ELECTROSTATIC IMAGING SYSTEM WITH MAGNETIC TONER

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ABSTRACT
An imaging system wherein an imaging member comprised of toner particles sandwiched between a substrate layer and a spaced surface layer with a resistivity above about 10^{10} ohm-cm is imaged by contacting a mechanical stylus to the spaced surface layer to triboelectrically create an electrostatic image thereon which is developed by said toner particles. An erasure mode is also set forth wherein a magnetic field, in relative motion to the electrostatic image which has been toned with magnetizable toner, is used to erase the magnetizable toner image and the electrostatic latent image when such is desired.

15 Claims, 5 Drawing Figures
ELECTROSTATIC IMAGING SYSTEM WITH MAGNETIC TONER

BACKGROUND OF THE INVENTION

This invention relates to electrostatic imaging, and, in particular, to a system for creating electrostatic images by the action of a mechanical stylus on an imaging member.

Those areas of technology interested in production of electrostatic images for display or reproduction are continually striving to simplify the apparatus and processes involved, from both operation and cost standpoint. Until now, no one has developed an electrostatic imaging system which is both simple and inexpensive, while exhibiting the desirable characteristics of reusability and high quality.

Present technology is exemplified by a simple electrostatic imaging device employing an electron beam to focus an image on an electrically nonconductive surface. Such an apparatus is disclosed in U.S. Pat. No. 3,109,062, wherein an electron beam is directed toward an electrically nonconductive surface capable of storing electrostatic charges in small discrete areas thereof. The electrostatic target surface is disposed in one end of an evacuated envelope having a transparent window therein. The target surface is disposed adjacent to but spaced from the transparent window, and disposed in the space between the target surface and the transparent window is a supply of small particles capable of retaining an electric charge. Upon completion of the electrostatic writing on the target surface, the charged particles are cascaded across the reverse side of the target. A flood beam of electrons is used to erase the image when such is desired.

Another example of the prior art is shown by U.S. Pat. No. 3,106,607. The structure required therein includes a transparent drum, formed by two coaxial cylinders with the intermediate space evacuated and containing magnetic particles having a photoemissive coating. An image to be recorded on magnetic tape is focused on the outer cylinder, and under the influence of a combination of electric and magnetic fields, the particles are oriented in accordance with the distribution of light presented by the image. A prepolarized magnetic tape is then passed adjacent to the oriented particles and an erasing magnetic field is applied. The combination of the oriented particles and the erasing field results in selective erasure of the prepolarization of the magnetic tape to form a stored image on the tape.

BRIEF SUMMARY OF THE INVENTION

One of the objects of this invention is to provide a simple system for producing an electrostatic image on an imaging member by the action of a mechanical stylus.

It is a further object of this invention to provide a simple and inexpensive display device upon which a mechanical stylus can act to produce a developable electrostatic image.

It is a further object of this invention to provide a loosely held magnetizable toner imaged member which can be completely erased or selectively erased by subjecting the toned image areas to a magnetic field, wherein there is relative motion between the toned areas and the magnetic field, selective erasure permitting selective updating.

It is a still further object of this invention to provide a novel imaging member upon which a mechanical stylus can act to produce an electrostatic image developable on either side of a contact surface.

It is a further object of this invention to provide a loosely held magnetizable toner imaged member wherein a magnetic field, in relative motion thereto, can erase the toner image and electrostatic latent image.

It is a still further object of this invention to provide a versatile imaging member for use in facsimile apparatus, which member can be erased and reused, or disposed of.

It is a further object of this invention to provide an imaging member which is suitable for use in an x-y plotter.

The foregoing objects and others are accomplished in accordance with this invention by providing an imaging system wherein an imaging member comprised of toner particles sandwiched between a substrate layer and a spaced surface layer with a resistivity above about $10^6$ ohm-cm is imaged by contacting a mechanical stylus to the spaced surface layer to triboelectrically create an electrostatic image thereon which is developed by said toner particles. An erasure mode is also set forth wherein a magnetic field, in relative motion to the electrostatic image which has been toned with magnetizable toner, is used to erase the magnetizable toner image and the electrostatic latent image when such is desired.

