

Aug. 31, 1965

W. D. HOPE ET AL

3,203,394

XEROGRAPHIC DEVELOPMENT APPARATUS

Filed Oct. 1, 1962

2 Sheets-Sheet 1

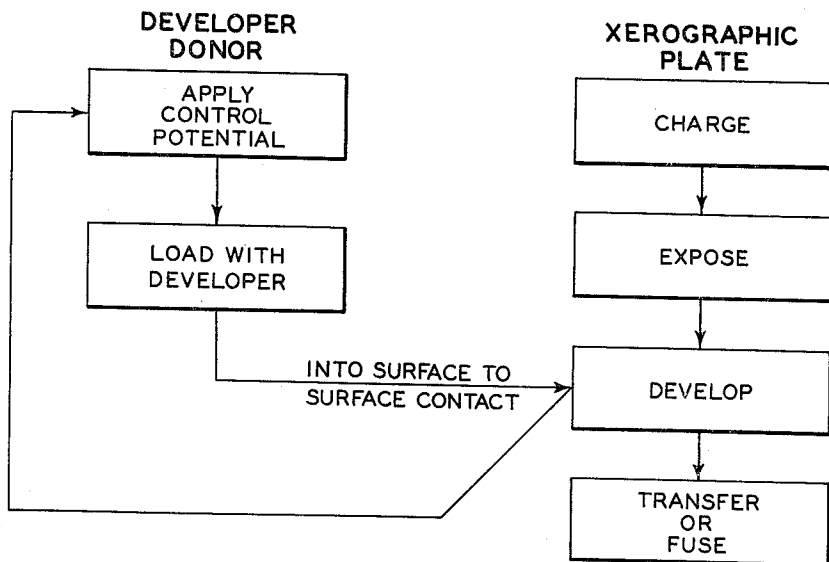


FIG. 1

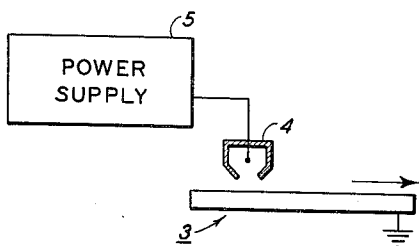


FIG. 2a

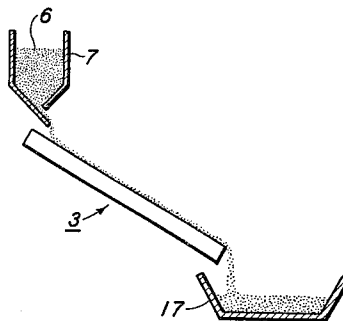


FIG. 2b

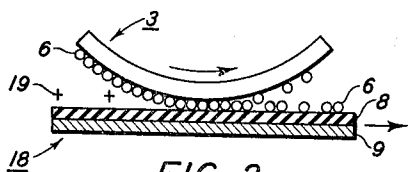


FIG. 2c

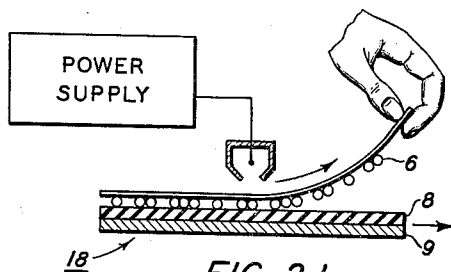


FIG. 2d

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Aug. 31, 1965

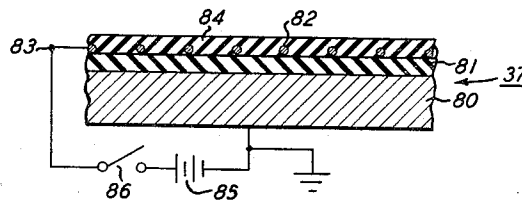
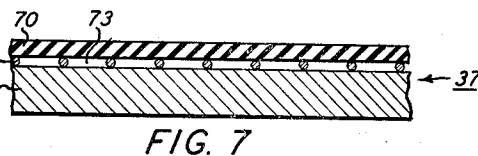
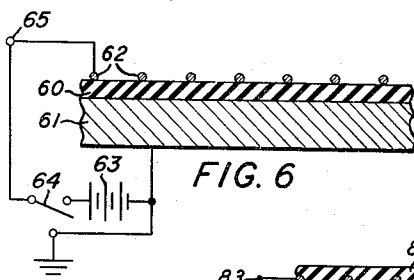
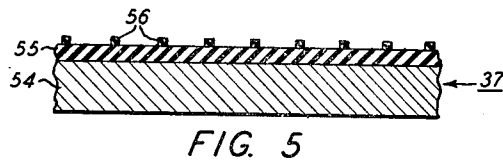
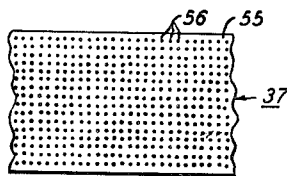
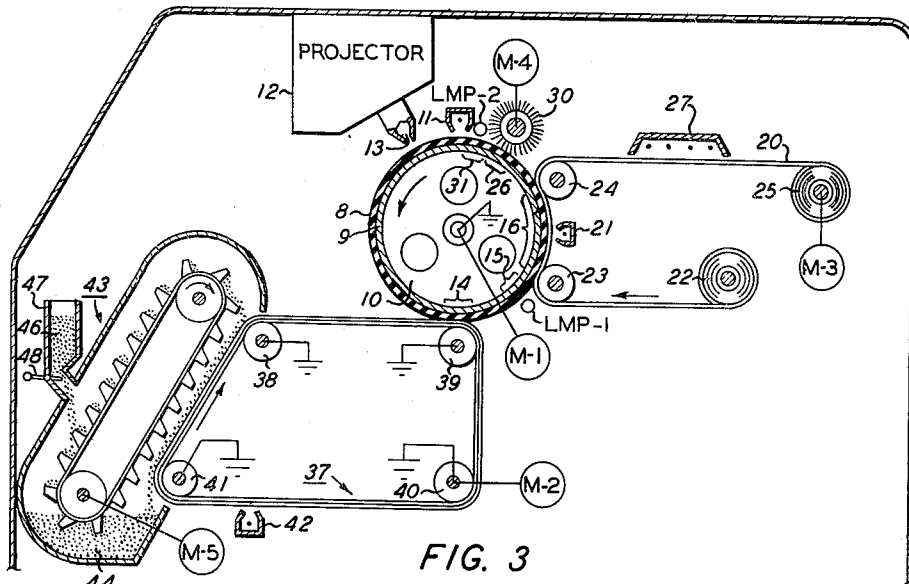
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XEROGRAPHIC DEVELOPMENT APPARATUS

