MULTIPLE COPY SELECTIVE RE-WETTING PRINTING

Original Filed Dec. 24, 1969

Fig. 1.

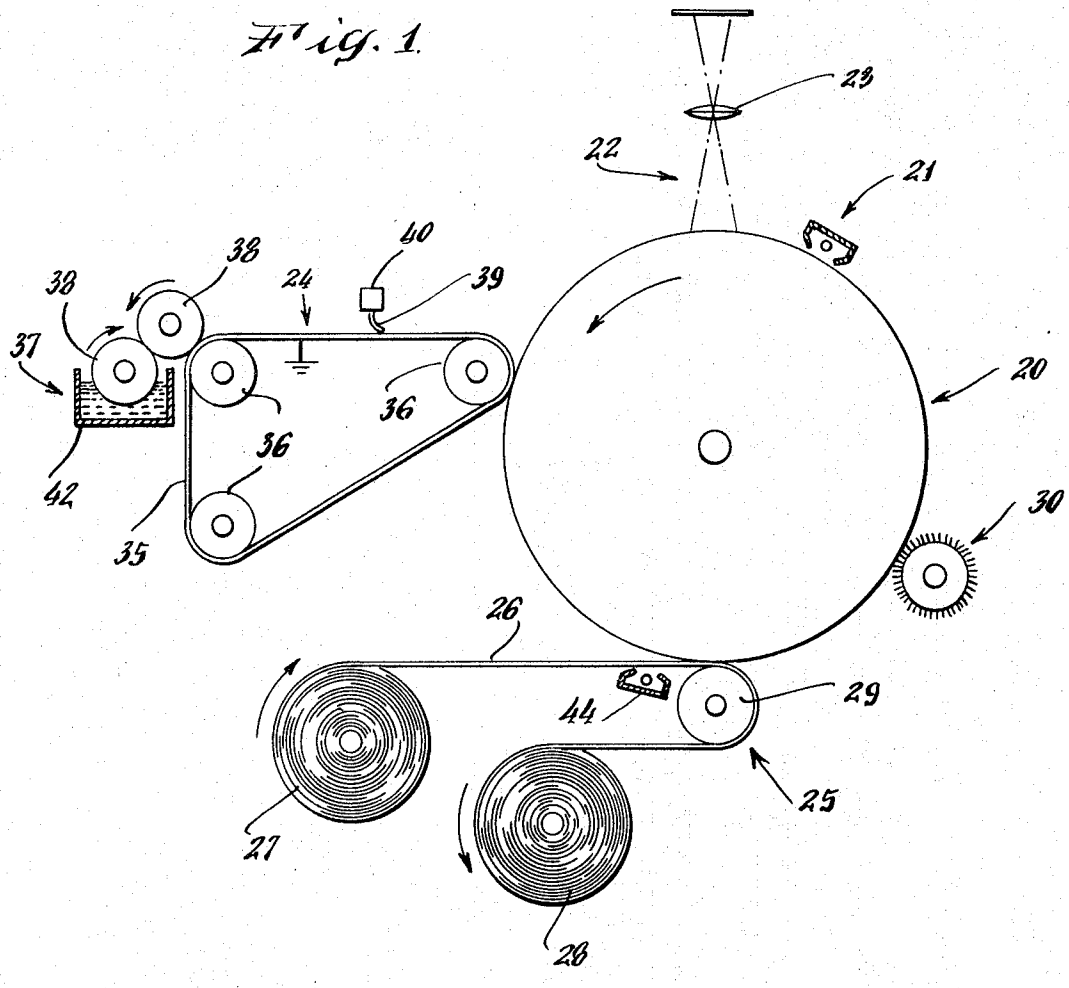
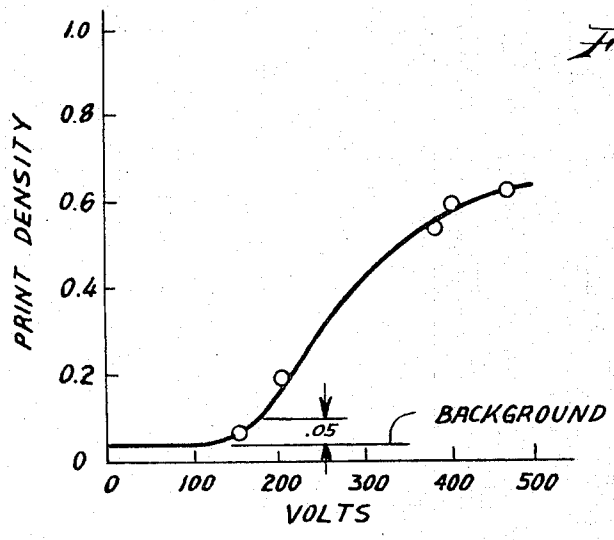


