Jan. 19, 1965 R. W. GUNDLACH 3,166,418

IMAGE DEVELOPMENT

Filed May 7, 1959 2 Sheets-Sheet 1

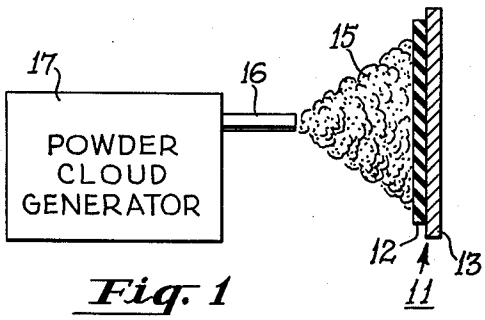


Fig. 1

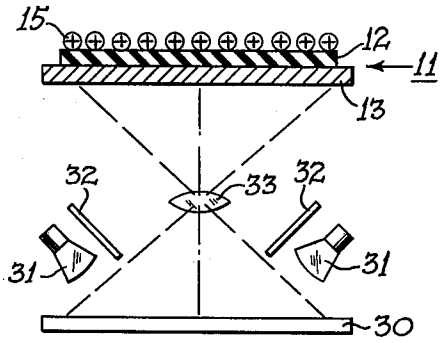


Fig. 3A

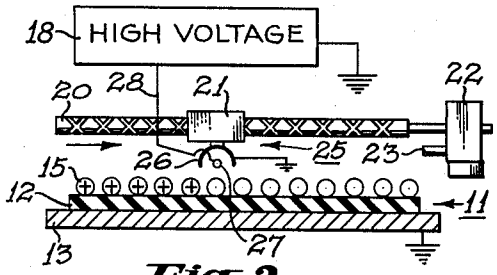


Fig. 2

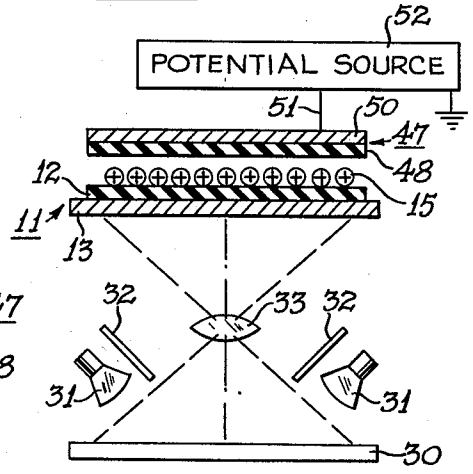


Fig. 4A

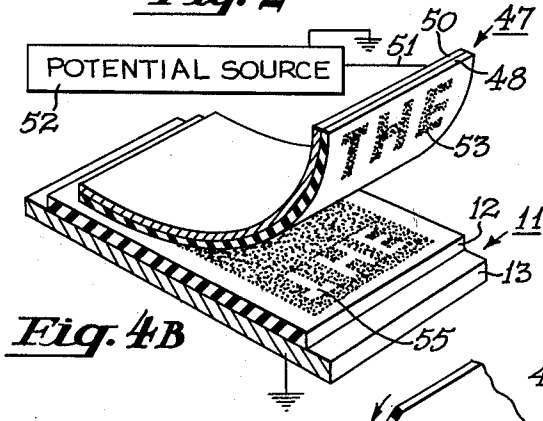


Fig. 4B

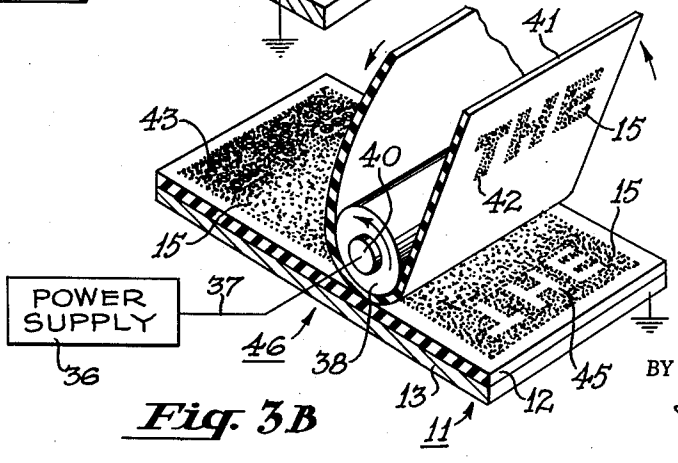


Fig. 3B

INVENTOR.
Robert W. Gundlach
BY
Stanley Z Cole
ATTORNEY

Jan. 19, 1965 R. W. GUNDLACH 3,166,418

IMAGE DEVELOPMENT

Filed May 7, 1959 2 Sheets-Sheet 2

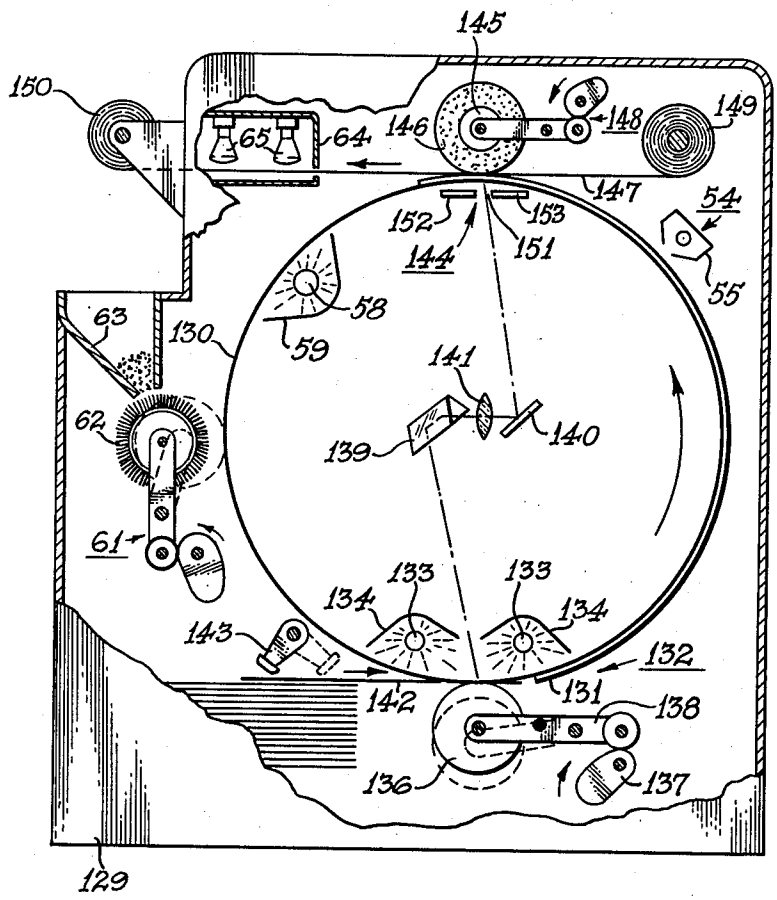


Fig. 5

INVENTOR.
Robert W. Gundlach

BY Stanley J. Role

ATTORNEY

United States Patent Office 3,166,418 Patented Jan. 19, 1965

3,166,418

IMAGE DEVELOPMENT

Robert W. Gundlach, Spencerport, N.Y., assignor to Xerox Corporation, a corporation of New York

Filed May 7, 1959, Ser. No. 811,591
2 Claims. (Cl. 96—1)

This invention relates in general to xerography and in particular to development of a formed image as well as development simultaneous with exposure. This is a continuation in part of my prior filed application Serial No. 613,333, filed October 1, 1956, now U.S. Patent 2,968,552.

In my copending applications, Serial No. 613,333, now U.S. Patent 2,968,552, and 718,693, now U.S. Patent 2,968,553, there are disclosed systems and apparatus of xerography in which images are formed by coating a xerographic plate with a substantially uniform layer of insulating developer particles and then while a field is applied across the plate, exposing the plate to a light image pattern. A conductive sheet or layer is positioned against the particle layer and the insulating particles move to this conductive sheet or layer under the influence of fields of force as controlled by the pattern to which the plate is exposed.

This invention constitutes an improvement over the aforesaid copending patent applications and embodies particle movement in a selective fashion from a substantially uniform layer of conductive particles on the surface of the plate either during exposure or after exposure and to an insulating surface. By conductive particles it is meant particles relatively more conductive than the conductivity of the plate member, and generally this includes particles having a resistivity less than about 10^{12} ohm-centimeters. Conductivity also means conductivity in the usual sense and involves resistivities generally in the range of 10^{-4} ohm-centimeters which typically would be the resistivity of metals and the like. By providing a technique and apparatus for image formation in xerography employing conductive materials, the choice of material to be employed is greatly expanded and by transferring to an insulating layer rather than a conductive layer as in my previous inventions, the choice of material to which the particles are transferred is substantially broadened.

