

July 21, 1959

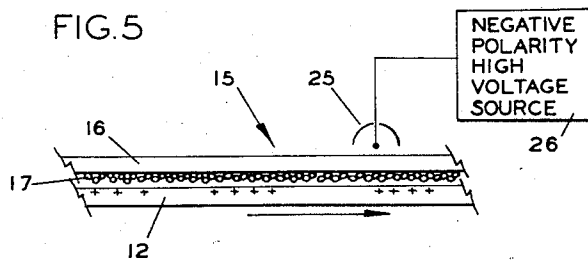
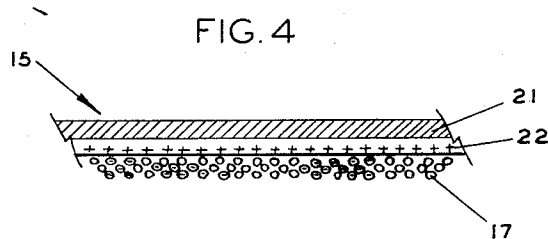
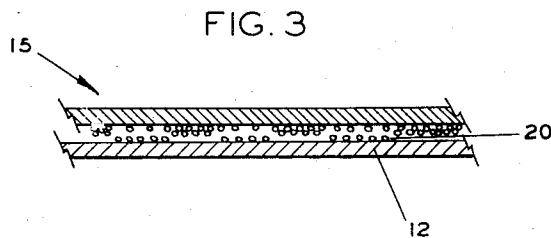
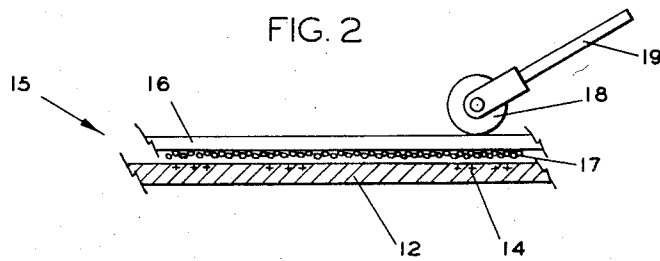
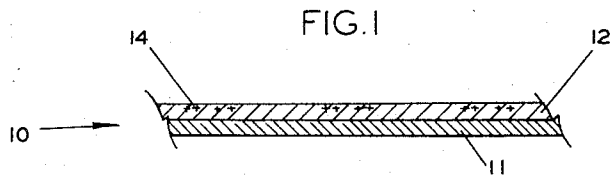
C. R. MAYO

