March 10, 1964 F. A. SCHWERTZ 3,124,457

DIFFERENTIAL IMAGE TRANSFER SYSTEM

Filed April 2, 1962 3 Sheets-Sheet 1

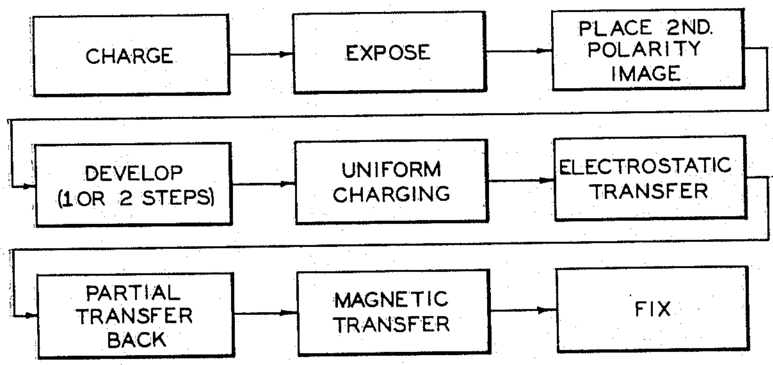

FIG. 1

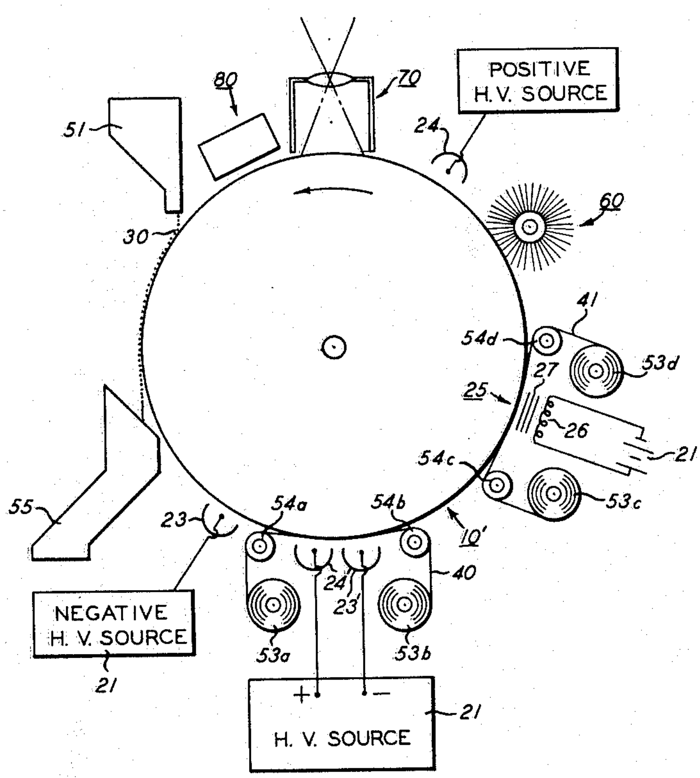

FIG. 5

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DIFFERENTIAL IMAGE TRANSFER SYSTEM

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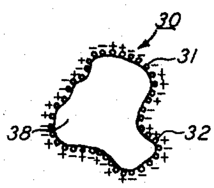