It is accordingly an object of this invention to devise new systems of image formation in xerography.

It is a further object of this invention to define new systems of image formation employing conductive particles as the developer particles in the xerographic process.

It is a further object of this invention to define new and novel systems of simultaneous image development during exposure in the art of xerography.

It is a still further object of this invention to define novel apparatus to improve the art of xerography.

It is a still further object of this invention to define novel image development apparatus in xerography.

It is a still further object of this invention to define novel xerographic apparatus to form developed images simultaneous with exposure.

For a better understanding of the invention and for additional objects thereof, reference is had to the following description to be read in conjunction with the drawings, wherein:

FIG. 1 is a representation of the loading of a plate according to this invention;

FIG. 2 is a diagrammatic representation of charging of a plate prepared in accordance with FIG. 1;

FIGS. 3–A and 3–B are diagrammatic representations of an embodiment of exposure and image development in accordance with this invention;

FIGS. 4–A and 4–B illustrate another embodiment of exposure and development in accordance with this invention; and,

FIG. 5 is an embodiment of an automatic xerographic apparatus in accordance with this invention.

Referring now to FIG. 1, there is illustrated schematically a method of preparing a plate generally designated 11 comprising a photoconductive insulating layer 12 overlying a conductive backing member 13 for exposure in accordance with this invention. Plate 11 is being coated with a uniform layer of conductive developer particles 15 fed thereto in aerosol form from nozzle 16 and powder cloud generator 17. Particles of this aerosol should be small in size and generally less than about 20 microns in diameter to permit high quality image formation. If continuous tone copies are to be formed, a particle size of about 5 microns or less is generally preferred. The particles should also be non-toxic, non-corrosive and preferably non-hygroscopic. Many powders meet these requirements. Powdered charcoal has been found to be particularly useful. Alternatively, other conductive particles, such as metallic particles and the like may be used. The aerosol of powder 15 is fed from nozzle 16 and powder cloud generator 17 for a sufficient time to at least mask, through the deposition of particles thereacross, the surface of photoconductive insulating layer 12. The interest should be that of depositing a substantially uniform layer rather than a particular amount of particles and this may be accomplished by moving plate 11 through the aerosol at a uniform speed for either one or a number of passes to accomplish uniform loading or, as shown, by placing an entire plate within a uniform aerosol.

Plate 11 may comprise any of the well known xerographic plates. Thus, and for example, it may comprise a commercially available xerographic plate comprising a layer of amorphous selenium overlying a conductive aluminum backing member. It may also comprise the commercially available plate which plate comprises a layer of zinc oxide in an insulating binder overlying a paper support base. The photoconductive insulating layer may also comprise various other known photoconductive insulators such as anthracene, selenium tellurium mixtures, various photoconductive materials supported in insulating binders, and the like. The backing member may comprise any conductive layer, but preferably includes a transparent material. Such a base may comprise a layer of glass carrying a conductive coating such as NESA glass or the like, as is well known in the art. The plate may be rigid or flexible, and the choice of whether rigid or flexible will depend on the desired subsequent utilization.

It is to be realized that the representation in FIG. 1 is only for illustrative purposes, since many modifications and alternatives exist which may be used for depositing a substantially uniform layer of powder on a plate 11. For example, powder particles may be cascaded across the surface of layer 12 of plate 11, or plate 11 may be immersed into a container of powder or a mixture of powder and coarse granular carrier or such a mixture may be poured over the surface of layer 12 of plate 11. A liquid mixture may also be fed across photoconductive insulating layer 12 to result in powder deposition on the surface of photoconductor 12. The powder may be allowed to settle thereon as from a shaker or the like. Typically, powder 15 which will remain in position on surface 12 of plate 11 will be held in position by van der Waals forces, and in fact, although other techniques employing other forces such as electrostatic or the like causing powder to remain in position exist, it is preferred that these other techniques be avoided in order that the powder remain bound to the surface with only minimum forces. If, however, electrostatic binding or the like is

employed to deposit the powder across the surface, then the electrostatic forces causing the particles to remain bound in position may be compensated for throughout the remaining steps in carrying out this invention so that the results sought in this invention are not distorted by these binding forces.