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2 Sheets-Sheet 2



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**XEROGRAPHIC DEVELOPMENT APPARATUS**  
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New York

Filed Oct. 1, 1962, Ser. No. 227,352  
12 Claims. (Cl. 118-637)

This invention relates to xerography and particularly, to improved apparatus for the development of electrostatic images. This application is a continuation-in-part of copending application, Serial No. 822,306, filed June 29, 1959.

In the process of xerography, for example, as disclosed in Carlson Patent 2,297,691, issued October 6, 1942, a xerographic plate including a layer of photoconductive insulating material has a uniform field applied therethrough as by charging and is then exposed to an activating radiation image of the subject matter to be reproduced, usually by conventional projection techniques. Exposure discharges the plate areas in accordance with the radiation intensity that reaches them, and thereby creates an electrostatic latent image on or in the photoconductive layer. Development of the latent image is effected with an electrostatically charged, finely divided material such as an electroscopic powder that is brought into surface contact with the photoconductive layer and is held thereon electrostatically in a pattern corresponding to the electrostatic latent image. Thereafter, the developed image is usually transferred to a support surface to which it may be affixed by any suitable means.

Another process for the formation of electrostatic images is termed "xeroprinting" in which a permanent image of electrically insulating light insensitive material on a conductive support may be repeatedly reused by recharging and developing the image areas as disclosed, for example, in Carlson Patent U.S. 2,357,809, Schaffert Patent U.S. 2,576,047 and in the parent of the instant application cited above.

Whatever method is employed for forming the electrostatic images, they are usually made visible by developing. Various developing systems are well known. These include cascade, brush development, magnetic brush, powder cloud and liquid development to name a few. Another method, as disclosed in Mayo Patent U.S. 2,895,847, employs a support layer such as a web, sheet or other member termed "a donor" which releasably carries the electroscopic developer particles to an image-bearing surface to be deposited thereon in conformity with the electrostatic image to be developed.

The method of Mayo has been found suitable for development of electrostatic images particularly where the image is representative of a line copy reproduction as opposed to continuous or half-tone reproduction. To obtain consistent high quality development with the apparatus of Mayo, it is necessary that the developer be supported on the donor with a uniformity of density and distribution. This assures reproducible results with each successive development. However, loading of the developer marking particles on the donor member to obtain uniform development has not been entirely satisfactory. The powder particles on the donor must be releasable to the electrostatic image and yet be presented in uniform distribution in order to effect uniformity of development in the final copy. This bonding relationship has been difficult to control particularly with automatic machines in which it is desired to load the donor and move it with the developer loosely held in various directions toward an image-bearing plate.

It has been found that techniques of the prior art in which powder particles are applied against a donor web

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by squeezegeeing, brushing, triboelectrification, or the like results in a donor which is not entirely satisfactory. In addition while the donor-type development has been found suitable for line copy images, it has generally been regarded as limited if attempts are made to apply it to other forms of images.

Now in accordance with the instant invention, there is achieved high quality donor type development by employing donor members susceptible to simplified and uniform loading and which provide superior and controlled bonding properties to present powder developer to an image to be developed. Not only are the donor members more easily loaded, but uniformity and loading bond is maintained through presentation to an image-bearing surface. At the same time, it has been found that marking particles presented on these donor members respond with greater fidelity to gradations of field strength of the electrostatic image to provide pleasing renditions. In addition, as will be understood, these donor members are adapted to geometric control to provide geometric control over plate development.

Accordingly, it is the object of the invention to provide method and apparatus to effect improved development of electrostatic images to be developed.

It is a further object of the invention to provide improved method and apparatus for donor type development of electrostatic images in the processes of xerography and xeroprinting.

It is a further object of the invention to provide improved donor members for donor type development that are simply and automatically loadable by controlled electrostatic forces.

It is a still further object of the invention to provide improved donor members that accord increased marking particle sensitivity to charge gradients of an image to be developed.

These and other objects will appear clearly in the following specification when read in connection with the following drawings, the novel features being pointed out in the claims at the end of the specification.

In the drawings:

FIG. 1 is a flow diagram in accordance with the invention;

FIGS. 2a through d illustrate the sequential process steps in accordance with the invention;

FIG. 3 is a sectional view through an automatic xerographic apparatus embodying donor-type development;

FIG. 4 is a plan view of a donor member in accordance with one embodiment of the invention;

FIG. 5 is a sectional view through the embodiment of FIG. 4;

FIG. 6 is a sectional view through a second embodiment of donor member in accordance with the invention;

FIG. 7 is a sectional view through a third embodiment of donor member in accordance with the invention; and,

FIG. 8 is a sectional view through a fourth embodiment of donor member in accordance with the invention.