Fig. 2.



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3,748,126

MULTIPLE COPY SELECTIVE RE-WETTING PRINTING

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Int. Cl. G03g 13/14
U.S. Cl. 96—1.4 12 Claims

ABSTRACT OF THE DISCLOSURE

A method is provided for producing a plurality of copies of an original by an electrostatographic process requiring only a single electrostatic latent image. After development of the latent image with liquid developer, the developed image is partially transferred to a copy web leaving behind a residual liquid film in image configuration. This residual liquid film is then redeveloped with liquid developer to form additional copies without further need of the latent image. Redevelopment can be accomplished after discharge of the latent image to below the development threshold.

This application is a continuation-in-part of Ser. No. 887,838, filed Dec. 24, 1969, now abandoned.

This invention relates in general to electrostatographic reproduction and, in particular, to a new and improved method for the production of a plurality of electrostatographic prints from one electrostatic latent image.

The formation and development of images on the surface of photoconductive materials by electrostatic means is well known. The basic electrostatographic process, as taught by C. F. Carlson in U.S. Pat. 2,297,691, involves placing a uniform electrostatic charge on a photoconductive insulating layer, exposing the layer to a light-and-shadow image to dissipate the charge on the areas of the layer exposed to the light and developing the resulting electrostatic latent image by depositing on the image a finely-divided electroscopic material referred to in the art as "toner." The toner will normally be attracted to those areas of the layer which retain a charge, thereby forming a toner image corresponding to the electrostatic latent image. This powder image may then be transferred to a receiving surface such as paper. The transferred image may subsequently be permanently affixed to a support surface by heat. Instead of latent image formation by uniformly charging the photoconductive layer and then exposing the layer to a light-and-shadow image, one may form the latent image by directly charging the layer in image configuration. The powder image may be fixed to the photoconductive layer if elimination of the powder image transfer step is desired. Other suitable fixing means such as solvent or overcoating treatment may be substituted for the foregoing heat fixing step.

Similar methods are known for applying the electroscopic particles to the electrostatic latent image to be developed. Included within this group are the "cascade" development technique disclosed by E. N. Wise in U.S. Pat. 2,618,552; the "powder cloud" technique disclosed by C. F. Carlson in U.S. Pat. 2,221,776 and the "magnetic brush" process disclosed, for example, in U.S. Pat. 2,874,063.

Development of an electrostatic latent image may also be achieved with liquid rather than dry developer materials. In conventional liquid development, more commonly referred to as electrophoretic development, an insulating liquid vehicle having finely divided solid material dispersed therein contacts the imaging surface in both charged and uncharged areas. Under the influence of the

electric field associated with the charged image pattern the suspended particles migrate toward the charged portions of the imaging surface separating out of the insulating liquid. This electrophoretic migration of charged particles results in the deposition of the charged particles on the image surface in image configuration.