Referring now to FIG. 2, there is illustrated charging in accordance with this invention. Plate 11 comprising photoconductive insulating layer 12 overlying conductive backing member 13 is positioned with backing member 13 grounded. Across the surface of photoconductive insulating layer 12 there are particles 15 deposited in a substantially uniform layer in accordance with the illustration in FIG. 1. Positioned above plate 11 is corona discharge electrode 25 comprising shield 26 and corona discharge wire 27. As illustrated, shield 26 is maintained at ground, and discharge wire 27 is connected through lead 28 to the high voltage source 18. Corona discharge electrode 25 is fastened to sleeve 21 which rides on screw drive shaft 20, driven by motor 22. Typically, in operation corona discharge electrode 25 would start along drive shaft 20 at a point adjacent to motor 22. With rotation of shaft 20, discharge electrode 25 is moved to the other extreme of shaft 20 and then, as shown, back toward motor 22. At motor 22 there is illustrated a microswitch 23 which is depressed by discharge electrode 25 when it returns back to the extreme of shaft 20 at motor 22. The microswitch, when depressed, will electrically disconnect the voltage from voltage source 18 as well as stop rotation of shaft 20. High voltage source 18 supplies to discharge wire 27 a corona generating potential and causes corona discharge to take place about wire 27. Because of the electric fields of force existing between discharge electrode 25 and the grounded backing member 13 of plate 11, ions of the corona discharge float toward plate 11 and deposit on particles 15 across the surface of photoconductive insulating layer 12. Because these particles are conductive and exist on an insulating layer 12, substantially no charge flows between these particles and photoconductive insulating layer 12, while layer 12 is maintained in darkness.

It is to be realized that other techniques to accomplish charging may be used with this invention. Thus, and for example, radioactive charging or the like may be employed. Also, in this embodiment charging is illustrated as deposting positive charges across particles 15. However, negative charges may be used and the choice of whether positive or negative charges are employed will generally depend on the particular photoconductive insulating layer 12 of plate 11.

Referring now to FIG. 3, particularly FIG. 3–A, there is illustrated exposure in accordance with an embodiment of this invention. In this embodiment, plate 11 comprising photoconductive insulating layer 12 overlying conductive backing member 13 and bearing across the surface of photoconductive insulating layer 12 a substantially uniform layer of particles 15, which have been electrostatically charged as illustrated by the positive signs across particles 15, in accordance with the illustration of FIG. 2, is positioned in respect to lens 33 and copy 30 to focus copy 30 on photoconductive insulating layer 12 through conductive backing 13. As should be apparent, conductive backing 13 is transparent in this embodiment to allow the light image pattern to reach photoconductor 12. Copy 30 is illuminated by lamps 31 which are shielded by shields 32 to prevent light radiation from lamps 31 from reaching plate 11 directly. In discussing plate 11 previously, it was mentioned that backing member 13 could be a solid, nontransparent material. As shown in this figure, exposure takes place through backing 13. Also, in this figure, exposure is to a light pattern, and when exposure is to a light pattern backing member 13 must be transparent, or substantially so. However, photoconductive insulating layer 12 is also photosensitive when exposed to X-rays and other radiation type energies, and materials which are not transparent to light are generally transparent to such energies. Thus, and for example, an aluminum backing could be employed when exposing through the backing to an X-ray image pattern. Also, when energy which penetrates light opaque material is employed it is not necessary to expose through the backing, but exposure could be directed first through the charged particles and then to photoconductive insulating layer 12.

Referring now to FIG. 3–B, there is shown plate 11 comprising photoconductive insulating layer 12 overlying conductive backing member 13 following exposure as illustrated in FIG. 3–A. To illustrate the effect of exposure on the charged and sensitive plate following FIG. 2, there is shown a charged area 43 within the particle layer on the surface of plate 11 and at the left side of the plate as illustrated in this figure. This situation would result if all areas except image areas 43 are exposed to light, thus resulting in dissipation of the charge placed across particles 15 during the charging step shown in FIG. 2. In those areas not exposed to light such as image areas 43, charge remains in position on particles 15. In this embodiment in effect, image 43 corresponds to areas of black in the original copy, whereas all discharged areas correspond to areas of white in the original copy. On the right-hand side of plate 11 there is shown an image area 45 of substantially no particles. In practice, whether or not particles would remain on the plate surface would depend upon the amount of particles originally deposited as, for example, through a loading step as illustrated in FIG. 1. If a thick load of particles 15 had been placed across plate 11, then although particles transfer from the particle layer and from plate 11, in all likelihood an image would not be clearly discernable on the plate as illustrated in this figure, only because sufficient contrast would not exist between the areas from which particles were transferred and those areas from which particles did not transfer. However, of course a developed image would exist on sheet 41.