As may be understood by reference to FIG. 1, an image-bearing member is processed in accordance with the conventional steps of xerography or xeroprinting as described above. Where the member is a xerographic plate, the steps include charging and then exposure to a radiation image to form an electrostatic latent image which is then developed and transferred. This is shown in the right-hand portion of FIG. 1. The development step, in accordance with the invention, is effected by means of a donor member characterized in its ability to accept potential in geometrically controlled areas. This potential acts as a control to achieve the loading distribution and degree of bonding of the developer material placed

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or presented to the donor surface. This is illustrated in the left-hand portion of FIG. 1. After loading, the donor member is advanced into face-to-face contact with the electrostatic image to effect image development by releasing the developing particles to the electrostatic fields of the image. Where the donor member is, for example, endless, developer contact with the image-bearing surface of the xerographic plate can be rendered continuous for automatic operation as suggested in FIG. 1 and as will be described in connection with FIG. 3.

Refer now to FIGS. 2a through 2d wherein the individual process steps of the invention are illustrated. In FIG. 2a a donor member 3, constructed in accordance with one of the different embodiments to be described below, may receive an application of a potential as by passing it below a corona generating device 4, being energized from a power supply 5. As will be understood, the potential is selectively retained on the surface of the donor member at least through the loading step in a geometrically controlled pattern and of magnitude adequate to retain the developer distribution on the donor surface through the developing step.

In FIG. 2b, the previously charged donor member is shown being loaded with developing material 6 from a hopper 7, which permits triboelectrically charged developing material to cascade across the surface of the donor to be attracted and held thereon in accordance with the fields created by the control potential. Excess developer falls into a receiving bin 17. Similarly, other means of loading can be employed by which the developing material is presented to the donor including powder cloud, brush, liquid immersion, etc., as are conventionally employed and known in the xerographic art for directly presenting developer to the electrostatic image.

After being loaded, the donor member is presented with the developer-laden surface into contact against an image-bearing member such as a xerographic plate 18 comprising a photoconductive layer 8 on a conductive backing 9 and containing an electrostatic image to be developed. The latent image is represented diagrammatically by the plus signs 19 on the photoconductive surface 8. Contact can be effected by contiguous overlaying of the respective surfaces after which the elements are separated. Alternatively, substantially tangential roller contact of the donor against the photoconductor can similarly be employed in the manner illustrated.

After development, the developed image is utilized in the conventional manner which may include transfer to a secondary support surface, such as paper 28, as by applying an electrostatic charge to the backside of the paper when in contact with the developed image and then separating the elements, as is well known in the art.

For a general understanding of an automatic xerographic processing system by which the invention is being illustrated, reference is made to FIG. 3 in which the various system components of an automatic xerographic apparatus are schematically illustrated. As in most xerographic systems based on the concept disclosed in the above-cited Carlson patent, a light radiation image of subject copy to be reproduced is projected onto the sensitized surface of a xerographic plate to form an electrostatic latent image. Thereafter, the latent image is developed similarly as before with oppositely charged developing material to form a xerographic powder image, corresponding to the latent image, on the plate surface. The powder image is then electrostatically transferred to a support surface to which it may be fused by a fusing device causing the image to permanently adhere to the support surface.

As illustrated, the xerographic plate comprises a xerographic drum 10 mounted in suitable bearings in the frame of the machine and driven in a counterclockwise direction by a motor M-1. The drum surface comprises a layer of photoconductive material 8 on a conductive backing 9 that is sensitized prior to exposure by means

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of a corona generating device 11 energized from a suitable high potential source.

As the drum rotates past projector 12, a light image of an original subject is projected through a slit aperture 13 onto the surface of the charged xerographic plate 10. The exposure of the drum to the light image discharges the photoconductive layer in the areas struck by light, and there remains on the drum a latent electrostatic image in image configuration corresponding to the light image projected from the original subject. As the drum surface continues its movement, the electrostatic latent image passes through the developing station 14 at which the developing apparatus of the invention presents electroscopic developer particles to the image for development thereof.

The developing apparatus comprises an endless, flexible web donor member 37 that will be described in more detail below. The web is continuously driven by means of a motor M-2 to pass over a guide rolls 38, 39, 40 and 41, each of which are suitably grounded through the apparatus. Prior to presenting the marking particles to the drum surface, the web member 37 is first charged uniformly on its top surface by a corona generating device 42 energized from a suitable source of high potential. After being charged, the web member passes over guide roll 41 and then is directed upwardly into a developer loading mechanism 43 in which two-component developing material 44 comprised of toner and carrier, which may be of the type disclosed in the Walkup Patent 2,618,551, is cascaded over the web surface to load the toner particles thereon as will be described.

In the loading mechanism, developing material is carried upwardly by a conveyor 45 driven by suitable drive means from a motor M-5 and is released at or near the top to cascade down over the web surface. As the developing material cascades downwardly, electrostatic forces on the web cause toner component to separate from its carrier and electrostatically adhere to the donor surface. Because the toner component of the developer is consumed in developing, it must be replaced to maintain a consistency of mixture for presentation to the web. Additional toner 46 is stored in a dispenser 47 and is released into developing material 44 in controlled quantities by gate 48 to replenish the material and assure uniform loading of the donor web member 37. As the web continues its movement, the developer particles supported on its surface are presented to the image-bearing surface of drum 10 to effect a powder image development.