FIG. 2a

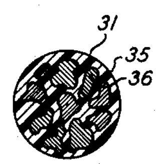

FIG. 2b

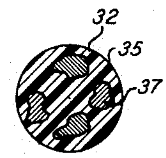

FIG. 2c

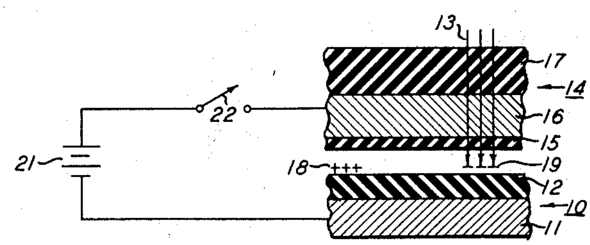

FIG. 3

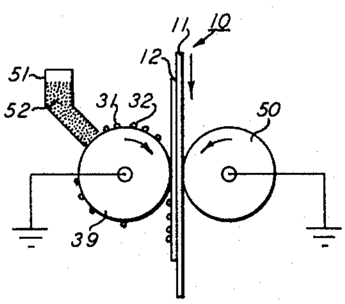

FIG. 4a

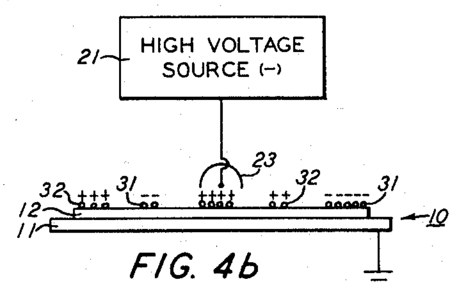

FIG. 4b

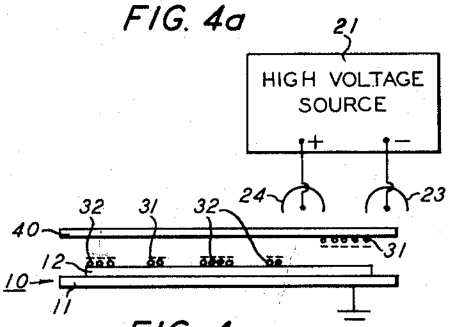

FIG. 4c

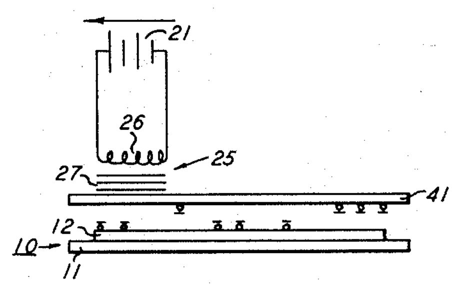

FIG. 4d

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DIFFERENTIAL IMAGE TRANSFER SYSTEM

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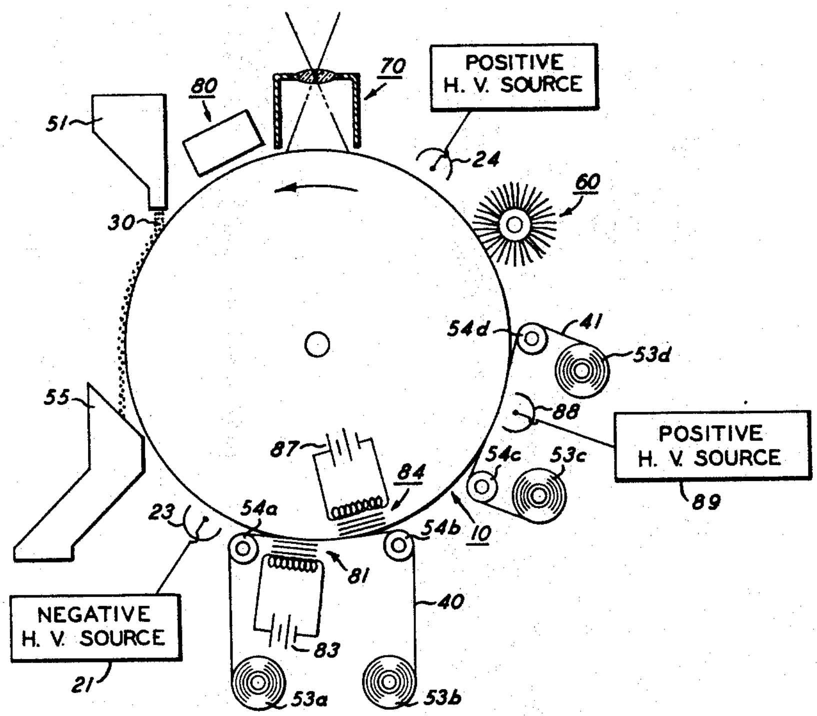

FIG. 6

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3,124,457

DIFFERENTIAL IMAGE TRANSFER SYSTEM

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Filed Apr. 2, 1962, Ser. No. 184,327
12 Claims. (Cl. 96—1)

This invention relates in general to xerography, and in particular to a method for differentially transferring the powder image adhering to an image support member by electrostatic attraction.