2,895,847

ELECTRIC IMAGE DEVELOPMENT

Filed Dec. 21, 1953

2 Sheets-Sheet 1



INVENTOR.
CLYDE R. MAYO

BY

Frank A. Stankiewicz
ATTORNEY

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C. R. MAYO

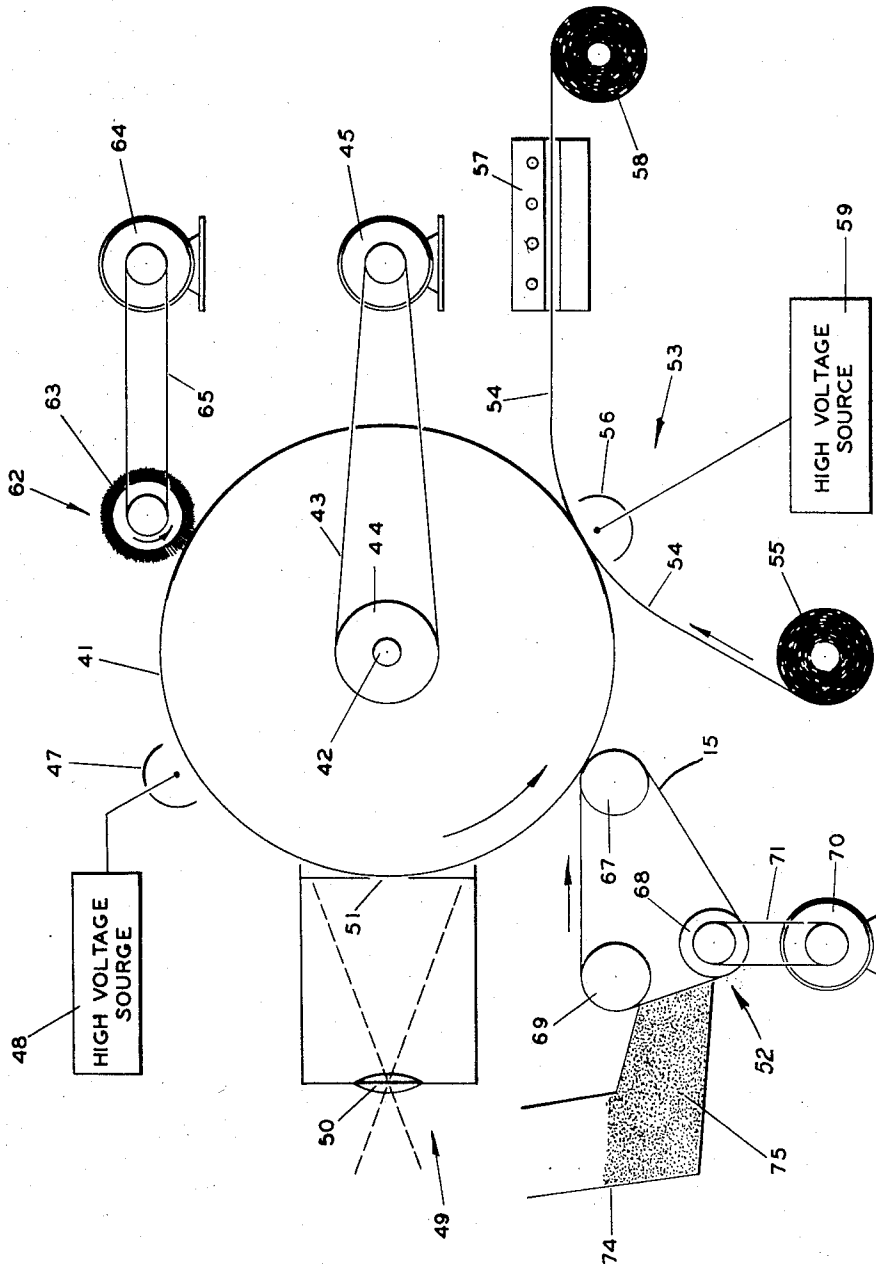
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2 Sheets-Sheet 2

FIG. 6



INVENTOR.
CLYDE R. MAYO

BY *Frank A. Stemmer*

ATTORNEY

1

2,895,847

ELECTRIC IMAGE DEVELOPMENT

Clyde R. Mayo, Rochester, N.Y., assignor, by mesne assignments, to The Battelle Development Corporation, Columbus, Ohio, a corporation of Delaware

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4 Claims. (Cl. 117—17.5)

This invention relates in general to a method and apparatus for development of an electrostatic image, and in particular relates to an improved method and apparatus for the deposition of visible powder material on an electrostatic image in conformity with an image such as, for example, the development of a xerographic image or the like.

In xerography it is usual to form an electrostatic image corresponding to a pattern of light and shadow to be recorded, and to develop this image or make it visible by deposition of electroscopic material thereon. Most simply and directly, a photoconductive insulating layer is electrically charged and exposed to a light pattern whereupon the charge is selectively dissipated to yield an electrostatic charge pattern on its surface, this charge pattern generally being called an electrostatic latent image. In order to utilize this latent image in the production of a visible print, it ultimately is desired to deposit visible material in conformity with the image. One method of accomplishing this result is disclosed in Wise Patent 2,618,552 in which a two-component developer mixture is cascaded or rolled across an image-bearing surface to deposit powder particles in conformity with the image, while other systems such as those disclosed in Carlson U.S. 2,297,691 employ sprayed dust particles or other means or methods for deposition on the electrostatic latent image. These various systems of development have their relative merits and disadvantages. For example, the cascading system is quick and easy and is well adapted to the formation of dense black images of high contrast. However, it gives rise to problems in maintenance of proper relative proportions of the two components during prolonged operation and gives rise to many mechanical problems in feeding the two-component developer to the image-bearing surface.