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 the invention taken in conjunction with the accompanying drawings wherein:

FIG. 1 is a partially schematic, partially cross-sectional view of one embodiment of the imaging member of the invention, showing a stylus in contact with the surface layer.

FIG. 2 is a partially schematic, partially cross-sectional view, similar to FIG. 1, showing the adhesion of toner to the surface layer after development.

FIG. 3 is a partially schematic, partially cross-sectional view of the imaging member showing erasure of the developed image by a magnet.

FIGS. 4 and 5 show another embodiment of the invention wherein the imaging member is an integral part of the document transport drum of a facsimile device and an electromagnet is used to erase the images formed thereon.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. 1–3, there is shown one embodiment of an imaging member according to the principles of the present invention. Imaging member 20 is comprised of a substrate layer 1 which has sealed thereto, in spaced relationship, along its periphery at 4 a transparent surface layer 2. The envelope thus formed by substrate layer 1 and the spaced surface layer 2 contains a fine powder 3 which may, or may not, be conductive. In the preferred embodiment, the toner is magnetizable. There is no criticality associated with the height of the envelope space, contact between the surface layer and the magnetizable powder 3 producing
results as satisfactory as an embodiment employing considerable spacing.

Referring further to FIG. 1, a mechanical stylus 5 is shown in contact with surface layer 2, graphically in position to form an image pattern thereon. The surface layer should have a resistivity above about $10^{10}$ ohm-cm. Preferred materials for the surface layer include, but are not limited to Tedlar, available from E. I. duPont de Nemours and Co., polystyrene, polyvinylchloride and Mylar, also available from E. I. duPont.

When stylus 5 is placed in either rolling, i.e., non-skidding or skidding contact with transparent surface layer 2 and moved about in an imagewise pattern, so long as the material of the stylus is at a different location on the triboelectric series than the surface layer material, the triboelectric contact of the two materials produces an electrostatic image upon the layer which corresponds to where the stylus has contacted the layer. For a further disclosure of the triboelectric effect, see U.S. Pat. No. 3,477,568, especially columns 5–7. The entire disclosure of U.S. Pat. No. 3,477,568 on triboelectric effects and series and especially all of columns 5–7, is hereby expressly incorporated herein by reference. Magnetizable powder 3 is then brought into contact with the electrostatic image, as at 6 in FIG. 2, thus developing the electrostatic image and making it visible through the transparent layer 2. The toned image may then be totally erased or selectively erased, for instance, to correct an error, by sweeping a magnetic field sufficient to move the magnetic particles over the layer as by magnet 7 shown in FIG. 3. It has been found that the magnetic field at the surface of the loosely held toned image should be approximately at least 100 gauss. It should be understood that the magnet need not be in contact with the surface layer, so long as the field acts upon the particles. The erase mechanism is thought to be a mechanical interaction of the toner particles abrading away the toner particles in the imaged areas, and at the same time sufficiently destroying the electrostatic image so that it is not capable of being redeveloped. Alternatively, erasure can be accomplished through mechanical agitation of the imaging member. The process is thought to be the same as magnetic erasure, in that the free toner particles abrade the particles in the imaged areas and destroy the electrostatic image.

A second embodiment for use in a facsimile display device is set forth in FIGS. 4 and 5. A rotating document transport drum 9 is covered with a surface layer 14 suitably spaced from the drum to create an envelope 10 therebetween. The means for holding the surface layer and document drum in spaced relationship is a matter of choice well within the skill of the average mechanic in the art, but, by way of example, can be done by using a rigid foil or multiple pins spaced around the outer surface of the drum. Magnetizable particles 11 are positioned within the envelope 10 and serve to develop the electrostatic image created by the action of stylus 12. It should be noted that surface layer 14 serves the same purposes as layer 2 of FIG. 1 and thus has the same characteristics. From the figures, it is readily apparent that development of the facsimile imaging member occurs simultaneously, or soon thereafter as it contacts the sump, with the creation of the latent image. Also, it should be noted that the positions of elements 12 and 13 can be in any relationship. Further more it is not necessary that the magnet create a brush to erase the image. Substrate 1 and its counterpart 9 can be either insulative or conductive. It may be advantageous to employ a conductive substrate to intensify the field effect of the electrostatic latent image formed on the toner.