In this figure and in this embodiment a roller, generally designated 46, comprising a conductive core 40 and an outer covering layer 38 of conductive material is being rolled against the back of sheet 41. Core 40 of roller 46 is connected through lead 37 to power supply 36 and in this embodiment there is applied from power supply 36 and to roller 46 a bias of about ground. By applying a substantially ground potential to roller 46 as roller 46 rolls sheet 41 into and out of contact with the layer of particles 15 across the surface of plate 11, those particles 15 which still retain charge after exposure as, for example, image 43, transfer to the surface of sheet 41 as shown by image 42 including particles 15. Accordingly, as roller 46 continues to roll sheet 41 into contact with particles 15 on plate 11 as it passes from right to left, image 43 of charged particles on plate 11 will transfer to sheet 41. Image transfer in this embodiment takes place due to the charges on particles 15 on the surface of plate 11 and due to an electric field applied between these particles and through sheet 41. In this illustration transfer of the charged particles is illustrated. However, it is to be realized that originally neutral conductive particles in an electric field, and sandwiched between two surfaces, each contacting the particles, and each in electrical circuit, will result in particle movement to the more insulating surface. Thus, through the application of a potential to roller 46 to create a neutral electric field in the charged image 43 areas and a field about the uncharged particles 15 on the surface of plate 11 a photographically reversed image of image 42 shown transferred will result on sheet 41. Thus, one can through the selection of the applied potential, transfer a photographically positive image 42 as illustrated, or a photographically negative image leaving behind those particles of image 42 indicated to be transferred. Sheet 41, in order to bring about transfer in accordance with this invention,

should be an insulating sheet and generally it should be more insulating than the insulating qualities of photoconductive insulating layer 12. For some applications, however, this invention will operate with materials a few orders of magnitude less resistive as long as they would be classified as insulating. Thus, and for example, if sheet 41 has a low resistivity and sufficient time were allowed to elapse while image 42 is in contact against sheet 41 and while electrical connection exists for sheet 41 at image 42 as through roller 46 it is to be expected that the charge on image 42 would be neutralized and the particles would tend to move back to insulating layer 12 since, charges induced into the conductive particle between the facing surfaces will cause movement to the more insulating surface whereat charge flow and charge neutralization in the particle are prevented to a large extent. Accordingly, if movement of roller 46 is sufficiently rapid across the back of sheet 41, so that charges cannot be induced into the transferred particles to cause them to transfer back and only because sheet 41 would be considered an insulator in the usual sense, then, as a matter of fact, sheet member 41 may comprise a more conductive material than insulating layer 12. In practice it is preferred to use layer materials such as polyethylene or polyethylene coated paper or the like. These surfaces have resistivities in the order of more than 10^{16} ohm-centimeters. Following movement of roller 46 across the sheet 41 bringing sheet 41 into physical contact across the entire particle layer across the surface of photoconductive insulating layer 12 there results image formation of transferred particles on the surface of sheet 41 in accordance with the original being reproduced.

Referring now to FIGS. 4–A and 4–B, there is illustrated particle transfer and image formation simultaneous with exposure. Referring first to FIG. 4–A, it is noted that the arrangement for exposure is quite similar to that shown in FIG. 3–A. In particular, there is positioned copy 30 relative to lens 33 and plate 11 to project a reflected image created by lamps 31 positioned behind shields 32 directed to copy 30 to photoconductive insulating layer 12 which overlies transparent backing member 13. Across the surface of photoconductive insulating layer 12 there are positioned particles 15 in a charged condition following charging as illustrated in FIG. 2. In addition, there is positioned across the charged particles transfer member 47 comprising insulating layer 48 backed by a conductive electrode 50. Conductive electrode 50 is connected through lead 51 to potential source 52. A bias is applied to electrode 50 as transfer member 47 is positioned across the charged particles 15 on plate 11 to avoid electric fields of force between the charged particles and insulating layer 48. Thus, and for example, if a potential of about 600 volts is across charged particles 15 on plate 11, a potential of about 600 volts or a potential which prevents fields is applied through lead 51 from potential source 52 to electrode 50. In practice it has been found that more than the measurable potential across the surface to which the electrode is being applied must be applied to the conductive electrode 50 and typically it would be expected that a potential in the range of about 800 to 1200 volts should be applied to avoid electric fields of force between a particle layer carrying a charge of about 600 volts and insulating layer 48. This additional voltage is necessary to overcome capacitance effects and the like as transfer member 47 is brought to plate 11. This applied potential from potential source 52 is maintained during exposure and as areas of plate 11 are exposed to light there results dissipation of charge across particles 15 on the surface of photoconductive insulating layer 12 in accordance with the light energy striking photoconductive insulating layer 12. Areas of particles 15 which are discharged then exist in an electric field of force. These particles move to insulating layer 48. If desired, one can also cause transfer of those particles not exposed to light. This may be accomplished by