Now, in accordance with the present invention, there are provided means, methods, and mechanisms for the development of an electrostatic latent image whereby powder particles or the like are carried to an image-bearing surface by a support layer such as a web, sheet or the like and are deposited thereon in conformity with said image to yield a print of excellent quality. The invention is particularly well suited to xerography in that it is inexpensive, convenient, and well adapted to automatic operation.

The general nature of the present invention having been set forth, there will now be presented a more detailed description in illustration but not limitation on the invention in the following specification and drawings in which:

Fig. 1 is a diagrammatic side cross section of an insulating surface supporting an electrostatic latent image;

Fig. 2 is a diagrammatic side cross section of developing

2

mechanism for developing the image illustrated in Fig. 1;

Fig. 3 is a diagrammatic side cross section of an image-bearing member and development member immediately after development has taken place;

Fig. 4 is a diagrammatic side cross section of a development member according to one embodiment of the invention;

Fig. 5 is a diagrammatic view of development mechanism according to another embodiment of the invention; and

Fig. 6 is a diagrammatic view of an automatic xerographic machine according to the present invention.

The present invention is particularly intended and adapted for the development of an electrostatic latent image, such as particularly a latent image of relatively fine detail composed of relatively charged and uncharged areas on an insulating surface. Such an image may, for example, be an electrostatic latent image corresponding to a pictorial subject such as a conventional photograph, snapshot, or the like, or may be an electrostatic latent image corresponding to a document, manuscript, or other representation of information to be reproduced. Images of this sort, and other images requiring an optical resolution in the order of about ten lines per millimeter or better, form the usual subject of development according to conventional xerographic systems.

Illustrated in Fig. 1 is such an image system, presented diagrammatically, comprising a xerographic member generally designated 10 consisting of a conductive backing member 11 and an insulating layer 12 thereover, which insulating layer desirably may be a photoconductive insulator. On or near the surface of the insulating layer 12 is an electrostatic image designated by the plus marks 14 at the surface of this layer. It is to be understood that the electrostatic latent image may be of either positive or negative polarity and may consist of gradations of potential or charge or may be, as illustrated in the figure, areas of charge interspaced by areas of substantially no charge. The particular image illustrated in Fig. 1 may be regarded as a line copy image consisting of respective areas of charge and absence of charge which desirably can be printed as areas of black on a white background.

In Fig. 2 is shown, diagrammatically, developing means and apparatus suitable for developing the image illustrated in Fig. 1. Thus, for example, there is shown an insulating layer 12 having electrostatic image areas 14 on one surface thereof. For this reason, disposed over that insulating layer is a development member being a sheet or web generally designated 15 consisting of a sheet or web of a support material 16 such as a sheet of paper, plastic, cloth, metal such as aluminum foil, metal-backed paper, or the like, on one surface of which is a loosely adhering coating of electroscopic material 17 consisting of finely divided powder particles electrostatically adhering to the surface of the support member 16. These powder particles may be any suitable xerographic toner material, this being generally a finely divided powder material which is visible against a printing surface, such as a surface of paper or the like, and which is electrostatically attractive to an electrostatic latent image. It may, for example, consist of finely divided pigment particles or finely divided compositions of colored or pigmented resins or the like such as are well known to the art of xerography. Positioned and disposed at the reverse side of the development member or web 15 is a contact member such as a roller 18 or the like adapted to bring the development member uniformly against the image-bearing

3

surface. This contact member serves to achieve substantial contact between the development member 15 and the image surface, and it is presently believed that pressure is unnecessary except to the extent needed to assure good contact. Desirably, the contact roller or like may be movable across the surface so as to bring the development web or sheet into contact at all portions of the image-bearing surface and thus, for example, the roller 18 is rotatively mounted on a handle 19 and is adapted to be rolled across the entire surface.

Fig. 3 is a diagrammatic illustration of a mechanism of the development process illustrating the image-bearing surface 12 and the development member 15 after development of the electrostatic image has been accomplished. It is observed at this stage that a portion of the powder particles 17 originally residing on the development member 15 has been transferred to form an image body 20 on the image-bearing surface. In general, the powder particles may be regarded as being oppositely charged with respect to the polarity of charge on the image-bearing surface so that these powder particles are loosely secured to the image-bearing member by means of the electrostatic attraction between these particles which may, for example, be negatively charged and the electrostatic latent image which in this same example would be positively charged.

