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ELECTROSTATIC IMAGE COPYING METHOD

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**Fig. 1.**

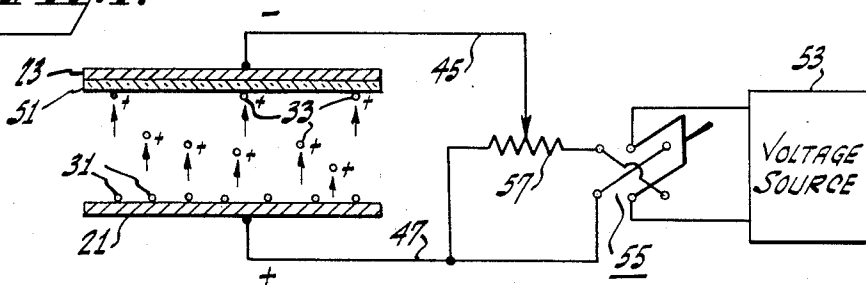


**Fig. 2.**

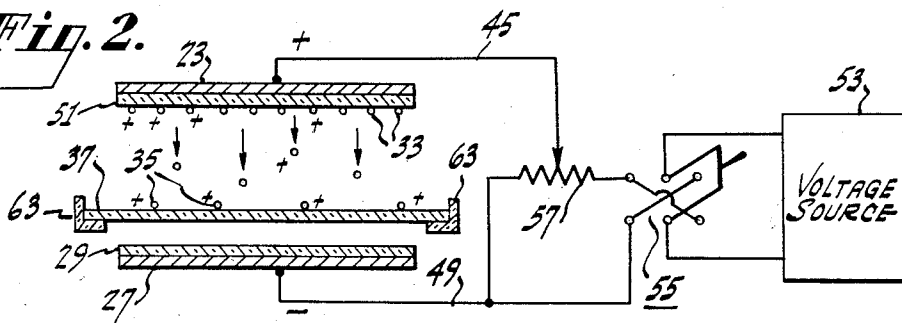
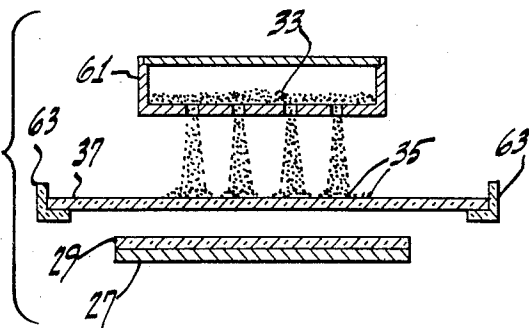


**Fig. 3.**



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## ELECTROSTATIC IMAGE COPYING METHOD

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2 Claims. (Cl. 101-426)

This invention relates to electrostatic printing and more particularly to methods and means for a plurality of visible image copies from a single electrostatic image.

An electrostatic printing process is, generally speaking, that type of process for producing a visible image, reproduction, or copy which includes as an intermediate step converting a light image or electrical signal into an electrostatic charge pattern on an insulating surface. The process may also include the conversion of the charge pattern into a visible image which may be a substantially faithful reproduction of an original, except that it may be of a different size.

A typical electrostatic printing process may comprise the steps of providing a conductive backing plate having a surface coated with a photoconductive insulating material such as selenium, anthracene or sulphur; applying a blanket electrostatic charge to the surface of the photoconductive coating; focusing a light image on the charged surface in order to discharge the portions irradiated by light rays, while leaving the unexposed areas of the surface in a charged condition thereby forming an electrostatic image. The electrostatic image is made visible by the application of a developer powder which is held electrostatically to the charged areas of the sheet. The powder image thus formed may be fixed directly to the photoconductive coating or it may be transferred to another surface, upon which the reproduced image is desired, and then fixed thereon. A detailed description of the steps of this process may be found in U. S. Patent 2,297,691, issued October 6, 1942, to C. F. Carlson.

A plurality of final copies of a particular image are frequently desired. One method of producing multiple copies is to repeat all of the steps of the basic process for each copy that is desired. While the prints obtained in this manner are satisfactory, the cost and time required for repetition of all of the steps detracts from its commercial value.