In xerography it is usual to form an electrostatic image on a surface. One method of doing this is to charge a photoconductive insulating surface and then dissipate the charge selectively by exposing to a pattern of activating radiation. These and other means of forming electrostatic images are set forth in U.S. 2,297,691, to C. F. Carlson. Still other means of forming electrostatic images are set forth in U.S. 2,576,047 to James P. Ebert, U.S. 2,576,447 to Ronald M. Schaffert, and U.S. 2,825,814 to Lewis E. Walkup. Whether formed by these means or any other, the resulting electrostatic pattern is conventionally utilized by the deposition of electroscopic material thereon through electrostatic attraction whereby there is formed a visible image of electroscopic particles corresponding to the electrostatic image. Alternatively, an electrostatic charge pattern may be transferred to an insulating film and then electroscopic particles deposited thereon to form the visible image. In any case, this visible image in turn may be transferred to a second surface to form a xerographic print.

Modern business and computer needs require a variety of image recording means. For many purposes, this information may be classified into groups of fixed and variable information. Many proposals exist for various combinations of xerographic and magnetic image techniques to obtain this desired differential presentation of information. Xerography, as a basic electrostatic process, has a great deal of flexibility permitting the formation of images by either optical or non-optical methods. In contrast to this, magnetic image formation requires more complicated plate structures and is limited strictly to non-optical image formation, i.e., using a stylus, a matrix, or a sheet hole piece. Thus, machines designed to record information in both electrostatic or magnetic form in order to obtain differential recording of data require the full complement of "electrostatic, magnetic and data recording instruments." Such machines are unduly cumbersome and complex. The basic xerographic process as discovered and disclosed in Carlson's basic patent on this process, U.S. 2,297,691, results in a positive-to-positive reproduction of the information to be recorded. Subsequent advances in xerography resulting in improved induction image-forming processes, and in particular in the transfer of electrostatic images (termed TESI), as described for example in U.S. 2,825,814, to Lewis E. Walkup, make possible formation of multiple electrostatic images corresponding to different informational impulses. There exists a need for a process whereby multiple visible reproductions of such multiple electrostatic images may be made with provision for transferring all of the information on an initial transfer with subsequent transfer of only a differential portion of the image.

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Thus, for example, modern billing practice often entails a wholesaler shipping directly to a customer in response to an order from a retailer. In billing such a shipment the wholesaler will send a bill to the retailer reciting quantity, destination, and price. The copy of the bill sent with the shipment generally contains only destination and quantity. To reduce the possibility of error as well as lower handling costs, it is essential to prepare both copies of the bill without the interposition of human processing as would be entailed in typing two bills. In general, it is now present practice to use carbon paper in preparing such copies and on the bill going to the customer the information such as price is blocked out. Accordingly, it is an object of the instant invention to provide means and techniques whereby differential image formation is recorded in electrostatic image formation and then utilized for the formation of a plurality of visible images or prints, the prints corresponding either to all or a portion of the differential data recorded. Other objects or advantages of the present invention, will, of course, become apparent and will immediately suggest themselves to those skilled in the art to which the invention is directed. From a reading of the following description in connection with the accompanying drawings in which:

FIG. 1 is a block diagram illustrating the process of the instant invention;

FIG. 2–*a* is a cross-section of a carrier granule coated with toner;

FIG. 2–*b* is a cross section of toner which is both ferromagnetic and electroscopic;

FIG. 2–*c* is a cross-section of a toner particle which is electroscopic;

FIG. 3 is a schematic diagram partly in cross-section of apparatus illustrating one method of forming both positive and negative electrostatic images;

FIG. 4–*a* is a schematic diagram of apparatus illustrating one means of developing two polarity images simultaneously;