Fig. 4 illustrates a specific embodiment of a development member according to the present invention wherein the development member, generally designated 15, comprises a support sheet or web 21 having coated or impregnated thereon a coating or layer 22 with a toner composition 17 loosely adhering to the coating 22. According to this figure, the support member 21 may be a sheet or web of paper, cellophane, or other sheet or web-like material including plastics parts, self-supporting resin films and the like, and is adapted to be a structural support for the development member and preferably a structural support which is repeatedly flexible. Impregnated or coated on the surface of the structural support is a suitable resin film to form a toner support body on at least one surface.

The coating 22 on the support member 21 may be any of a number of coating or impregnating compositions carefully selected with reference to the nature of the toner particles in the powder layer 17. With any particular powder composition selected for the powder layer, and for a particular type of electrostatic image to be developed, a specific and particular coating or impregnating composition should be chosen in order to give superior results. Thus, for example, there may be selected a developer composition such as is disclosed in U.S. Patent 2,659,670 and in conjunction therewith there may be used as a coating composition a resin material such as is disclosed in U.S. Patent 2,618,551 as a coating composition for a carrier bead or the like. A coating composition of the type selected will be applied to the support sheet or web by coating, impregnating or like methods. In general, better results are achieved with such coated sheets and good development has been recorded with coated metal foil, paper of both clay-coated and non-coated bases having the carrier coating thereon, cloth such as nylon and the like with the carrier coating, and other sheet-like members as shown in the figure.

Various coating compositions may be used depending on whether positive or negative polarity images are being developed and depending on the toner or powder employed. For example, in U.S. Patent 2,659,670 there is disclosed a toner comprising a pigmented, modified phenol formaldehyde resin, which toner is commercially available under the name XeroX toner. User in conjunction with this material such coating compounds as polyvinyl resins, acrylic and methacrylic resins, cellulosic derivatives, and protein materials will, in general, form a coating to impart negative charge to the toner upon triboelectric contact. On the other hand, asphaltum powder

4

in combination with coatings such as polystyrene will tend to provide positively charged powder particles.

The layer of powder material 17 on the development member 15 is characterized by being loosely adhering and by being secured to the support sheet or web substantially exclusively by electrostatic attraction. In general, this layer of powder is applied to the support member prior to its use as in development by application of the powder to the support member with mild frictional action. For example, a suitable support sheet of uncoated or coated paper, plastic or the like is treated with a powder composition by brushing the powder onto the surface of the support member with a camel's-hair brush or the like. Thus, the powder layer is readily applied to the paper or like surface. Alternatively, a layer of powder may be shaken across or onto the surface of the support member or may be applied from a rotating brush bearing a quantity of the toner composition, or by passing the support member into or through a body of such toner composition. In the case of a porous support such as a sheet of paper, a highly desirable method for applying the powder to the surface is by blowing through the pores of the member a stream of air carrying a suspension of the toner composition. Other methods of depositing the powder layer on a support member will be obvious to those skilled in the art. For example, a powder layer formed on a sheet or web in any desired way may be charged by corona discharge or other ion deposition. Likewise, a two-component xerographic developer as described in U.S. 2,638,416 may be cascaded across a sheet or web, preferably with excess powder or toner, to form a dense deposit of charged powder thereon.

It is to be understood that either positively charged or negatively charged powder may be coated on the development member. Desirably, the surface of the member then should be of opposite triboelectric relationship to the powder. Thus, for positively charged powder, the development member surface should be negative with respect to the powder, and where the layer is coated by cascading, as just described, the granular carrier of the two-component system likewise should be negative with respect to the powder.

In Fig. 5 is illustrated another apparatus and mechanism for development according to the present invention. According to this embodiment, an electrostatic latent image support 12 is developed by means of a development member 15 comprising a support sheet or web 16 and a powder layer 17 with a corona discharge electrode 25 connected to a negative polarity high voltage source 26 and adapted to be passed across the reverse surface of the development member 15. The development sheet is placed with the powder side against the image-bearing surface 12 and corona electrode 25 is passed across the surface, causing corona discharge from the electrode to charge the development member 15 and secure it firmly against the image-bearing member 12. When the development member is stripped from the image surface, it is found that a substantial portion of the powder has been transferred to the image surface in the image areas thereof.