controlling the potential applied from potential source 52 to electrode 50 to vary in accordance with the light decay characteristics of photoconductive insulating layer 12. Decay curves are known for photoconductive insulating layers. Such curves are discussed and disclosed in copending patent application Serial No. 706,809 and one could, for example, form a resistive element and including a sliding contact to move thereacross which is actuated with exposure of plate 11 to cause the bias applied from potential source 52 to vary in accordance with the decay curve of the plate to maintain the condition of no field between areas being exposed and insulating layer 48. At the same time, an electric field of attractive force between particles 15 in areas not exposed and insulating layer 48 would exist and there results transfer of the charged particles 15 in areas not exposed. Layer 48 of transfer member 47 should, as in the previous embodiment, comprise an insulating material, preferably above the range of insulating qualities of photoconductive insulating layer 12. When transfer in this embodiment is of particles corresponding to areas of plate 11 exposed to light, then the requirement of more insulating than photoconductive insulating layer 12 is controlled by the light resistive characteristics of photoconductive insulating layer 12 as long as transfer member 47 is separated from plate 11 soon after exposure and preferably immediately following exposure. This resistivity is about 3 orders of magnitude less than the dark resistivity of the photoconductor and generally is above about 10^{13} ohm-centimeters. It is noted that when particles corresponding to areas of the plate exposed to light are transferred during exposure as just described, there results a stronger attraction for the particles to transfer than in any of the other embodiments discussed. This occurs because of the conductivity of the photoconductor in the areas of the particles which are to transfer resulting in induction of additional charges into the particles to cause increased attraction of the particles to transfer member 47 as compared to all situations where charges cannot flow as readily.

In FIG. 4–B there is shown separation of transfer member 447 comprising conductive layer 50 and insulating layer 48 from plate 11 comprising photoconductive insulating layer 12 overlying conductive backing member 13 following exposure as illustrated in FIG. 4–A. As shown in this figure, potential source 52 remains connected through lead 51 to conductive backing layer 50 of transfer member 47, and the bias applied as exposure is completed is maintained during separation. Thus, and for example, if a bias is applied to transfer those areas which are exposed to light which is the same bias which neutralizes any fields between the charged particle layer on plate 11 and transfer member 47 as transfer member 47 is placed across plate 11, then this same bias is maintained during separation and removal of transfer member 47 from plate 11. Similarly, if the bias is varied during exposure in accordance with the light decay of the plate, then the potential finally reached at the completion of exposure is maintained during separation. In such a case the transferred image would be photographically reverse of image 53 made up of particles about void 55.

As shown in this figure, transfer member 47 comprises an insulating layer 48 backed by a conductive layer 50. It is to be realized that various layers might be used as, for example, a conductive material having an insulating surface coated thereon or an insulating sheet may be positioned against a conductive sheet and following separation of transfer member 47 from plate 11 the conductive sheet may be separated away from insulating layer 48. Other equivalents will readily occur to those skilled in the art, and such equivalents are intended to be incorporated herein. It is also to be realized that this invention may also be carried out by depositing a layer of charge across the back of insulating layer 48 but it is preferred to use a conductive solid member.

Referring now to FIG. 5, there is illustrated a machine for intermittent or sheet feed operation to produce copies of letters, documents and the like, according to the present invention. Generally illustrated within a light-tight cabinet **129** is a xerographic cylinder **130** comprising a conductively coated support cylinder such as, for example, a cylinder of NESA glass or the like. In an image area comprising a 180° segment of the cylinder surface, the xerographic cylinder is coated with a photoconductive insulating layer **131** such as a layer of selenium or the like, and in the remainder of the surface area the cylinder is substantially transparent. The cylinder is suitably rotatably mounted and provided with drive means such as, for example, an electric motor or the like, or optionally manual drive mechanism to cause the cylinder to be rotated.