After development, the xerographic powder image passes a discharge station 15 at which the drum surface is illuminated by a lamp LMP-1, whereby residual charges in the non-image areas of the drum surface are discharged. Thereafter, the powder image passes through an image transfer station 16 at which the powder image is electrostatically transferred as aforesaid to a support surface web 20 by means of a corona generating device 21.

The support surface to which the powder image is transferred may be paper or the like obtained from a supply roll 22 and is fed over suitable guide rolls 23 being directed into surface contact with the drum in the immediate vicinity of transfer corona generating device 21. After transfer, the support surface is separated from the drum surface and guided over a guide roll 24 and through a suitable fusing apparatus 27 which may, for example, be a heat fuser as described in Crumrine U.S. Patent 2,852,651 that is effective to permanently affix the powder image to the support web. Thereafter, the support surface is fed over a further system of guide and tensioning rolls then onto a takeup roll 25 that is driven by a motor M-3 or optionally may be passed directly out to a cutter or the like in which the web is cut into severed lengths.

After transfer, the xerographic drum surface passes

through a cleaning station 26 at which a surface is brushed by a brush 30 rotated by a motor M-4 whereby residual developing material remaining on the drum is removed. Thereafter, the drum surface passes through a second discharge station 31 at which it is illuminated by a fluorescent lamp LMP-2, whereby the drum surface in this region is completely flooded with light to remove any electrostatic charge that may remain thereon. Suitable light traps are provided in the system to prevent any light rays from reaching the drum surface, other than the projected image, during the period of drum travel immediately prior to sensitization by corona generating device 11 until after the drum surface is completely passed through the developing station.

Reference is now more particularly directed to FIGS. 4 and 5 in which different views of a first structural embodiment of donor members 3 and 37 are illustrated. This particular embodiment is termed a "time decay" donor element. It comprises a layer of electrically conductive material 54 having coated thereon a layer 55 of poorly insulating, light insensitive material to be described in detail hereafter. On top of layer 55 is formed a pattern of posts 56 of electrically insulating light insensitive material.

Layer 55 is so selected as to have a resistivity sufficiently high to accept electrostatic charge thereby permitting electrostatic charging of the entire donor surface including the posts and the area or interstice layer portions therebetween to a uniform potential. However, the resistivity is sufficiently low so that by the time the donor member has moved from the charging position above the corona generating device 42 into the developer loading mechanism 43, substantially all of the electrostatic charge on the layer portions has been lost, i.e., discharged to the conductive backing 54. This then leaves the posts 56 uniformly charged to a desired potential. Suitable resistivities for layer 55 lie in the range of about  $5 \times 10^{11}$  to  $10^{13}$  ohm-cms. Such materials will lose over two-thirds of the applied voltage in a period ranging from about two seconds for the upper limit of resistivity to less than one-tenth of a second for material having the lower limit of resistivity. In very high speed processes, a resistivity of about  $10^{10}$  ohm-cms. decayings in about two-milli-seconds may be used. The time rate of decay of voltage is also dependent on the dielectric constant of the material and may be either higher or lower than the figures given dependent on this factor. The material for posts 56 is highly insulating. Thus layer 55 has a resistivity selected so as to discharge before the cascade of developing material over the donor member while posts 56 have a resistivity selected as to retain an electrostatic charge at least until passing through loading mechanism 43. As the rate of donor movement may vary, similarly the relative resistivities of layer 55 and posts 56 may vary as described.

Therefore, the donor member is passed upwardly through loading mechanism 43 while retaining surface charge of a selected polarity only on the post members 56. The two-component developing material is selected with components properly related in the triboelectric series such that in this instance, the toner component becomes triboelectrically charged to the same polarity as the charge retained on the posts 56. By this means, as the developing material cascades across the surface of the donor member, the toner component is repelled by the electrostatic forces on the posts into the recessed interstices to be retained for subsequent presentation to the image to be developed. Donor members of this type have proved highly suitable both from a loading point of view as well as the development effect when presented to the image to be developed. The electroscopic developer particles, when held in this manner, are maintained in position through presentation and yet are accorded a degree of mobility permitting them to migrate sensitively to gradients of image charge to develop pleas-

ing halftone patterns of continuous tone images. The sensitivity has been found to vary to some degree dependent upon the relative areas occupied by the post members and the interstice areas, with greatest sensitivity occurring with the posts constituting in a range of about five to about ten percent of the total area. It should be noted also in connection with this embodiment that the marking particles will be physically separated from the image-bearing surface to which they are presented as a function of the post height.

In operation, a uniform charge is first applied to the surface of a donor member, as by corona discharge, which brings the entire surface to a uniform electrostatic potential. The charge on the high resistivity portion of the surface, that is, the posts 56, is static while the charge in a moderately high resistivity portion of the surface, that is, layer 55, leaks to the substrate 54. The resulting electrostatic charge is then selectively contained on posts 56 and on passing through developer loading mechanism 43, electroscopic developer particles of like charge are repelled into the interstice areas of the donor member.

One type of donor member made in this manner was formed by coating an aluminum plate with a film of alkyd resin (obtained from E. I. du Pont de Nemours & Company under the tradename "Duco Black Gloss Enamel"). After drying the enamel layer, it was then coated with a layer of Kodak Photoresist. The plate was then exposed to a screen image using ultra-violet light to form a line copy screen image thereon. The unexposed photoresist was then removed by washing with the developer recommended by the manufacturer. The plate was thoroughly dried and then used as a donor member.