In Fig. 6 is illustrated a continuous machine adapted to form a xerographic print on a sheet or web member following upon exposure to a suitable light source or other source of a pattern of light and shadow to be recorded. A cylindrical support 41 is mounted on an axle 42 with drive means comprising a belt 43 operating on pulley 44 from a drive motor or the like 45. The surface of cylinder 41 is coated with an insulating image-bearing surface comparable to surface 12 of Fig. 1 or one or more of such image-bearing surfaces are mounted on a cylinder support. In the embodiment specifically illustrated in the figure, it is to be understood that the apparatus is designed to reproduce from a pattern of light and shadow in which case the image-bearing surface corresponding to surface 12 of Fig. 1 is a photo-conductive insulating surface adapted to receive and retain an elec-

trostatic charge and to dissipate this charge upon exposure to light.

Positioned adjacent to the path of motion of the surface of the cylinder 41 is a charging station 47 comprising, for example, a positive polarity corona discharge electrode consisting of fine wires suitably connected to a high voltage source 48 of potential high enough to cause a corona discharge surrounding the wires. Subsequent to the charging station 47 in the direction of rotation of the cylinder is an exposure station 49 generally comprising suitable means for imposing a pattern of light and shadow on the surface of the cylinder and including, for example, a projection lens 50 or other exposure mechanism as is conventional in the art, preferably operating with slit projection methods to focus a moving image at an exposure slit 51.

Next subsequent to the exposure station is a developing station generally designated 52 as will be further described hereinafter. Beyond the development station 52 is a suitable transfer station 53 adapted to transfer a xerographic image from the surface of the cylinder to a transfer web 54 which passes from a feed roll 55 into contact with the cylinder surface at a point beneath a transfer electrode 56 and desirably subsequently through a fusing or fixing device 57 to a take-up roll 58. Desirably, electrode 56 is a corona discharge electrode operably connected to a high voltage source 59 of like polarity with respect to high voltage source 48 whereby an image body deposited on the cylinder surface is transferred to the transfer web. Fusing device 57 permanently fixes a transferred image on the web to yield a completed xerographic print.

Optionally, a cleaning station 62 may be disposed adjacent to the surface of cylinder 41 along with other auxiliary devices or stations or the like, whereby residual powder image, electrostatic charge or other material or phenomenon may be cleaned or erased from the cylinder surface. Thus, for example, a rotating brush 63 driven by motor 64 through belt 65 may be brought to bear against the surface of the cylinder to erase residual powder image therefrom, or further charging means, floodlight means or the like may affect electrical or photon controlled operations.

At the development station, as illustrated in Fig. 6, is a development belt 15 passing around roller 67 which is disposed and positioned to bring the belt 15 to firm contact with the surface of cylinder 41. The belt 67 also passes around a drive roller 68 and a guide roller 69. Desirably, drive roller 68 is driven by a motor or other drive means 70 operating through belt 71, preferably to drive the belt in the same direction as the surface rotation of cylinder but at a speed substantially in excess of the speed of rotation of such cylinder. Thus, there is maintained between belt 15 and cylinder 41 a sliding contact which serves the dual purpose of insuring extremely quick contact between all points of the surface of cylinder 41 and the development belt, and further bringing to each point of the cylinder surface a substantially greater quantity of the powder layer than is carried by any one point of the developer belt.

Adjacent to one portion of the path of motion of the developer belt 15 is a powder-loading station which may, for example, comprise a developer hopper 74 containing a supply of developing powder, preferably as mixed powder and carrier developer. This hopper opens against the development web or belt 15, whereby the belt passes in contact with the developer supply and is coated with powder as the belt passes upwardly against the developer. Other belt loading mechanisms may, of course, be substituted for the one shown herein.

In operation of the invention in general, a xerographic electrostatic latent image or like electrostatic latent image is formed on an image-bearing surface 12 and the development member 15 is placed against this surface. Firm contact between the development member 15 and

image surface 12 is obtained, for example, by means of roller 18 of Fig. 2 or roller 67 of Fig. 6, or other like device or mechanism. After the entire surface of the development member has been brought into contact with the electrostatic latent image-bearing surface, the development member is removed from the surface leaving an image body deposited thereon. This image body is utilized as may be desired, and in Fig. 6 is illustrated the utilization of this image body by transfer to a transfer web followed by fusing or permanent fixing of the image body in its configuration thereon.