A further technique for developing electrostatic latent images is the liquid development process disclosed by R. W. Gundlach in U.S. Pat. 3,084,043 hereinafter referred to as polar liquid development. In this method, an electrostatic latent image is developed or made visible by presenting to the imaging surface a liquid developer on the surface of a developer dispensing member having a plurality of raised portions or "lands" defining a substantially regular patterned surface and a plurality of portions depressed below the raised portions or "valleys." The depressed portions of the developer dispensing member contain a layer of relatively conductive liquid developer which is maintained out of contact with the electrostatographic imaging surface. Development is achieved by moving the developer dispensing member loaded with liquid developer in the depressed portions into developing configuration with the imaging surface. The liquid developer is believed to be attracted from the depressed portions of the applicator surface in the charged or image areas only. The developer liquid may be pigmented or dyed. The development system disclosed in U.S. Patent 3,084,043, differs from electrophoretic development systems where substantial contact between the liquid developer and both the charged and uncharged areas of an electrostatic latent imaging surface occurs. Unlike electrophoretic development systems, substantial contact between the polar liquid and the areas of the electrostatic latent image bearing surface not to be developed is prevented in the polar liquid development technique. Reduced contact between a liquid developer and the non-image areas of the surface to be developed is desirable because the formation of background deposits is thereby inhibited. Another characteristic which distinguishes the polar liquid development technique from electrophoretic development is the fact that the liquid phase of a polar developer actually takes part in the development of a surface. The liquid phase in electrophoretic developers functions only as a carrier medium for developer particles.

An additional liquid development technique is that referred to as "wetting development" or selective wetting as described in U.S. Pat. 3,285,741. In this technique, an aqueous developer uniformly contacts the entire imaging surface and due to the selective wetting and electrical properties of the developer substantially only the charged areas of the imaging surface are wetted by the developer. The developer should be relatively conductive having a resistivity generally from about 10^6 to 10^{10} ohm-cm. and having wetting properties such that the wetting angle measured when placed on the imaging surface is smaller than 90 degrees at the charged areas and greater than 90 degrees at the uncharged areas.

Although liquid development provides certain advantages over dry development, such as a reduction in moving parts and a reduction in size of the developer station, one of the problems associated with liquid development has been the difficulties encountered in cleaning the electrostatographic imaging surface after the developed image has been transferred. It would be desirable to provide a method whereby more efficient utilization of a given reproduction cycle could be obtained thereby increasing the output per cycle and reducing the amount of cleaning required per copy.

An electrostatic method of making multiple copies of an image is described in U.S. Pat. No. 3,363,555 to R. G. Olden. According to this patent, an electrostatic image is formed on an insulating surface and then developed ac-

cording to known techniques. The developed image is then transferred to a copy substrate and the original latent image is redeveloped. Redevelopment is said to be possible because the original latent image is not fully dissipated by the first development step. This second image can then be transferred to a copy sheet, and the original latent image redeveloped several more times. With each successive redevelopment and transfer step, the magnitude of the charge of the original latent image becomes decreased; however, for redevelopment to occur the magnitude of charge of the latent image must always be above the development threshold for the particular system. The development threshold is defined as the minimum voltage on a dry electrostatographic surface which produces a barely perceptible developed image contrast.

A common feature of all of the previously discussed imaging systems is that they depend upon the presence of a latent electrostatic image to achieve development and redevelopment. It would be desirable to have a method for producing a plurality of copies from an original, which would allow the production of copies even after the discharge of the latent image to below the development threshold for the system.

Accordingly, it is an object of the present invention to provide methods which overcome the above-noted deficiencies.

It is another object of the present invention to provide a method for the production of a plurality of electrostatographic prints from one electrostatic latent image after discharge of the latent image to below the development threshold for the system.

It is another object of this invention to provide a method for increasing the efficiency of a given reproduction cycle thereby reducing the cleaning problems normally associated with liquid developer.

It is still another object of the present invention to provide a means of simplifying or eliminating the cleaning of the electrostatographic imaging surface in a liquid development process.

It is a still further object of the present invention to provide a method for rapidly retrieving an original document while making multiple copies thereof.