Another donor member of the same type was prepared by coating a contact printing paper (obtained from Xerox Corporation, Rochester, New York under the tradename "Haloid F-2 Contact Print Paper") with Kodak Photoresist and drying the coated paper. The paper was then exposed to an ultra-violet light image of a screen pattern which not only hardened the photoresist but also formed a corresponding, visible, sepia print in the print out paper. The donor member was then processed to remove the unexposed photo-resist with the developer recommended by the manufacturer. The member was thoroughly dried, mounted on a sheet of aluminum with adhesive and utilized as described above.

Still another donor member of the same type was constructed of an aluminum base on which was applied a coating of a thinned epoxy plastic (obtained from Emerson and Cummings of Canton, Massachusetts, under the tradename of "Eccocoat VE" thinned with a recommended thinner termed "Cellosolve"). This plastic has a volume resistivity of about  $10^{12}$  ohm-cms. and a dielectric constant of about 3, giving a time constant of several tenths of a second. Two different methods were employed to form the insulating screen pattern. The first method entailed applying a layer of Kodak Photoresist and then processing to form a screen insulating pattern in the same manner as described above. The second method involved applying a coating of Eccocoat VE on the aluminum substrate as above. Before the coating polymerized, a sheet of one mil brass shim stock was carefully placed in contact with the leaky dielectric coating. After the coating polymerized, a screen pattern of small dots was photo-chemically etched through the one mil brass sheet. Polystyrene was then used to fill the holes etched in the brass. A solution of ferric chloride was then applied to the brass sheet to remove the brass and leave a screen pattern of small polystyrene posts supported on the leaky dielectric coating.

Each of the donor members thus prepared was loaded as described in connection with FIGS. 2 and 3 and presented to a xerographic plate for development of an electrostatic latent image previously formed thereon. Uniform loading resulted in good quality development

while providing surprisingly pleasant half-tone rendition of continuous tone images. In addition to Kodak Photoresist, xerographic toners as from polystyrene or resin modified phenol-formaldehyde without conductive pigments such as carbon black have been successfully used for forming post sections 56; while material successfully used for layer 55 includes additional items such as Warren's Lustro Gloss and Chrome Coat paper, epoxy resin (obtained from the Bakelite Co. under the tradename "ERL2774" with hardener "ZZL0803"), rubber adhesives (obtained from the B. F. Goodrich Company under the tradenames "604" and "A598B"), and bleached shellac. The thickness of layer 55 is not critical. In examples given, the thickness ranges from about 0.001 to about 0.005 inch.

Reference is now made to FIG. 6 in which a second donor embodiment is illustrated. In this embodiment, the donor is formed by an insulating coating 60 applied over a conductive substrate 61 and then placing a continuous metallic screen 62 over the insulating layer. Two methods were used to form the continuous metallic screen. The first method involved coating the insulating layer with copper by means of a chemical dipping process. The copper coating was then selectively etched away to give a continuous metallic screen pattern on the plastic coating. The second method included placing a metallic screen on the plastic coating by flash evaporating a layer of chromium and then copper. The metal was then selectively removed with photo-chemical techniques.

It was found that high fringe fields could be created on the surface of this type donor member by either connecting the continuous metallic screen to a potential source of about 600 volts or corona charging the member while the metallic screen was held at the same polarity potential and then grounding the metal screen after the charging was completed. The former can be effected as shown in FIG. 6 by applying a D.C. potential as from a battery 63 through a switch 64 to a terminal 65 connected to the screen. The latter is accomplished similarly in combination with corona generator 42 and throwing switch 64 to the ground connection after charging is completed. The donor member was then loaded by cascading a two-component developer over the surface. In the first instance in which the metallic screen alone was energized, the loading material employed assumed triboelectric charges whereby the toner was charged to the same polarity as that being applied to the screen in order that the toner be repelled into the interstices of the screen. In the second instance, the material selected permitted toner to assume polarity opposite to that on the insulating material to be attracted thereto and fill in the donor member in a waffle pattern. Each of these donor members gave satisfactory results when employed in the manner of FIGS. 2 and 3.

Still another type of donor member in accordance with the invention is illustrated in FIG. 7. Such a donor member is termed a "variable capacitance" donor member. It comprises a thin insulating film 70 in contact with a raised conductive screen pattern 71 including air spaces 73 overlying a conductive support 72. Such a donor member was constructed by placing a layer of polyethylene terephthalate 0.5 mil thick over a metallic screen on a conductive backing such as aluminum. The surface of layer 70 is then charged to a uniform potential as by corona charging. The differential electrostatic charge pattern obtained with this donor member arises from the fact that those areas of the insulating film, which are in contact with the screen, have a high capacitance and, hence, accept a large charge density while those areas of a film 70 which are in contact with the air space are separated from conductive support 72 by a dielectric (in this case, air, although the space 73 may be filled with a solid dielectric termed "backfilling" either the same or different from that used for layer 70,

if desired), have a low capacitance and, hence, accept negligible quantity of charge. Therefore since as is known in xerography, the deposition of electrostatic charged marking particles is in response to electrostatic fields and not charge only, those areas of the insulating film in contact with the underlying screen, that is, those areas contacting the screen will repel like-charged toner during cascade of developer to the areas over the air space. Thus when cascading toner charged to the same polarity as the charge previously applied to the donor surface, only those areas of the insulating film not in contact with the underlying screen will acquire a deposit of toner thereon. Similarly with a fine mesh screen or, if otherwise desired, an opposite polarity toner can be employed to be attracted to the areas in contact with the screen. An epoxy resin (obtained from the Bakelite Co. under the tradename "ERL2795" with "ZZLD0814" hardener) was used to backfill the interstices of the screen providing a flush surface. The resulting donor with a solid dielectric for space 73 operated satisfactorily. Polystyrene film has also been used satisfactorily for insulating film 70.