Positioned at an appropriate point around the circumference of the xerographic cylinder is an exposure station **132**. There may be, for example, suitable lighting means such as fluorescent tubes **133** mounted within the cylinder at the exposure station. Light shields **134** are positioned to protect the photosensitive portion of the drum from undesired exposure to the light of the exposure light source.

Mounted outside the cylinder **130** at the exposure station is a roller **136** adapted to be moved in and out of position in contact with the xerographic drum surface. Preferably, a suitable cam **137**, operating through rocker arm **138** moves the roller **136** into contact with the drum through 180° of rotation so as to bring the roller into contact only at those points which are not coated with the photoconductor.

Mounted within the cylinder is a suitable optical system adapted to focus a light projection image of the original onto the opposite surface of the cylinder at a position removed from the exposure zone by 180°. This optical system may, for example, comprise a roof mirror or prism **139**, a reversing mirror **140**, and a lens **141** so aimed and adjusted as to project and focus the image at the desired point. An original **142** to be copied may be fed between the cylinder and the drum and is carried through the exposure station by the rotating cylinder and roller in co-action. Suitable paper feed means **143** is operably positioned to feed the sheets of the original into roller **136** and cylinder **130**.

Positioned adjacent the circumference at a point 180° from the exposure station is an image formation station generally designated **144**. At this station is a suitable roller **145** having a soft, resilient surface such as, for example, a thick sponge rubber layer **146** which is electrically conductive. Conductivity may be imparted to otherwise non-conductive material by impregnation with a conductive material such as, for example, a graphite dispersion. A suitable cam and rocker arm combination **148** is positioned and adapted to move roller **145** into and out of contact with the xerographic cylinder essentially simultaneously with roller **136**. A suitable copy paper **147** is adapted to be fed between and in contact with the sponge rubber roller **145** and the xerographic cylinder and to be carried through simultaneously with and in reverse direction from the original being copied. The copy paper may, if desired, be sheet fed or may, as illustrated, be web fed from feed roll **149** to take-up spool **150**. The copy paper should be insulating as previously discussed and preferably has a resistivity greater than about 10^{16}. The entire copy paper **147** may be so insulating or, if desired, the surface in contact with cylinder **130** may be coated with an insulating material since it is this surface which must at least be insulating to the level described rather than the entire copy paper layer.

An exposure frame or slit **151** is defined by shield edges **152** and **153**, these edges being adjustable in position so as to control the width of the exposure slit opening. Thus, as the original is being fed against the surface of the xerographic cylinder, at one point an image thereof is being focused onto the opposite surface of the cylinder through the optical system and slit at a position 180° removed from the original.

Positioned along the path of rotation of cylinder **130** is a developer supply means **61** comprising, for example, a rotatable brush **62** bearing a supply of finely divided developer material optionally maintained in supply by brushing against a developer feed hopper **63** which is adapted to supply additional developer material thereto. Developer material fed to brush **62** comprises a conductive material relative to the conductivity of the photoconductive insulating layer **131**. Thus, it generally will have a resistivity in the order of less than 10^{13} ohm centimeters and may, if desired, be as conductive as 10^{-5} ohm centimeters. The brush is movably mounted to be brought into and out of contact with the rotating cylinder with suitable cam and rocker arm **61** adapted to move the brush into contact only with the photoconductor coated portion of the cylinder. Positioned also along the circumference of cylinder **130** and shielded from both the exposure light source and the projected image is charging station **54**. At this charging station is positioned suitable charging means such as, for example, a corona discharge electrode **55** supplied with high potential to generate a corona discharge.

Optionally, there is positioned a flood light source such as, for example, a fluorescent tube **58** mounted within a light shield **59** adapted to shine light through the xerographic cylinder onto the photoconductive insulating layer.

