductive substrates is in roller form and is caused to effectively back the insulating layer by rolling it across said layer.
15. A charging method according to claim 1 wherein in step (e) the two insulating layers are in virtual contact with each other.
16. A charging method according to claim 13 wherein said roller also serves as a pressure roll to press the two insulating layers in virtual contact with each other.
17. A charging method according to claim 1 wherein said charge bearing member is a web advancing in a direction substantially parallel to the surface of said second electrically insulating layer.
18. A charging method according to claim 17 wherein said web comprises in addition transverse electrically insulating strips physically and electrically separating the conductive backing of the first electrically insulating layer into separate areas in the longitudinal direction of said web.

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