These, as well as other objects, are accomplished in the present invention, which provides a method for the production of a plurality of copies from an original comprising:

(a) Forming an electrostatic latent image on an electrostatographic surface;

(b) Developing said electrostatic latent image by contacting said image with a liquid developer;

(c) Contacting said developed image with a transfer web under pressure thereby providing a partial transfer of said developer in image configuration to said web and retaining a residual liquid film in image configuration on said electrostatographic surface;

(d) Developing the residual liquid film image with said liquid developer after discharge of the latent image to below the development threshold; and

(e) Contacting said developed residual image with a transfer web under pressure thereby partially transferring said developer in image configuration to said web to obtain a plurality of electrostatographic copies.

The present invention will become more apparent from the following specification and drawings in which:

FIG. 1 is a schematic diagram of one embodiment of an electrostatographic apparatus operating in accordance with the present invention; and

FIG. 2 is a graph illustrating the development threshold for an exemplary system.

Referring now to FIG. 1, there is illustrated a continuously operating electrostatographic apparatus employing a rotatable electrostatographic surface in the form of a drum generally designated **20** comprising an electrically conductive support base having on its surface a photoconductive insulating layer such as, for example, a vitreous or amorphous selenium coating on a metal base or a layer of a photoconductive pigment in a suitable insulating binder as is well known in the electrostatographic arts. The drum **20** is rotatably mounted so as to move past a series of electrostatographic stations for image formation. Positioned around the drum is a charging electrode **21**, such as, for example, a high voltage corona discharge electrode adapted to supply ions for electric charges to the drum surface. At an exposure station generally designated **22** an image to be reproduced is projected onto the drum surface by means of a lens **23** desirably operating in conjunction with slit exposure mechanisms (not shown) synchronized to the motion of the drum.

At a development station generally designated **24** is located a continuous or cyclic liquid development mechanism as will be described more completely hereinafter. At this development station, the electrostatic latent image on the drum is developed or made visible by deposition of developer thereon in image configuration.

Next in the direction of rotation following development station **24** is a transfer station, generaly designated **25**, at which a suitable transfer web **26** such as a web of paper or the like is fed from a supply roll **27** to a take up roll **28** passing between the drum **20** and a transfer roll **29**. Inasmuch as development according to the present invention generally contemplates the use of liquid developer, transfer by means of pressure alone is generally satisfactory although it is to be understood that additional transfer means such as electrostatic fields may be employed if desired. It has been found that a transfer pressure ranging between about 0.5 and about 8 pounds per linear inch maintained along the line of contact between the drum and transfer web is sufficient to cause the developer to be transferred in image configuration to the transfer web. Preferably, pressures of from about 2 to about 3 pounds per linear inch are employed. The surface of the drum then moves past an optional cleaning station generally designated **30** where residual developer material, if any, may be removed from the drum surface to prepare the drum for recycling past the electrostatographic operational stations.

At development station **24** is positioned a mechanism for development in accordance with one embodiment of the present invention. Suitably mounted to bear against the drum **20** and to move simultaneously with the surface of the drum is a liquid developer dispenser **35**. This dispenser, in general, comprises a substantially uniformly patterned or grooved surface applicator such as a roller or an endless web or belt developer dispensing member such as, for example, that described in the Gundlach patent, U.S. 3,084,043 and which includes, for example, a developer receptive support base bearing a raised pattern of developer repellent spacing material. A suitable series of guide rolls **36** guide the web in a continuous path into contact with the drum surface and into a developer supply station generally designated **37**. At station **37**, a suitable developer supplying means serves to apply marking material or liquid developer to the surface of a developer dispensing web **35**. The developer supplying means optionally may include rollers **38** loading at a developer source **42**. Desirably, a wiper **39** mounted on a support **40** is positioned to bear against the developer dispensing web disposed between the developer supply station **37** and drum **20** so as to remove excess developer from dispensing web **35** after loading and prior to its use in development. Alternatively, endless web **35** may be omitted and the surface characteristics of this member may be incorported into a roller, as for example roller **38** illustrated contacting web **35**, and this roller may be positioned to directly contact the surface to be developed. The development station **24** can be operated continuously or cyclically. For cyclic operation, the dispensing web **35** can be intermittently disengaged from pressure contact with drum **20**.