FIG. 4–*b* is a schematic diagram partly in cross-section illustrating applying a uni-polarity charge to a photoconductive insulating surface having thereon a two polarity powder image;

FIG. 4–*c* is a diagrammatic view of apparatus illustrating the formation of a powder image on a transfer member containing all of the image areas of the initial image bearing member while permitting subsequent transfers of all or a portion of this information;

FIG. 4–*d* is a diagrammatic view of apparatus for transferring selective portions of the powder image to the image support member;

FIG. 5 is a diagrammatic view of apparatus for performing the process of the instant invention in a continuous manner; and,

FIG. 6 is a diagrammatic view of an alternative embodiment of the apparatus according to this invention.

For purposes of clearer explanation the present invention will be described in terms of xerography for which it is particularly suited. In the preliminary steps from which the present invention follows, it is usual in xerography to form an electrostatic image on the xerographic plate. Thus, for example, a xerographic plate **10** comprising a photoconductive insulating layer **12** overlying a conductive backing member **11** as of metal, is charged to a uniform electrostatic charge and this charge selectively dissipated by exposure to a pattern of light and shadow whereupon results an electrostatic charge pattern corresponding to the shadow pattern of the image. For the differential presentation of information, it is now essential to form a second electrostatic image on the surface of layer 12 having a polarity opposite to that of the first image formed in the conventional xerographic process. This second image may be formed using TESI processes as described in the above referred to patents or alternatively by a method known as induction image formation. If desired, both polarity electrostatic images may be formed using the induction image process. In this process a sheet of highly insulating material 15 as polyethylene terephthalate is placed on top of layer 12 and is backed up by a transparent conductive surface 16 as of tin oxide coated on a transparent support base 17 such as glass, the three layers forming a sandwich electrode 14. A potential is now applied between layers 16 and 11 by suitable high voltage source 21, the polarity of the applied potential being such that layer 11 is connected to the negative side of potential source 21 and layer 16 to the positive side during exposure (these polarities are applied when the polarity of the initial electrostatic image is positive and it is desired to produce a negative polarity electrostatic image by induction). While the potential is applied activating radiation 13 illuminates the plate in the image areas as opposed to the first step wherein the incident radiation constitutes the background areas. The use of a photographic negative as the original in the induction step assures that the initial image is not erased during the second exposure. Care should be taken to assure that the exposures are carried out in register. When the radiation impinges on the layer 12 it creates hole-electron pairs. Upon application of fields from source 21 the holes migrate through layer 12 to conductive backing 11 while electrons 19 are retained on the surface layer 12 thereby creating image areas of negative polarity charges. These negative charges 19 are trapped on the surface of layer 12 facing illumination 13. When this illumination is shut off, whereupon the potential source may be removed by opening switch 22. On removing layer 15 there is now presented a surface having image areas of both positive and negative electrostatic potential. In the process described above, the insulating layer 15 is tightly pressed against photoconductive surface 12. However, even under these conditions there is inherently a thin layer of air between layer 12 and layer 15. The drawing is exaggerated to more clearly depict the electrical relationship. The use of layer 15 increases the voltage break-down across conductors 11 and 16 and thus the voltage which may be used to induce charge on layer 12 during illumination. In any event, the resulting positive and negative images are developed; i.e., made visible, preferably by simultaneous development, by contacting the surface bearing the electrostatic images with a carrier surface having thereon both positively and negatively charged toner particles. Such a carrier is illustrated in FIG. 2–*a* wherein there is shown a cross-section of a granular carrier particle 38 having electrostatically coated thereon toner particles 31 and 32. In this case the negatively charged toner particles 31 are both electroscopic and ferromagnetic and are shown in more detail in FIG. 2–*b*. As are illustrated, such particles comprise a ferromagnetic pigment 36 as finely divided higher ferrite, etc., dispersed in an electrostatically insulating resin 35. The positively charged toner particles 32 illustrated in more detail in FIG. 2–*c* comprise a similar electrically insulating resin binder 35 by having dispersed therein a non-ferromagnetic pigment 37 as carbon black, etc. Alternatively, the dye such as nigrosine may be used. Such developer compositions are more fully described in U.S. Patent 3,013,890 to William Bixby. To assure crisp, sharp reproduction of