Another method employed to construct a variable capacitance donor member was to etch a screened pattern (using Kodak Photoresist or xerographic toner for masking) on a sheet of copper clad epoxy-filled fiber glass. After etching a screen pattern on the copper surface, it was placed in contact with an electrically grounded base and the surface of the epoxy-filled fiber-glass charged as by corona charging. By cascading two-component developing material in which the toner is triboelectrically charged to the same polarity as the charge applied to the insulating fiber-glass surface, the toner is repelled in the areas over the copper to the areas over the air space. Preferably the conductor should be thick and the dielectric thin as, for example, 0.005 inch for the conductor and 0.001 inch for the dielectric. The conductor thickness is limited by etching and the dielectric by the requirement for support. However, the relative dimensions may vary widely. Thus, in the instant case, the copper foil was 0.0015 to 0.0010 inch while the epoxy filled fiber glass was 0.0035 to 0.0040 inch thick.

Still another embodiment is shown in FIG. 8. This type of donor member is termed a "floating electrode" member and comprises a four-layer sandwich comprising a conductive base material 80, a thin electrically insulating layer 81 thereon having formed on its upper surface a continuous, electrically conductive screen pattern 82 connected to a terminal 83 and finally, a uniform electrically insulating layer 84 covering both the screen pattern 82 and insulating layer 81.

In operation, the uppermost insulating layer 84 is charged to a uniform potential as by corona discharge and the terminal 83 of the conductive screen pattern is then connected to a source of D.C. potential such as battery 85 as by closing switch 86. Where the potential of the source 85 is such as to apply a potential to conductive pattern 82 of opposite polarity to the sensitizing charges applied uniformly on layer 84, the result will be to create a strong internal electrostatic field between pattern 82 and the portions of electrostatically charged layer 84 immediately above such pattern. When electrostatically charged developer particles of opposite polarity as applied to layer 84 are contacted with such a surface, they will see only the electrostatic fields from the areas having no underlying conductive pattern 82. Thus, they will deposit on such areas giving a negative or reversal of the screen pattern 82. Contra, by applying a potential to the screen 82 of the same polarity as that applied on the free surface of layer 84, these voltages will be additive with the voltage on the free surface resulting in a substantially greater electrostatic potential over the area of layers 84 corresponding to the conductive screen 82. In the latter instance, triboelectrically charged toner of the same polarity as the charge applied on the free surface must be em-

played in order to deposit into the areas of layer 84 absent of screen 82 below.

In other words, with the top surface of layer 84 charged to a given potential, then the potential applied to the conductive screen pattern alters the field configuration on the surface of layer 84 over the screen pattern while the surface potential of the portions of layer 84, not over the screen pattern, remains constant. Therefore, utilizing a developer loading process such as cascade which deposits toner relative to potential gradients rather than absolute potential, permits selective deposition of toner on the free surface of layer 84 without deposition of toner particles in the areas corresponding to the screen below.

Thus the instant invention includes novel donor members chargeable to uniform potential to produce a charge density which varies from point to point in a pattern either immediately on charging or thereafter independent of any light radiation sensitivity. Since the donor members can be geometrically shaped as required, combinations of donor members having different color developer can be adapted for sequential development in registration as, for example, to provide a three-color cluster rendition. A latent image of this type can be formed on exposure through an appropriate color filter. Thus the instant invention is in developing electrostatic images, not in any particular electrostatic charging or transfer process or means known to those skilled in the art may be used in conjunction with the novel development process of the instant invention. The term "electrostatic image" as employed herein includes not only those images formed in the manner of xerography described above to constitute an electrostatic latent image but also those images which constitute permanent images and electrostatically charged in the manner of xeroprinting as disclosed in above-cited patents and in the parent application hereof.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the drawings and specification should be interpreted illustrative and not in a limiting sense.

What is claimed is:

1. Developing apparatus for the development of electrostatic images previously formed on an image-bearing surface comprising in combination:

(a) a donor member capable of retaining a controlled quantity of electroscopic marking particles along one surface thereof, said donor member comprising:

- (1) an electrically conductive support base; and,
- (2) at least two separate electrically different material elements, at least one of which is characterized by substantially higher electrical resistivity than others of said elements and arranged combined relative to each other in a structurally distinct geometric configuration overlying said base and adapted to effect a surface charge retention pattern correlated to said configuration to retain charge predominantly in the areas of the higher resistivity elements.

(b) charging means to apply a uniform charge to the upper-exposed surfaces of said different elements to produce controlled electrostatic field patterns along said surface correlated to the relative electrical properties of said different elements in their configuration;

(c) developer loading means to present electroscopic powder marking particles to said upper surfaces of said donor, said marking particles being charged to a polarity which under the influence of said electrostatic fields causes said particles to deposit onto a predominance of surface area; and,

(d) means to bring an image-bearing surface and the particle bearing donor member into a closely spaced relationship in which particles on said donor member are selectively attracted to the electrostatic fields of an electrostatic image to be developed.