In operation, an electrostatic latent image is formed on the electrostatographic surface, for example, by charging the drum surface and exposing it to a light image to be reproduced. The image bearing drum surface then moves into the development station where it is contacted with developer dispensing web **35** and selectively attracts developer from the dispensing web in response to the charge pattern on the drum. The drum surface containing developer in image configuration then moves to the transfer station to transfer the developer in image configuration to the print receiving web to form the electrostatographic print.

After the initial print has been made, the electrostatographic surface containing the residual developer in image configuration continues to rotate, but bypasses all operational stations with regard to additional image formation, i.e., the charging and exposure stations. It has been found in accordance with the present invention that the residual developer image is sufficient by itself to enable multiple copies to be obtained without further charging or imaging. Thus, according to the present invention it is possible to produce additional copies even after the latent image has been discharged to below the development threshold.

As noted above, the development threshold is defined as the minimum voltage on a dry electrostatographic surface which, when developed, produces a barely perceptible developed image contrast. It has been determined by experience that images displaying a contrast below about 0.05 density units above background are barely perceptible; and, this numerical value is therefore selected to define a barely perceptible image. The graph in FIG. 2 shows the relationship between developed (or transferred) density and the magnitude of the potential of an electrostatic latent image on an electrostatographic surface. The curve represents the characteristics for a polypropylene glycol based ink which is similar to the inks described in the examples below. It is noted that the development threshold will vary for various inks and electrostatographic surfaces, but that all systems have their characteristic development threshold.

The method of the present invention will allow the production of additional copies by selective re-wetting of the residual developer image after discharge of electrostatic latent image to below the development threshold. The manner in which the latent image becomes discharged is not critical to the present invention. The latent image may be discharged during development where the liquid developer is highly conductive. Likewise the latent image may be discharged due to dark decay. It is also possible, and a feature of this invention, that the latent image may be formed and developed in the dark in conventional manner and then directly exposed to ambient light for any one of a number of reasons. For example, it may be desirable to form the first copy in a machine which has charging and exposure stations and then remove the copy to a second, less-complex machine for duplicating without the need for charging and exposing for each copy.

Referring again to FIG. 1, the residual developer image on the electrostatographic surface is returned to the development station wherein additional developer is deposited thereon in image configuration. Thereafter, the redeveloped image is passed to the transfer station where the developer is partially transferred to the print receiving web in image configuration to form a plurality of electrostatographic prints. Although not considered necessary, the transfer of the developed image from the drum surface to the support material can, if desired, be aided by means of a corona transfer device **44** located at or immediately before the line of contact between the support material and the rotating drum. In operation, the electrostatic field created by the corona transfer device is effective to tack the support material electrostatically to the drum surface, whereby the support material moves synchronously with the drum while in contact therewith. Simultaneously with the tacking action, the electrostatic field is effective to attract the developer in image configuration from the drum surface and cause it to adhere electrostatically to the surface of the support material. Although the use of pressure alone is generally satisfactory to effect transfer, it is considered preferable to employ both pressure and a corona transfer device conjointly to obtain a plurality of electrostatographic prints.

Although the present invention has been described with reference to continuous redevelopment of the partially transferred image, intermittent or periodic redevelopment is also considered to be within the scope of the present invention and has been found effectual in obtaining a plurality of electrostatographic prints from a single electrostatic latent image.

After the desired number of multiple prints are obtained, the cleaning station **30** can be engaged to remove any residual developer material from the drum and to prepare the drum for recycling past the electrostatographic operational stations.