image areas it is essential in using such a two-component developer composition to draw the lines of force to the electrostatic image areas externally above the image-bearing surface. This is done by positioning an electrostatically conductive electrode closely adjacent to the image-bearing surface during development. One means for doing this in conventional cascade development is to utilize a device known as a tone tray which is more fully illustrated in U.S. Patent 2,777,418 to Gundlach. An alternative means is illustrated in 4–*a*. As there shown a xerographic plate 10 having thereon areas of both positive and negative electrostatic charge is passed between two electrically conductive grounded rolls 39 and 50 as of electrically conductive rubber. The surface of roller 39 acts as a substitute for carrier particle 38 and is covered with electrostatically coated toner particles 31 and 32. Both cylinders 39 and 50 are rotatably mounted on and longitudinally affixed. A suitable means as a hopper 51 holds a supply 52 of two types of toner in a position so as to assure rubbing contact between the surface and cylinder 39 and the toner supply 52. The toners in supply 52 are selected according to their position in the triboelectric series relative to the material comprising the surface of cylinder 39 so that one of the two toners is given a positive charge during this rubbing contact while the other is given a negative charge. Thus, the surface of drum 39 becomes coated with positively charged toner particles 32 and negatively charged toner particles 31 just as does the granular carrier of FIG. 2–*a*, the toner particles being bound to the surface of drum 39 by the combined forces of friction and electrostatic attraction. As stated cylinder 39 is desirably formed of conductive rubber or if necessary to assure the right triboelectric properties may be coated with a plastic having the desired triboelectric properties relative to the toner particles. Thus, cylinder 39 constitutes a grounded conductive electrode closely positioned relative to surface 12 of xerographic plate 10 bearing the electrostatic images thereon. Hence cylinder 39 acts as a development electrode to draw the lines of force of the electrostatic images externally above the surface of layer 12. Toner particles 31 and 32 are attracted to layer 12 and deposit thereon in faithful conformity to the electrostatic image pattern thereon. Thus cylinder 39 serves the triple function, first, of supplying the toner particles for development of the electrostatic image, second, drawing the lines of force of the electrostatic lines of force externally above the surface of layer 12 thereby preventing blurring due to fringe effects, and, third, preventing deposition of toner particles in non-image areas due to the electrostatic attraction between the surface of cylinder 39 and the toner particles 31 and 32. A uniform polarity electrostatic charge is now applied to the resulting powder image as shown in FIG. 4–*b*. This is most conveniently accomplished by passing over the surface of layer 12 a corona charging means as shown in U.S. Patents 2,777,957 to Walkup and 2,836,725 to Vyverberg thereby supplying the uniform polarity charge to layer 12 and the outer image thereon. On exposure to light there remains on the surface of layer 12 the powder image corresponding to both the first and second sheet of information to be reproduced, the powder having a single plurality electrostatic charge but the areas differing in that the differential information only is both electroscopic and ferromagnetic. An image transfer member 40 is now positioned in contact with the surface of layer 12 bearing the unipolarity powder image. This is illustrated in FIG. 4–*c*. The spacing between the transfer member 40 and layer 12 illustrated in the drawing is merely an exaggeration to more clearly illustrate the relationships involved. In practice, member 40 will physically rest on the surface of layer 12. Next, an electrostatic charge or field is applied between member 40 and conductive backing 11 by suitable means such as for example the deposition with a corona generator of the type in the Walkup and Vyverberg patents of corona discharge on the back of member **40**, the polarity being such as to transfer the image body from layer **12** to member **40**. Next, and without separating member **40** from layer **12** the field of opposite polarity is applied between the two members for example, by deposition of charge of opposite polarity on the same surface of member **40** as was used to effect the initial transfer. This is illustrated schematically in FIG. 4–*c* which shows a first corona discharge electrode **24** connected to a source of positive potential voltage passing over the back of member **40** followed by a second corona discharge electrode **23** connected to a source **21** of negative high voltage potential. The result of this operation is that the preponderance of the image body containing powder **31** and **32** has been retransferred to layer **12** in image configuration but a substantial portion of the image body stays on member **40** in the form of a residual image thereon. Member **40** is then withdrawn and the powder image thereon permanently affixed to the member as by heat solvent vapor, a plastic spray or other means. The differential image transfer is accomplished as illustrated in FIG. 4–*d*. An electromagnet **25** comprising windings **26** around a magnetic core **27** connected to a voltage source **21** is passed over the back of a second image transfer member **41**. Those image areas containing powder which is both electroscopic and ferromagnetic is transferred in image configuration to support member **41** as shown in FIG. 4–*d*. As in FIG. 4–*c* member **41** is in physical contact with the surface of layer **12**, the spacing having been exaggerated to show the relationships.