The operation of the invention according to the device of Fig. 6 is generally in accord with the operation as applied to all figures. Thus, for example, a xerographic photosensitive member on the surface of cylinder 41 is carried past the charging station wherein an electrostatic charge is applied to the photosensitive member. According to present commercial xerographic operations, this surface charge is of positive polarity. The cylinder then rotates to bring the charged surface to an exposure station where a pattern of light and shadow to be recorded is imposed on the surface of the charged xerographic member, and the charge is thereby selectively dissipated to leave an electrostatic latent image. The image-bearing surface then passes to the development station where it is firmly contacted by development member 15. As the process continues, development member 15 constantly passes through the loading zone wherein additional toner or powder is applied to the surface of the support member, and this reloaded surface is continuously again brought into contact with the surface of cylinder 41. The relative speed of motion of belt 15 and cylinder 41 may be varied according to the individual needs and purposes. Thus, for example, the two surfaces may be in synchronized motion whereby substantially no slippage occurs. However, it has been found, surprisingly enough, that sliding motion has certain advantages, chief among which are the increased degree of point contact achieved between various points of the surfaces of the two members and the additional fact that a greater quantity of toner or powder can thus be carried to the image surface. Contrary to expectations, sliding contact seems not to cause smearing of the deposited image body. It is presently believed desirable to adjust the relative motion of the members so as to bring a greater area of belt 15 into contact with a lesser area of cylinder 41. Thus, it is generally desirable to operate belt 15 and cylinder 41 at different speeds with the motion generally being in the same direction and with belt 15 traveling at a speed substantially greater than the speed of travel of cylinder 41. Desirably, the belt may travel at a speed slightly in excess of the rate of travel over the cylinder, up to a speed of as much as 5 to 10 times as fast as the travel of the cylinder.

At the transfer station, the image body deposited on the image surface at the development station is transferred to a print support member such as a continuous roll of paper or the like to yield a xerographic print which desirably is made permanent by heat or vapor fusing or the like. As illustrated in Schaffert Patent 2,576,047, this transfer may be achieved by a corona discharge electrode of the same polarity as the charging electrode 47. Other methods of transfer to a sticky surface or the like are known to the art and are within the scope of the invention as are other means or methods either obviating transfer or employing transfer mechanisms of different types.

Leaving the transfer station member are two members, the transfer web 54 bearing the powder image body corresponding to the pattern of light and shadow being recorded and the xerographic photosensitive surface which may bear a residual powder image and/or residual electric charge resulting from the previous steps of the operation. The photosensitive surface is prepared again for renewal of the cycle of operations by such cleaning or regenera-

7

tion steps or techniques as may be desired. A mechanical cleaning operation to remove the residual powder images is specifically disclosed in the figure but it is to be understood that other mechanical or electrical preparation steps may be employed.

Many modifications may be made without departing from the scope of the invention. Thus, development may be carried out on a sheet or web, preferably a very good insulator, overlying an image-bearing surface as by passing web 54 of Fig. 6 between cylinder 41 and belt 15 or by similar modifications of the other figures. In view of these and other modifications, the following examples are in illustration, not limitation of the invention.

Example 1

A xerographic toner prepared in accordance with U.S. Patent 2,659,670 and available under the name XeroX toner was employed as a developer material for a xerographic image consisting of an electrostatic charge pattern corresponding to typed information. This toner was placed on the surface of a bond paper by cascading over the paper a mixture of this toner with a carrier composition as disclosed in Walkup U.S. 2,618,551. Several passes of developer mixture over the paper were made until the paper was thoroughly covered with toner and a substantially uniform coating of the toner was loosely adhering to the surface of the paper. The powder-coated paper was placed on the image-bearing surface with the powder coating face down, and the sheet was pressed into contact with the image surface by means of a rubber roller which was passed lightly over the back surface. The sheet was then removed from the image surface and a deposit of powder in the configuration of the electrostatic image was observed on the image surface. This powder or image body was then transferred to a second sheet of paper by conventional methods to yield a xerographic print.