Although the invention has been described with reference to a continuously operating electrostatographic machine employing a rotatable drum bearing a photoconductive surface, the process described herein is equally applicable and suitable for use with any electrostatographic imaging surface of either a photoconductive or non-photoconductive material and of any suitable configuration including drums, webs, belts or plates. Any surface which is capable of receiving and holding a charge pattern for a short period of time can be suitably employed. Typical photoconductive materials include selenium, selenium alloys and binder compositions comprising zinc oxide, cadmium sulfide, cadmium sulfo selenide, and the organic photoconductors including phthalocyanine binder coatings and polyvinyl carbazole. Particularly preferred materials are selenium or selenium alloy coated drums, paper coated with a zinc oxide binder layer and paper coated with a phthalocyanine binder composition. Most particularly preferred for use in the present invention are electrostatographic surfaces comprising organic or inorganic photoconductive binder compositions applied to suitable webs such as, for example, paper coated with a zinc oxide binder layer or a phthalocyanine binder layer. Such electrostatographic surfaces can be employed conveniently and economically on a one-time basis thereby eliminating the need for cleaning the surface prior to re-use. Thus, with such imaging surfaces, an image need only be formed once, multiple copies can be obtained therefrom in accordance with the present invention and then, the imaging surface can be discarded, avoiding the troublesome cleaning step. Typical of materials for non-photoconductive electrostatographic surfaces are polyethyleneterephthalate, polystyrene, and other organic and inorganic materials capable of charge retention.

Any suitable liquid developer may be employed. Specific developers may be selected from the group of polar and nonpolar liquids. To provide balance between charge retention at high resistivity and charge dissipation at low resistivity, the developers selected generally have resistivities between about 10^3 to 10^{14} ohm-cm. The liquid developers can be selected from the classes of materials used in polar ink development and selective wetting development. The most important factor in this regard is that the ink should not be so highly conductive that the electrostatic latent image is discharged before successful development of the image for the first copy. However, as noted previously, the production of copies after the first one, does not depend on the presence of an electrostatic latent image. Further copies are formed according to the present invention after the initial charge pattern is neutralized by the ink during the development step. The resistivity of the ink is a useful criterion for determining whether the initial electrostatic latent image has been discharged below the development threshold.

Generally, for typical development speeds of about 1 to 10 inches per second, relatively highly conductive liquid developers, exhibiting resistivities of less than about 10^{10} ohm-cm., substantially discharge the electrostatographic surface during the initial development step, leaving practically no residual electrostactic latent image. At slower imaging speeds, substantially complete discharge will occur with less conductive liquid developers.

The liquid developers can be prepared by suspending or dispersing a pigment within a liquid vehicle, the liquid vehicle can contain a dye dissolved in it, or the liquid vehicle can contain both a dye and a pigment. Pigmented developers in general provide better density and have better archival permanence. Desirably, the particular developers selected should have a relatively long shelf life and be compatible with the particular materials they come in contact with during the development operation. That is, the chemical attack of any single element of the developer device by the liquid developer should be avoided or minimized by appropriate selection of compatible materials. Preferably, the developer should wet the applicator grooves to permit uniform application. Generally, the liquid developers of the present invention are capable of being selectively attracted from the developer dispenser in response to the charge pattern on the electrostatographic surface with substantially no particle separation or migration out of the insulating medium.

Typically, the liquid developers that may be employed are selected from the commercially available water and oil based inks, and include among others as vehicles mineral oil, oleic acid, polypropylene glycol, 2,5-hexanediol, glycerol, sorbitol, vegetable oils such as castor oil, peanut oil, sunflower seed oil, rapeseed oil, corn oil, olive oil. Additional typical vehicles include aliphatic hydrocarbons such as mineral spirits, kerosene, petroleum naphtha; aromatic hydrocarbons such as benzene, toluene and xylene; and esters such as butyl stearate and butyl oleate. These liquids may be employed with or without colorant materials. A particular application for the use of these materials without a colorant would be in a process involving secondary development by a powdered or coated colorant. Generally, however, it is preferred to employ colored liquid developers. Suitable colorants include carbon black, charcoal, iron oxide, ultramarine blue, zinc oxide, titanium dioxide, methylene blue, methyl violet tannate, and benzidine yellow. The liquid developer may also contain a dispersant such as alkylated polyvinyl pyrrolidone to aid in dispersion of the pigment in the vehicle and to promote absorption of the developer into the paper to which the developed image is transferred. In addition, resins such as nitrocellulose and the ester gums may be added to impart smudge resistance to the transferred print.