Another method for producing a plurality of copies utilizes the residual electrostatic image that remains on the insulating surface after a previous visible powder image has been transferred to its copy sheet. The residual image is made visible by the application of a developer powder, and may then be transferred to its copy sheet and fixed thereon. While several visible image records may be produced from a single electrostatic image by this method, each successive development weakens the charge comprising the electrostatic image. Thus, only the first visible image is a faithful copy while the succeeding copies exhibit losses in tonal values and a general weakening in color intensity. Finally, only a very limited number of copies may be made.

When a visible image of developer powder is transferred to a copy sheet, not all of the powder is transferred. Part of the visible powder image may be transferred to the first copy sheet, part to the second copy sheet, and so forth. However, successive copies exhibit a loss in tonal values and a general weakening of the image, and only a limited number of copies may be made.

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An object of the present invention is to provide an improved electrostatic printing process.

A further object is to provide an improved method of and means for producing a plurality of visible image copies from a single electrostatic image.

A further object of this invention is to provide an improved electrostatic printing process and apparatus wherein successive powder images may be formed on separate copy sheets from a single electrostatic image without loss in tonal values or intensity of the image.

The foregoing objects and other advantages may be accomplished in accordance with the present invention which comprises establishing an electrostatic image on a surface of a dielectric image sheet, bringing one surface of a copy sheet into closely spaced relation with the electrostatic image, and bringing a quantity of charged developer substance in finely divided form into contact with the other surface of the copy sheet whereby a visible image corresponding to the electrostatic image is formed on said other surface of the copy sheet.

The invention will be described in greater detail by reference to the accompanying drawing in which:

Figure 1 is a sectional view of an apparatus for charging a developer powder.

Figure 2 is a sectional view of an apparatus for developing a plurality of powder images from a single electrostatic image using the charged powder of Figure 1.

Figure 3 is a sectional view of another arrangement for developing a plurality of powder images from a single electrostatic image.

Similar reference characters are applied to similar elements throughout the drawing.

### Example 1

Referring to Figure 1, a layer of finely powdered suitably colored nylon 31 is placed on the upper face of a lower brass electrode 21. An upper electrode comprising a brass plate 23 having a dielectric coating 51 of polystyrene about .055" thick on its lower face is supported about 1/8" away from the lower electrode 21. Leads 45 and 47 connect the upper and lower electrodes to a source 53 of voltage of the order of 400 volts through a double pole double throw reversing switch 55 and a potentiometer 57. The switch 55 is closed so that the polarity of the upper electrode is negative with respect to the lower electrode. The nylon powder 31 resting on the lower electrode 21 becomes positively charged due to conduction from the lower electrode. The potentiometer 57 is adjusted such that when a sufficient positive charge has formed on each particle, the electric field existing between the upper and lower electrodes causes the particle to move upwards towards the upper electrode where it is held on the dielectric coating 51.

Referring now to Figure 2, the lower electrode 21 of Figure 1 is removed and a brass plate 27 having a photoconductive dielectric layer 29 on its upper face, is substituted therefor. The previously negatively-charged photoconductive dielectric layer is exposed to a light image to provide a corresponding electrostatic image on its upper surface, and is brought about 1/8" below the charged powder layer 33. An insulating sheet 37 of polystyrene, or the like, about .005 inch thick is held on supports 63 about 1/16 inch above the photoconductive layer 29. Leads 45 and 49 connect the upper brass plate 23 and the lower brass plate to the voltage source 53 through the double-pole, double-throw reversing switch 55 and the potentiometer 57. The switch 55 is reversed so that the polarity of the upper plate 23 is positive with respect to the lower plate 27. The potential difference is raised gradually to the order of 200 volts by adjustment of the potentiometer 57, until the electric field between the plates almost causes the powder to leave

the upper electrode. However, extra attraction is afforded by the negatively-charged areas of the image. The field lines from the image extend through the polystyrene sheet 37 attracting powder from the upper electrode to the polystyrene sheet 37 in the form of powder image 35. The colored powder image is a faithful visual copy of the electrostatic image on the surface of the dielectric sheet 29. It may be fixed to the sheet 37 by heating or other known means to provide a permanent copy.

The optimum electric fields to apply to the developer powder particles in the above-described example will depend upon the nature of the developer powder and the spacing of the electrodes. However, fields of the order of 1600 to 5000 volts per inch of electrode spacing are preferred.