Example 2

The procedure of Example 1 was repeated with the use of a coated or impregnated sheet prepared as follows. A 3% solution of zein in 90% ethyl alcohol and 10% water was spread onto a base sheet of bond paper. The solvent was evaporated at about 150 degrees F. in air until the sheet appeared fully dry.

The toner powder of Example 1 was applied to the surface of the thus prepared sheet by the same method, and the coated paper sheet was then employed as a developer member as in the previous example. In this case, it was observed that a slightly heavier powder deposit could be obtained on the surface of the sheet and a substantially denser image body was developed on the image-bearing surface. The developer sheet member likewise was characterized by areas from which the powder deposit was substantially completely removed. These areas were corresponding to the deposition areas on the image-bearing surface. The developer sheet member, therefore, is a photographically negative copy of the completed xerographic print, which was formed on the image-bearing surface.

Example 3

The procedure of Example 1 was repeated with a sheet of cellophane which was dusted with powder from a camel's-hair brush to form the developer member. Upon completion of the developing procedure there was formed a developed image body on the image surface and a negative transparency comprising the cellophane sheet and the residual or untransferred powder thereon.

Example 4

The procedure of Example 1 was repeated employing a sheet of bond paper dusted with toner powder. This sheet was placed face down on a plate bearing a xerographic electrostatic latent image, and was held in firm contact therewith by means of a weighted roller. The

8

developer sheet was removed from the image surface by a sliding action in which the sheet was slid along the surface in one direction while the roller moved down the surface in an opposite direction, thus causing sliding contact between the developer sheet and the image surface. The toner particles were removed from the developer sheet in lines corresponding to image areas on the plate and a clear image of typed information was represented on the image-bearing surface by developer or toner material removed from the developer member. The image body was transferred to a second sheet of paper to yield a xerographic print of substantially increased density with respect to the print of Example 1. Resolution in the deposited image was about 15 lines per millimeter, and did not show substantial directional difference.

What is claimed is:

1. The method of developing an electrostatic image on an electrostatic image-bearing member comprising forming a substantially uniform layer of finely-divided electrostatically charged powder marking particles on a smooth support surface extending across the image-bearing portion of said image-bearing member, said particles loosely adhering to said surface by electrostatic attraction, contacting said image-bearing member with said layer of marking particles, sliding said surface bearing said layer of marking particles relative to said image-bearing member and removing said surface from said image-bearing member whereby said marking particles are selectively transferred from said layer to said image-bearing member in the pattern of the electrostatic image.

2. The method of developing an electrostatic image on an electrostatic image-bearing member comprising forming a substantially uniform layer of finely-divided electrostatically charged powder marking particles on a resin layer permanently bonded to a support surface extending across the image-bearing portion of said image-bearing member, said marking particles and said resin layer having a triboelectric relationship of opposite polarity whereby said particles loosely adhere to said resin layer by electrostatic attraction, contacting said image-bearing member with said layer of marking particles, sliding said surface bearing said layer of marking particles relative to said image-bearing member and removing said surface from said image-bearing member whereby said marking particles are selectively transferred from said layer to said image-bearing member in the pattern of the electrostatic image.

3. In the method of developing an electrostatic image on an electrostatic image-bearing member in which a substantially uniform layer of finely-divided electrostatically charged powder marking particles loosely adhering to a support surface by electrostatic attraction is brought into contact with the image-bearing surface of an image-bearing member and removing said support surface from said image-bearing surface whereby said marking particles are selectively transferred from said layer to said image-bearing member in the pattern of the electrostatic image, the improvement consisting of sliding said support surface bearing said layer of marking particles relative to said image-bearing member while said layer of marking particles contacts said image-bearing surface.

4. A method of developing an electrostatic image comprising forming an electrostatically charged substantially uniform layer of finely-divided powder marking particles on a support sheet, said marking particles adhering to said sheet by electrostatic attraction, positioning an insulating film member in contact with the electrostatic image-bearing member, contacting said insulating film member with said layer of marking particles while said film member contacts said image-bearing member, sliding said surface bearing said layer of marking particles relative to said insulating film member and removing said surface from contact with said insulating film member whereby said marking particles are selectively transferred from said layer to said insulating film member in the

pattern of the electrostatic image on said image-bearing member.

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5

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