Furthermore, it should be understood that the surface layer need not be an integral part of the transport drum 9. While it is not shown in the drawings, a reusable or disposable display member suitable for almost any facsimile device can be made similar to that shown in FIGS. 1–3, except that the substrate is electrically conductive rather than electrically insulating. Any non-magnetic conducting material produces acceptable results, and, by way of example, it has been found that aluminized Tedlar or Mylar, or NESA glass, available from Pittsburgh Plate Glass, will suffice.

The movement of stylus 12 is regulated by electromechanical device 15 which may be the control circuitry of a facsimile device. When erase is desired, the electromagnet 13 is energized and destroys by toner abra sion the loosely toned image and the electrostatic image as it passes within the magnetic field.

The following examples further specifically define the present invention with respect to the use of materials and apparatus set forth in the above electrostatic imaging system.

Example I – IV are carried out with a surface layer of Tedlar, available from duPont, about 1/2 mil thick having a resistivity of about $4 \times 10^{14}$ ohm-cm. The magnetizable powder used for development is iron, with a particle size of about 100 mesh, available from Fischer Scientific Company of Philadelphia, Pa.

**EXAMPLE I**

A 10 cm × 12 cm rectangular sheet of Tedlar is sealed around its periphery to a 12 cm × 14 cm cardboard substrate about 0.9 mm thick. Within the envelope thus created, about 5 grams of iron powder is deposited.

A glass stylus with a resistivity of about $10^{18}$ ohm-cm is then put into contact with the surface of the Tedlar sheet and moved about in an imagewise pattern. The sandwich is then picked up and gently shaken to cause a portion of the toner to adhere to the latent electrostatic image.

When the sandwich is held in a relatively vertical position, a toned image, of high quality, grey in color, is seen through the transparent Tedlar. The excess toner falls to the lower edge of the sandwich and forms a border therealong.

The image thus created is suitable for use as a projection transparency, if separated from the cardboard substrate.

To erase the developed image, the sandwich is placed in a horizontal position and a horseshoe magnet about 8 cm long, 1.5 cm wide and 1.5 cm thick is dragged across the outer surface of the Tedlar sheet.

**EXAMPLE II**

Example I is followed except that a metal stylus with a resistivity of about $10^{18}$ ohm-cm is used. The results are the same.

**EXAMPLES III**

A 10 cm diameter rotatable metal document transport drum of a facsimile device is covered with a Tedlar...
sheet suitably spaced by pins from the drum to permit
free movement of about 50 grams of iron powder loc-
cated in the space between the drum and the sheet.

The covered drum is affixed in proper position in a
400 Telecopier transceiver facsimile machine, manu-
factured by Xerox Corporation, which has been modi-
ified by the addition of an elongated electromagnet and
circuitry therefor, as shown in FIGS. 4 and 5.

The stylus of the facsimile machine contacts the ro-
tating Tedlar surface and creates an imagewise pattern
thereon which is simultaneously developed by the pow-
der. The observed image is a continuous helical pat-
tern, black in color and fair in quality.

The developed image is erased by energizing the
 electromagnet while the drum is rotating.

EXAMPLE IV

Example I is followed, including erasure, and then re-
peated, except for erasure. No objectionable ghosting
from redevelopment of previous images is seen on the
Tedlar surface.

Although specific apparatus and process steps have
been described in the above examples, other elements
and steps may be used where suitable.

Also, for example, the toner need not necessarily be
a dry powder, but may instead comprise particles in a
liquid carrier, or a dyed carrier, or may be marking par-
ticles combined with carrier particles or developer in
with other particles conventional as taught in xerogra-
phy.

Additionally, the image need not be erased, but can
be fused or made permanent by other techniques well
known in the art.

Furthermore, it is possible to put a removable plug in
the device to allow access to the interior thereof for ad-
justment of toner content.