A device is illustrated in FIG. 5 in diagrammatic form for carrying out the operations of the instant process in a continuous manner. As they are shown, the apparatus includes a xerographic plate **10** in the form of a cylindrical drum rotatably mounted on its longitudinal axis. Located sequentially around the circumference of the drum are means for carrying a uniform sensitizing charge on the surface of the drum as by corona discharge **24**. The thus sensitized surface is then exposed to the pattern of light and shadow by suitable optical means as the photographic enlarger **70**, thus forming a pattern of electrostatic images on the surface of drum **10** corresponding to the image to be reproduced. A second pattern of electrostatic charges is now placed on the surface of drum **10** as by induction image formation as described above or by a TESI process using a matrix electrode array or shaped character electrode cylinder **80** as described for example in U.S. Patent 2,919,967 to Schwertz. The two polarity electrostatic image on the surface of drum **80** is now made visible by cascading over the surface of drum **10** a developer composition **30** comprising a carrier with the two polarity toner thereon as shown and described in connection with FIG. 2 above. Developer **30** is cascaded across the surface of drum **10** from hopper or other means **51** being collected at the other end of its path of travel over the arc of drum **10** by suitable means as a bin **55**. A development electrode not shown is closely positioned next to the surface of drum **10** along the arc of travel of developer particles **30**. As a result of this development step there is now placed on the surface of drum **10** a visible powder image consisting of both positive and negative polarity particles corresponding accurately and faithfully to the pattern of electrostatic charges to be reproduced. A uniform electrostatic charge is now placed on the powder bearing surface as by corona discharge with corona electrode **23** powered by a suitable high voltage source **21**. An image transfer member feed from feed roll **53*a*** to take-up roll **53*b*** is urged into firm contact with an arc of drum **10** by rollers **54*a*** and **54*b***. During this arc of contact between the surface of drum **10** and transfer unipolarity member **40** the powder image is caused to transfer across the surface of drum **10** to transfer member **40** by applying to the back of transfer member **40** the uniform electrostatic charge by corona discharge electrode **24** of polarity opposite the polarity of charge impressed on said powder image by corona electrode **53**. The major portion of the powder image now adhering to transfer image **40** is now transferred back to the surface of drum **10** by applying electrostatic charge to the back of transfer member **40** with electrode **23** the same polarity as that applied by corona electrode **23**. A substantial portion of the powder remains affixed to transfer member **40** after the retransference of the powder image. In effect, this transfer and retransfer by means of opposing polarity electrostatic fields impressed across the transfer member while maintaining contact between the transfer member and the image bearing surface divides the image bearing surface into two portions, a substantial portion adhering to the transfer member at the conclusion of the process while the major portion remains on the image bearing surface of drum **10**. The powder image thus formed on transfer member **40** faithfully conforms to the powder image on the surface of drum **10** and represents all of the image areas on drum **10** as the powder used to develop both the positive and negative portions of the original electrostatic image were electroscopic. The drum surface now passes through a magnetic transfer station wherein a transfer member **41** supplied by feed roll **53*c*** is fed to take-up roll **53*d*** is urged into firm contact with an arc of drum **10** by rollers **54*c*** and **54*d***. While such contact is maintained, lines of magnetic flux are passed through transfer member **41** and drum **10** by electromagnet **25** comprising windings **26** powered by a suitable voltage supply **21** on magnetic core **27**. Whereas the toners used to develop both the positive and negative portions of the electrostatic image are electroscopic, only the toner used for one of the two polarities is also ferromagnetic. Hence, only the information represented by the electroscopic, ferromagnetic toner or a partial image is transferred to image transfer member **41**. The powder image adhering to transfer members **40** and **41** is desirably permanently affixed to the transfer members by suitable means as heat solvent, vapor fixative, lacquer, etc. Residual powder remaining on the surface of drum **10** is removed therefrom after the magnetic transfer station by suitable means as a rotating fur brush **60**.