### Example 2

Referring to Figure 3, a photoconductive dielectric layer 29 mounted on a brass plate 27 and having an electrostatic image on its upper surface is provided as in Example 1. An insulating sheet 37, of polystyrene, or the like, about .005 inch thick, is placed about  $\frac{1}{16}$  inch above the image layer 29. Black stained lycopodium powder 33 from a shaker 61 is sprinkled upon the polystyrene sheet 37. The field lines from the electrostatic image on the layer 29 extend through the polystyrene sheet 37 attracting the lycopodium powder. The polystyrene sheet 37 is subjected to a gentle draft of air such as by directing a mild stream of air from the nozzle of a suitable blower against the dusted surface. All loose powder not held by electrostatic attraction is blown off, leaving a faithful visual copy of the electrostatic image on the dielectric layer 29.

The polystyrene sheet 37 of Examples 1 and 2, with the powder image 35 thereon may be removed. The powder image 35 may be fixed to the polystyrene sheet 37 or may be transferred to another surface and fixed thereon by any of the conventional methods. For example, an adhesive may be sprayed on the powder image, or the powder may be fused to the surface upon which it rests by the application of heat.

During the entire process, the electrostatic image on the dielectric layer 29 remains unimpaired. Hence, upon the removal of the polystyrene copy sheet 37, another sheet may be inserted in its place and the process repeated as many times as desired to make the desired number of copies.

This process may be combined with any of the electrostatic image producing processes. If the dielectric layer 29 bearing the electrostatic image is a photosensitive material, the process of this invention should be carried out in the darkness. However, if the electrostatic image is on a material that will not discharge, the process may be carried in ordinary daylight.

Almost any copy sheet material may be used in place of the polystyrene sheet. It is preferred to use materials that are semiconductors or dielectrics. Examples of preferred materials are paper, acrylic resins, cellophane, wood and glass.

Almost any developer powder may be used, but materials that have a relatively low resistivity will lose their charge very rapidly, and therefore development must be accelerated. It is preferred to use materials having resistivity of at least  $10^{10}$  ohm-centimeters. There are numerous examples of materials that have a sufficient resistivity to hold a charge sufficiently long to allow development by the method of the instant invention. Examples are: polyvinyl acetate and polyvinyl chloride resins, sawdust, magnesium silicate, bentonite, shellac, and glass. Besides powders, finely divided liquids may also be sprayed or otherwise employed.

The developer powder may be applied by the methods described above or by any of the other methods, for ex-

ample, applying a powder cloud, applying a powder coated roller, cascading a mixture of granular carrier particles and developer powder or applying a magnetic brush containing the developer powder. The developer powder particles may have or may be given an electrostatic charge or may be uncharged. The method of charging the developer powder particles and applying the charged particles to the image described in Example 1 is preferred because it is responsive to relatively low field strengths and minimizes spurious deposit of developer powder on the image copy.

There has thus been described an improved method of and means for producing a plurality of visible image copies from a single electrostatic image. It comprises simple and economical dry processes which have the advantage that the original electrostatic image remains unimpaired regardless of the number of copies made from it.

What is claimed is:

1. A method of producing a plurality of powder images from a single electrostatic image which comprises repeating the following steps for each of said powder images: charging in one polarity of charge a layer of powder having a bulk resistivity of at least  $10^{10}$  ohm-centimeters, attracting the powder to a surface of a dielectric body, bringing the electrostatic image having the opposite polarity of charge into closely spaced relation to the charged powder on the dielectric body, for each of said powder images interposing a dielectric copy sheet between the electrostatic image and the charged powder; and applying a unidirectional electric field in a direction for attracting said powder toward said electrostatic image between the charged powder and the electrostatic image to attract the powder toward the electrostatic image and to deposit said attracted powder on said copy sheet for producing a powder image said electric field being in addition to the electric field produced by the electrostatic image.

2. A method of producing a plurality of powder images from a single electrostatic image which comprises repeating the following steps for each of said powder images: disposing a layer of electroscopic powder having a bulk resistivity of at least  $10^{10}$  ohm-centimeters closely adjacent to a dielectric surface, applying in one polarity a first electrical potential of at least 400 volts across said layer and said surface to attract electroscopic powder from said layer to said surface, removing said layer of electroscopic powder, disposing an electrostatic image having a polarity of charge opposite to said first electrical potential closely adjacent to said surface, interposing a dielectric copy sheet between said electrostatic image and said surface, and applying a second electrical potential of substantially 200 volts less than and in opposite polarity to said first electrical potential across said electrostatic image and said surface to produce in combination with said electrostatic image an electrostatic field for attracting electroscopic powder from said surface to said dielectric copy sheet.

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