The present invention enables multiple copies to be obtained by a simple low cost process. After transferring the deposited developer material to a sheet of paper, the electrostatographic surface is employed as a master and can be redeveloped by conventional gravure rollers. No recharging or re-exposure steps are necessary when subsequent copies are made by the present re-wetting printing process.

The following examples aid in further explaining and illustrating the present invention which enables the production of multiple copies from a single electrostatic latent image, with copies being produced after the electrostatic latent image has been dissipated to below the development threshold. Parts and percentages are by weight unless otherwise indicated.

EXAMPLE 1

A sheet of Bruning ZnO Electrofax paper, type 2000 is charged by means of a corotron to a negative potential of 380 V. It is imagewise exposed to a light and shadow pattern, sufficient to produce potentials of −360 v. in dark areas and 0 v. in illuminated areas. The latent image is developed by the polar liquid ink development process in U.S. 3,084,043 using Lewis Roberts black ink type WCP 1004, an ink which is based upon a water-compatible colloid believed to contain a glycol type solvent, having a bulk resistivity of approximately 1200 ohm-cm. A satisfactory ink image is produced on the ZnO sheet and immediately transferred to Xerox 4024 bond paper leaving a residual ink pattern behind on the ZnO photoconductor. After transfer, the room lights are turned on to the ZnO paper so as to drop the voltage in image as well as in background areas. The average transferred image density is found to be 0.36 (optical density units).

The ZnO poper is again redeveloped (without being recharged or treated in any other special manner), producing a transferred image of substantially equal density (0.38) on the second transfer paper.

The ZnO paper is again redeveloped (without being recharged or treated in any other special manner) to form a third copy with essentially the same results.

EXAMPLE 2

The procedure of Example 1 is repeated, precisely as stated, with the exception that the ZnO paper is not illuminated after transfer of the first image. A solid area covered with ink is electrometered and found to have a residual potential of about 120 v. The image is re-developed and transferred, as in Example 1. The images produced are (within experimental error) identical in density to those in Example 1.

Comparison of Examples 1 and 2 shows that it does not matter whether the inked image is uniformly exposed to light prior to re-development or whether the potential merely drops below the development threshold, e.g., by dark decay such as by dark charge injection from the conductive ink into the photoconductor.

EXAMPLE 3

A ZnO sheet identical to that used in Example 1 is charged to −120 v. (the potential left after development in Example 2). The latent image is now developed, precisely as in Examples 1 or 2. No visible image is developed on the photoconductor, and no discernible image can be transferred to plain paper.

Thus, as is expected, no development of the dry photoconductor will occur when the magnitude of the latent image is below the development threshold.

EXAMPLE 4

The procedure of Example 1 is repeated to the point where a first image is transferred from the ZnO paper. (Transfer pressure is lightened somewhat, so as to leave as much ink on the ZnO paper as possible for use in second and third transfers. Accordingly, the density on the first transfer sheet is somewhat lower than that cited in Example 1.) The ZnO paper with ink residue was passed through the transfer station twice more. The densities of the transferred images are:

Original transfer sheet: 0.28
Second transfer sheet: 0.08
Third transfer sheet: not detectable (<0.02)

Thus, it is seen that the amount of ink adhering to the electrostatographic surface from the initial development cycle is insufficient to produce more than one or two legible copies.

EXAMPLE 5

A sheet of commercial zinc oxide paper available from Charles Bruning Company (32–155 White) is charged to 350 to 400 volts by means of a laboratory corotron unit powered by a high voltage power supply. The charging current is 0.1 milliamp at 7500 volts. A transparent positive USAF test chart is placed on the zinc oxide paper and exposed with a 75 watt photo flood lamp. An exposure of about 15 foot-candle seconds is required for the zinc oxide paper. The electrostatic latent image pro-

duced is then developed with Lewis Roberts WCP 97 water-based Indicia Black ink by applying said ink by means of a doctored gravure roll running at one inch per second. The developer is transferred in image configuration to sheets of bond paper containing about 5% starch. After the initial charging, imaging, developing and transfer, the photoconductive sheet bearing the residual developed image is passed again through the developer station wherein the gravure roller redevelops the photoconductive sheet and selectively develops the same pattern. The redeveloped pattern is transferred to paper and then redevelopment and transfer are repeated up to five times without appreciable loss of image definition or contrast. All copies so obtained exhibit an image density in the range of from 0.8 to 1.0.