In use and operation the machine of FIG. 5 is adapted to produce copies of suitable sheet-by-sheet originals. The desired original is fed between roller **136** and cylinder **130**, and simultaneously appropriate copy paper is fed between rollers **145** and cylinder **130**. As these rollers are moved by the cams into contact with the cylinder they draw the original and the copy paper simultaneously through the exposure and image formation station at identical rates of speed. While the two are being drawn through the machine, the light image of the original is being forcused through slit **151** and through the transparent conductive support of the cylinder onto the photoconductive layer. Prior to movement of the photoconductor to the exposure station, it is loaded with developer and at the image formation station a developed visible image is placed on the copy paper in accordance with the description appearing in connection with FIGURES 1, 2 and 4. The copy paper is then passed through suitable fixing apparatus such as, for example, a solvent vapor chamber or a heating oven **64** including heat sources such as heat lamps **65** or the like. By operation of this machine the series of operations illustrated in FIGURES 1, 2 and 4 are sequentially repeated on the photoconductive layer. Thus, the loading of the photoconductor with a substantially uniform layer is carried out by the developer deposition means **61**, followed by charging by charging electrode **55**. Next, exposure and particle transfer is carried out simultaneously at the exposure station and the image formation station whereby copy paper is fed to the image formation station and a light image is produced by feeding the original at the exposure station. Lamp **58** may be used to release charge before recycling the drum.

As should be apparent, variations and modifications in procedure and apparatus may be made within the scope of this invention. For example, although the apparatus shown in FIG. 5 shows simultaneous transfer of particles with exposure in accordance with the description in connection with FIG. 4, it should be apparent that exposure may take place first and transfer subsequently as shown, for example, in FIG. 3 and that such a modification of the apparatus in FIG. 5 is intended to be encompassed within the scope of this invention. Also, as should be apparent, although the plate in the apparatus of FIG. 5 comprises a half-transparent cylinder and a half-photoconductive insulating layer coated cylinder an entire drum compris-

ing a continuous layer of photoconductive insulating material overlying a transparent NESA glass cylinder may be employed and the light image may be fed through the glass portion of the cylinder to the photoconductor through an optical system including mirrors and the like, thereby producing a continuous automatic machine resulting in continuous exposure of the drum as well as continuous printing and output from the drum. In such a continuous machine printing may be simultaneous with exposure or, if desired, exposure may first take place and then subsequently the transfer sheet of insulating material may be fed to the previously exposed drum carrying a uniform layer of selectively charged particles for transfer selectively of an image to the transfer member. Also, although the present invention has been described with reference to document copying it is to be understood that it is of general application to the reproduction or copying of any photographic image including three-dimensional objects, scenes and the like. Similarly, by offering new possibilities of developer materials and web materials to which the image is transferred to or formed on, it is seen that many new utilizations of the art of xerography exist. For example, it now becomes more feasible to consider using magnetic materials in the developer particles. Magnetic materials tend to make the developer too conductive for normal uses in xerography. However, many uses of magnetic images exist. In accordance with this invention magnetic particles may be used for image development. Other benefits which will be readily apparent to those skilled in the art follow from this invention, and variations and modifications which are obvious to those skilled in the art and can be made without departing from the scope of this invention are intended to be encompassed within the appended claims.

What is claimed is:

1. The method of producing a powder image on an insulating transfer surface which comprises, in sequence:

forming a substantially uniform layer of charged powder particles on the surface of a photoconductive insulating layer supported on a conductive base;

placing the transfer surface in contact with said layer of charged particles with an electrical field externally applied behind and across said transfer surface, said field of direction and magnitude to oppose movement of the charged particles toward said transfer surface and to create a condition of no field between said insulating surface and the charged particles;

exposing said photoconductive insulating layer to a pattern of light and shadow to selectively vary the conductivity through said photoconductive insulating layer, and, simultaneously therewith, reducing said electrical field in accordance with the varying conductivity through the areas of the photoconductive layer exposed to light to maintain a condition of no field between said insulating surface and the particles on said areas exposed to light;

whereby a powder image is transferred to the insulating transfer surface from the non-exposed areas in accordance with the shadow areas of said pattern.

2. The method of claim 1 in which the electrical resistivity of said powder particles is no greater than 10^{-4} ohm-centimeters.

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2,808,328	10/57	Jacob	96—1
2,817,598	12/57	Hayford	96—1 X
2,839,400	6/58	Moncrieff-Yeates	96—1
2,843,084	7/58	Hayford	96—1 X
2,862,816	12/58	Moncrieff-Yeates	96—1
2,901,374	8/59	Gundlach	96—1 X
2,940,847	6/60	Kaprelian	96—1
2,968,552	1/61	Gundlach	96—1
2,968,553	1/61	Gundlach	96—1

NORMAN G. TORCHIN, *Primary Examiner.*

MILTON STERMAN, PHILIP E. MANGAN,

Examiners.