2. Developing apparatus for development of electrostatic images contained on an image-bearing surface comprising in combination:

(a) an endless donor member capable of retaining a controlled quantity of electroscopic marking particles along one surface thereof, said donor member comprising:

- (1) an electrically conductive support base;
- (2) a layer of material overlying said support base and characterized by greater electrical resistivity than said support base; and,
- (3) a uniformly spaced pattern formed of more electrically insulating material than said layer extending above said layer and adapted to retain electrostatic charge; and,

(b) means to continuously advance said donor member past a plurality of treating stations, said treating stations, comprising:

- (1) a charging station at which electrostatic charge is applied onto the surface of said insulating pattern and areas of said layer therebetween to produce time variant electrostatic fields correlated to the electrical properties of said insulating pattern and said resistive layer;
- (2) a developer loading station positioned past said charging station at which to pass electroscopic powder marking particles in contact over the areas charged at said charging station, which particles are influenced by the existent electrostatic fields thereon to deposit predominantly onto the areas of said layer; and,
- (3) a developing station at which electroscopic marking particles loaded onto said donor member at said loading station are presented in closely spaced relationship to an electrostatic image on an image-bearing surface.

3. Developing apparatus for development of electrostatic images contained on an image-bearing surface comprising in combination:

(a) an endless donor member capable of retaining a controlled quantity of electroscopic marking particles along one surface thereof, said donor member comprising:

- (1) an electrically conductive support base;
- (2) a screened electrically conductive pattern overlying said support base; and,
- (3) a thin layer of electrically insulating material overlying said screen; and,

(b) means to continuously advance said donor member past a plurality of treating stations, said treating stations comprising:

- (1) a charging station at which electrostatic charge is applied onto the insulating surface of said donor member to produce time variant electrostatic fields correlated to the underlying pattern of said conductive screen;
- (2) a developer loading station at which to pass electroscopic powder marking particles over the areas charged at said charging station, which particles are influenced by existent electrostatic fields on said donor member to deposit on said insulating surface in areas predominantly non-overlying of said conductive screen; and,
- (3) a developing station at which electroscopic marking particles loaded onto said donor member at said loading station are presented in closely spaced developing relation to an electrostatic image on an image-bearing surface.

4. Developing apparatus for developing an electrostatic image contained on an image-bearing surface comprising:

(a) a donor member capable of retaining a controlled quantity of electroscopic marking particles along one surface thereof, said donor member being comprised of:

- (1) an electrically conductive support member;
- (2) a thin layer of electrically insulating material overlying said base member; and,
- (3) a continuous electrically conductive screen pattern overlying said insulating layer;

(b) charging means adapted to apply a potential to said conductive screen pattern;

(c) developer loading means operative to present a quantity of electroscopic electrostatically charged powder marking particles over said screen whereby the marking particles are repelled to the interstices of said screen; and,

(d) means operative after loading to present the electroscopic marking particles on said donor into closely spaced developing relation with the electrostatic image on an image-bearing surface.

5. Developing apparatus for developing an electrostatic image on an image-bearing surface comprising:

(a) a donor member capable of retaining a controlled quantity of electroscopic marking particles along one surface thereof, said donor member being comprised of:

- (1) an electrically conductive support member;
- (2) a thin layer of electrically insulating material overlying said base member; and,
- (3) a continuous electrically conductive screen pattern overlying said insulating layer;

(b) first charging means adapted to apply a charge potential to said conductive screen pattern;

(c) second charging means operative concomitantly with said first charging means and adapted to apply a same polarity charge to the same surface including said insulating layer exposed in the interstices of said screen;

(d) means to ground said screen following application of charge by said second charging means;

(e) developer loading means operative after charging to present a quantity of electroscopic electrostatically charged powder marking particles over said donor whereby the marking particles are deposited on the interstice areas of said insulating layer; and,

(f) means operative after loading to present the electroscopic marking particles on said donor into closely spaced developing relation with the electrostatic image on an image-bearing surface.

6. Developing apparatus for developing an electrostatic image on an image-bearing surface comprising:

(a) a donor member capable of retaining a controlled quantity of electroscopic marking particles along one surface thereof, said donor member being comprised of:

- (1) an electrically conductive support member;
- (2) a thin electrically insulating layer overlying said support member;
- (3) a continuous electrically conductive screen pattern overlying said insulating layer; and,
- (4) a second thin layer of electrically insulating material overlying said screen pattern and contacting said first recited insulating layer at the interstices of said screen pattern,

(b) first charging means adapted to apply a charge onto the surface of said second insulating layer;

(c) second charging means operative concomitantly with said first charging means and adapted to connect a potential to said conductive screen pattern;

(d) developer loading means operative to present a quantity of electroscopic electrostatically charged powder marking particles over said surface of said

insulating layer whereby the marking particles are deposited onto the areas of said layer representative of an absence of screen therebelow; and,

(e) means operative after loading to present the electroscopic marking particles on said donor into closely spaced developing relation with the electrostatic image on an image bearing surface.

7. In a xerographic apparatus including means to develop an electrostatic image with electroscopic marking particles, the improvement comprising improved developing means comprising:

(a) an endless donor member capable of retaining a controlled quantity of electroscopic marking particles along one surface thereof, said donor member being comprised of:

- (1) an electrically conductive support member;
- (2) a layer of material of greater electrical resistivity than said support member overlying said support member; and,
- (3) a uniformly spaced pattern formed of electrically insulating material extending above said layer and adapted to retain electrostatic charge;

(b) charging means adapted to charge said donor member by the application of electrostatic charge of a selected polarity to the insulating pattern and the areas of said layer in the spacing therebetween;

(c) developer loading means operative in time spaced relation after charging to cascade a quantity of electroscopic powder marking particles electrostatically charged to said same selected polarity over the charged area of said donor whereby the marking particles are repelled by said charged pattern onto the inbetween areas of said layer;

(d) means operative after loading to present the electroscopic marking particles on said donor into closely spaced developing relation with the electrostatic image contained on a supporting surface; and,

(e) drive means adapted to continuously advance said donor member sequentially past each of said above recited means whereby electroscopic particles are continuously presented to electrostatic images to be developed.