It should be further understood that the structure and
method of the invention may be used for producing im-
ages of all kinds, those to be read out by the human eye
as well as those to be read out by physical or mechan-
ical read-out equipment, such as those using light reflec-
tion or radiation, electrical conductivity, magnetic
properties and the like as the means for reading the im-
age.

It will be understood that various changes in the de-
tails, materials, steps and arrangements of parts, which
have herein been 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 the disclosure within the principles and scope of the
invention.

What is claimed is:

1. A process for electrostatic imaging comprising the
steps of:
a. providing an imaging member comprised of a sub-
strate layer, a surface layer with a resistivity above
about 10^10 ohm-cm and toner sandwiched between
said substrate layer and said surface layer;
b. producing an electrostatic image on said imaging
member by moving a mechanical stylus in contact
with the surface layer in an imagewise pattern; and,
c. contacting said toner to said electrostatic image.

2. The process of claim 1, wherein step 1 (c) occurs
simultaneously with step 1 (b) because the surface
layer, toner layer and substrate layer have no relative
spacings therebetween.

3. The process of claim 1, further comprising the step
of: stripping the surface layer from the substrate layer
after step 1 (c).

4. The process of claim 3, wherein said surface layer
is sufficiently transparent to see a toned image there-
through.

5. The process of claim 1, further comprising the step
of: regulating the contact between the stylus and the
imaging means with an electromechanical control de-
vice.

6. The method of claim 5, wherein said electrome-
chanical control device receives signals from a location
remote from said device and said imaging member.

7. The process of claim 1, wherein said toner is mag-
netizable and said substrate member and said surface
member are sealed in spaced relationship about their
respective edges one to the other, forming an envelope.

8. The process of claim 7, wherein said contacting of
step (c) is accomplished by gently vibrating said imag-
ing member to cause said magnetizable toner to adhere
to said electrostatic image.

9. The process of claim 7, wherein at least one of said
substrate and surface layers are sufficiently transparent
to see a toned image thereforthrough.

10. The process of claim 7, further comprising the
step of: erasing the developed electrostatic image by
subjecting the image to a magnetic field in relative mo-
tion thereto.

11. A process for electrostatic imaging in a facsimile
device of the type employing a rotatable document
transport drum comprising the steps of:
a. attaching an imaging member with a resistivity
above about 10^10 ohm-cm in sealed spaced relation-
ship to the document transport drum of the fac-
simile device with toner within the envelope thus
created;
b. rotating the document transport drum;
c. producing a latent electrostatic image by selec-
tively contacting the thus rotating imaging member
with a mechanical stylus which is regulated by the
control circuitry of the facsimile device; and
d. developing the electrostatic image by contacting
same with said toner.

12. The process of claim 11 wherein said toner is
magnetizable and, further comprising the step of: sub-
jecting the developed electrostatic image on the rotat-
ing imaging member to a magnetic field to thereby
erase the image.

13. An electrostatic imaging member comprising:
a. a substrate layer;
b. a covering layer with a resistivity in the range
above about 10^10 ohm-cm sealed to said substrate
layer along the periphery thereof and in spaced rela-
tionship thereto, creating an envelope between the
two layers; and
c. magnetizable particles disposed in said envelope.

14. An electrostatic imaging member comprising:
a. a metallic cylinder;
b. a covering layer with a resistivity above about 10^10
ohm-cm spaced from said metallic cylinder so as to
form two concentric cylinders with a space be-
tween the two;
c. sealing means on the end of said metallic cylinder
forming a sealed space between said metallic cylin-
der and said covering layer; and
d. magnetizable particles disposed in said sealed
space.
In an electromechanical facsimile device wherein control signals are transmitted from a location remote from said device, received by said device and converted into controlled movement of a mechanical stylus into and out of contact with an imaging member, the improvement comprising:

a. a reusable imaging member comprising:
   a. a substrate layer,
   b. a covering layer with a resistivity above about $10^{10}$ ohm-cm sealed to said substrate layer along the periphery thereof and in spaced relationship thereto, creating an envelope between the two layers,
   c. magnetizable particles disposed in said envelope; and
   d. a magnet positioned adjacent said imaging member for selective erasure thereof.