Alternatively, magnetic transfer to the first copy sheet may take place prior to electrostatic transfer to the second sheet. This embodiment of the invention is illustrated in FIG. 6 where like numerals are used to identify apparatus components which are identical with those of FIG. 5. Identical structural components include the cylindrical xerographic drum **10** and those components around the drum periphery beginning with cleaning brush **60** and going around the drum in a counterclockwise direction to corona electrode **23**. In addition webs **40** and **41**, rolls **54*a*** through **54*d***, feed rolls **53*a*** and **53*c*** and take-up rolls **53*b*** and **53*d*** may also be identical in structure and function with the identically numbered components of the FIG. 5 embodiment. It is to be noted, however, that in place of corona electrodes **23** and **24** in the FIG. 5 embodiment there are substituted two electromagnets, **81** behind web **40** and **84** within the drum **10** connected to suitable sources of potential **83** and **87** respectively. In addition, electromagnet **25** behind web **41** in the FIG. 5 embodiment of the invention has been replaced by a corona electrode **88** connected to a suitable source of positive high voltage **89**. Up to the point where the drum **10** comes in contact with web **40**, the process steps of the FIG. 6 embodiment are identical with that of the FIG. 5 embodiment. However, at this point, it is seen that the portion of the particles making up the developed image on the surface of drum **10** which include a ferromagnetic component are transferred to copy web **40** by a electromagnet **81** and when web 40 passes under electromagnet 84 a substantial portion of these ferromagnetic toner particles are retransferred back to the drum surface. The drum then continues on in its rotation, coming into contact with web 41, and since all developer particles or toner including those particles containing a ferromagnetic component have previously been uniformly charged to a negative polarity by corona electrode 23 all of the particles remaining on the drum surface at this point are transferred to web 41 by the positive corona electrode 88 behind this web. The result of the operation of this apparatus is that the one image which is developed with that polarity of toner particles which contain a ferromagnetic component is formed on copy web 40 while a composite image including both the image developed with toner particles containing a ferromagnetic component and the image developed with toner particles which do not contain a ferromagnetic component is transferred to copy web 41.

This application is a continuation-in-part of my copending application S.N. 664,136, now Patent No. 3,045,644.

Another alternative is using adhesive transfer to transfer a portion of the toner particles to the first copy surface prior to magnetic transfer of the remaining magnetic particles to the second copy surface.

What is claimed is:

1. An electrostatic apparatus for forming differential images on copy surfaces comprising:
(*a*) an insulating image surface,
(*b*) means to apply two image patterns of opposite polarity electrostatic charge in register with each other to said insulating image surface,
(*c*) means to apply finely divided electroscopic developing particles charged to both polarities to said images, the particles charged to one of said polarities also being magnetic,
(*d*) means to charge the developing particles of both developed image patterns to one polarity,
(*e*) means to transfer a substantial portion of said particles on said images to a first copy surface,
(*f*) and means to magnetically transfer the remaining magnetic particles to a second copy surface.