8. In a xerographic apparatus including means to develop an electrostatic image with electroscopic marking particles, the improvement comprising improved developing means comprising:

(a) a donor member capable of retaining a controlled quantity of electroscopic marking particles along one surface thereof, said donor member being comprised of:

- (1) an electrically conductive support member;
- (2) a screened electrically conductive pattern overlying said support member; and,
- (3) a thin layer of electrically insulating material overlying said screen;

(b) charging means adapted to apply charge to the insulating surface of said donor member of a selected polarity;

(c) developer loading means operative in time spaced relation after charging to present a quantity of electroscopic powder marking particles electrostatically charged to said same selected polarity over the charged area of said donor to deposit on said insulating surface in areas non-overlying said conductive screen; and,

(d) means operative after loading to present the electroscopic marking particles on said donor surface into closely spaced relationship with an electrostatic image contained on a supporting surface.

9. In a xerographic apparatus including charging means to apply a uniform charge onto the surface of a xerographic plate, exposure means to expose a radiation image of copy to the charged surface of the xerographic plate

to form an electrostatic latent image, and means to develop the electrostatic latent image with electroscopic powder marking particles, the improvement comprising improved developing means for developing an electrostatic latent image on a xerographic plate, said developing means comprising:

- (a) a donor member capable of retaining a controlled quantity of electroscopic marking particles along one surface thereof, said donor member being comprised of:
  - (1) an electrically conductive support member;
  - (2) a layer of material of greater electrical resistivity than said support member and overlying said support member; and,
  - (3) a uniformly spaced pattern formed of electrically insulating material extending above said layer and adapted to retain electrostatic charge;
- (b) charging means adapted to charge said donor member by the application of electrostatic charge of a selected polarity to the insulating pattern and the areas of said layer therebetween;
- (c) developer loading means operative in time spaced relation after charging to cascade a quantity of electroscopic powder marking particles electrostatically charged to said same selected polarity over the charged area of said donor whereby the the marking particles are repelled by said charged pattern to the inbetween areas of said layer; and,
- (d) means operative after loading to present the electroscopic marking particles on said donor into closely spaced developing relation with the electrostatic latent image formed on the xerographic plate.

10. In a xerographic apparatus including means to develop an electrostatic image with electroscopic marking particles, the improvement comprising improved developing means comprising:

- (a) a donor member capable of retaining a controlled quantity of electroscopic marking particles along one surface thereof, said donor member being comprised of:
  - (1) an electrically conductive support member;
  - (2) a thin layer of electrically highly insulating material overlying said base member; and,
  - (3) a continuous electrically conductive screen pattern overlying said insulating layer;
- (b) charging means adapted to apply a potential to said conductive screen pattern;
- (c) developer loading means operative to present a quantity of electroscopic powder marking particles electrostatically charged opposite to that applied by said charging means across said screen whereby the marking particles are repelled by the charge on said screen to the interstices of said screen; and,
- (d) means operative after loading to present the electroscopic marking particles on said donor into closely spaced developing relation with the electrostatic image on an image-bearing surface.

11. In a xerographic apparatus including developing means to develop an electrostatic image on an image-bearing surface, the improvement comprising improved developing means comprising:

- (a) a donor member capable of retaining a controlled quantity of electroscopic marking particles along one surface thereof, said donor member being comprised of:
  - (1) an electrically conductive support member;
  - (2) a thin layer of electrically insulating material overlying said support member; and,

- (3) a continuous electrically conductive screen pattern overlying said insulating layer;
- (b) first charging means adapted to apply a charge potential to said conductive screen pattern;
- (c) second charging means operative concomitantly with said first charging means and adapted to apply a charge which effects a raised potential on the surface of said insulating layer exposed in the interstices of said screen;
- (d) means to ground said screen following application of charge by said second charging means;
- (e) developer loading means operative after charging to present a quantity of electroscopic electrostatically charged powder marking particles over said donor whereby the marking particles are deposited on the surface of said donor member in conformity with the electrostatic fields existent thereon; and,
- (f) means operative after loading to present the electroscopic marking particles on said donor into closely spaced developing relation with the electrostatic image on an image-bearing surface.

12. In a xerographic apparatus including developing means to develop an electrostatic image on an image-bearing surface, the improvement comprising improved developing means comprising:

- (a) a donor member capable of retaining a controlled quantity of electroscopic marking particles along one surface thereof, said donor member being comprised of:
  - (1) an electrically conductive support member;
  - (2) a thin electrically insulating layer overlying said support member;
  - (3) a continuous electrically conductive screen pattern overlying said insulating layer; and
  - (4) a second thin layer of electrically insulating material overlying said screen pattern and contacting said first recited insulating layer at the interstices of said screen pattern;
- (b) first charging means adapted to apply a charge onto the surface of said insulating layer;
- (c) second charging means operative concomitantly with said first charging means and adapted to apply a potential to said conductive screen pattern;
- (d) developer loading means operative to present a quantity of electroscopic electrostatically charged powder marking particles over said surface of said insulating layer whereby the marking particles are deposited onto said layer in conformity with the electrostatic fields created by said first and second charging means; and,
- (e) means operative after loading to present the electroscopic marking particles on said donor into closely spaced developing relation with the electrostatic image on an image-bearing surface.

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