2. An electrostatic apparatus for forming differential images on copy surfaces comprising:
(*a*) an insulating image surface,
(*b*) means to apply two image patterns of opposite polarity electrostatic charge in register with each other to said insulating image surface,
(*c*) means to apply finely divided electroscopic developing particles charged to both polarities to said images, the particles charged to one of said polarities also being magnetic,
(*d*) means to charge the developing particles of both developed image patterns to one polarity,
(*e*) means to transfer the particles on said images to a first copy surface,
(*f*) means to transfer a substantial portion of said particles back to said image surface,
(*g*) means to magnetically transfer the magnetic particles in said retransferred image to a second copy surface.

3. An electrostatic apparatus for forming differential images on copy surfaces comprising:
(*a*) an insulating image surface,
(*b*) means to apply two image patterns of opposite polarity electrostatic charge in register with each other to said insulating image surface,
(*c*) means to apply finely divided electroscopic developing particles charged to both polarities to said images, the particles charged to one of said polarities also being magnetic,
(*d*) means to charge the developing particles of both developed image patterns to one polarity,

(*e*) means to electrostatically transfer the particles on said images to a first copy surface,
(*f*) means to electrostatically transfer a substantial portion of said image particles back to said image surface, and
(*g*) means to magnetically transfer the magnetic particles in said retransferred image to a second copy surface.

4. Apparatus according to claim 1 in which said means to charge the developing particles of both the developed image patterns to one polarity comprises a corona generator.

5. Apparatus according to claim 1 in which said electrostatic transfer means comprise opposite polarity corona generators.

6. An electrostatic apparatus for forming differential images on copy surfaces comprising:
(*a*) an insulating image surface,
(*b*) means to apply two image patterns of opposite polarity electrostatic charge in register with each other to said insulating image surface,
(*c*) means to apply finely divided electroscopic developing particles charged to both polarities to said images, the particles charged to one of said polarities also being magnetic,
(*d*) means to magnetically transfer the magnetic developing particles making up one of said images to a first copy surface,
(*e*) means to magnetically retransfer a substantial portion of said magnetic particle image back to said image surface,
(*f*) means to charge the developing particles of both developed image patterns to one polarity, and
(*g*) means to electrostatically transfer said one polarity particles to a second copy surface.

7. Apparatus according to claim 4 in which said means to charge the developing particles of both developed image patterns to one polarity comprises a corona generator.

8. Apparatus according to claim 4 in which said means to magnetically transfer said magnetic developing particles to said first copy surface comprises a magnet on the opposite side of said copy surface from said image surface.

9. Apparatus according to claim 4 in which said means for retransferring a substantial portion of said magnetic particles back to said image surface comprises a magnet on the opposite side of said image surface from said first copy surface.

10. A process for the formation of two differential images comprising:
(*a*) placing two opposite polarity latent electrostatic charge patterns in register with each other on an insulating image surface,
(*b*) developing said two charge patterns by bringing finely divided electroscopic material, portions of which are charged to each polarity, into proximity with said charge patterns, the electroscopic material charged to one of said polarities also being ferromagnetic,
(*c*) charging the particles residing on said two developed images to one polarity,
(*d*) transferring a portion of said images from said image surface to a copy surface,
(*e*) and then magnetically transferring said ferromagnetic particles to a second copy surface.

11. A process according to claim 8 in which at least one of said electrostatic charge patterns is placed on said surface by a TESI discharge.

12. A process for the formation of two differential images comprising:
(*a*) placing two opposite polarity latent electrostatic charge patterns in register with each other on an insulating image surface,
(*b*) developing said two charge patterns by bringing finely divided electroscopic material, portions of

which are charged to each polarity, into proximity with said charge patterns, the electroscopic material charged to one of said polarities also being ferromagnetic,

(*c*) charging the particles residing on said two developed images to one polarity,

(*d*) magnetically transferring a portion of said magnetic particle image from said surface to a copy surface,

(*e*) and then electrostatically transferring remaining particles on said image surface to a second copy surface.

References Cited in the file of this patent

UNITED STATES PATENTS

3,013,890	Bixby	Dec. 19, 1961
3,045,587	Schwertz	July 24, 1962