In contrast to the above, the identical procedure is repeated; however, after the initial charging, imaging, developing and transfer, the photoconductive sheet bearing the residual developed image is employed to make multiple copies without additional development.

The table below summarizing the effect on image density of each additional cycle without redevelopment clearly establishes the need for redevelopment in each additional cycle. The produced image from the second and subsequent cycles became increasingly mottled.

TABLE I

Cycle:	Image density
1	1.0
2	0.3
3	0.1
4	0.05
5	Hardly legible

EXAMPLE 6

A sheet of zinc oxide paper as described in Example 5 is charged, exposed and developed using ink of the following composition:

	Parts by weight
Drakeol 9, a mineral oil obtained from Pennsylvania Refining Company	45
Microlith CT Black (this is a resinated carbon black pigment obtained from Ciba	27
Ganex V–216, an alkylated polyvinylpyrrolidone compound obtained from GAF Corporation	23
VM550, methyl violet tannate pigment obtained from Magruder Color Company	4.5

The developed image of the zinc oxide paper is transferred to a sheet of bond paper containing about 5% starch. The photoconductive zinc oxide sheet bearing the residual developed image is passed again through the developer station wherein the gravure roller redevelops the photoconductive sheet and selectively develops the same pattern. The redeveloped pattern is transferred to bond paper.

The procedure is repeated 7 times without appreciable loss of image definition or contrast. Similar results are obtained employing paper coated with cadmium sulfide or cadmium sulfo selenide binder compositions.

EXAMPLE 7

A 9" x 10" plate of 500 micron thick amorphous selenium coated onto an aluminum substrate 1/16" thick is corona-charged to a positive potential of about 450 volts, exposed and developed as described in Example 5 above, using the ink composition of Example 6. The developed image is transferred to a sheet of bond paper. The selenium plate having the residual developed image is passed again through the developer station wherein the gravure roller selectively redevelops the same pattern.

The redeveloped pattern is transferred to paper. The procedure is repeated five more times without appreciable loss of image definition or contrast. After the fifth image, the residual image remaining on the selenium plate is cleaned away using an absorbent powder as described in U.S. patent application Ser. No. 873,103 entitled "Cleaning System," filed Oct. 31, 1969, by Joseph Mammino, now U.S. Pat. 3,697,263. The selenium plate is then reprocessed with a new image as described above.

Although specific materials and conditions were set forth in the above exemplary processes for the production of a plurality of copies from an electrostatic latent image, these are merely intended as illustrations of the present invention. Various other electrostatographic imaging surfaces, liquid developers and reproduction techniques such as those listed above may be substituted in the examples with similar results.

Other modifications of the present invention will occur to those skilled in the art upon a reading of the present disclosure. These are intended to be included within the scope of this invention.

What is claimed is:

1. A method for the production of a plurality of copies from an original comprising:
   (a) forming an electrostatic latent image on an electrostatographic surface;
   (b) developing said electrostatic latent image by contacting said image with a liquid developer;
   (c) contacting said developed image with a transfer web under pressure thereby providing a partial transfer of said developer in image configuration to said web and retaining a residual liquid film in image configuration on said electrostatographic surface;
   (d) developing the residual liquid film image with said liquid developer after discharge of the latent image to below the development threshold; and
   (e) contacting said developed residual image with a transfer web under pressure thereby partially transferring said developer in image configuration to said web to obtain a plurality of electrostatographic copies.

2. The method of claim 1 wherein the electrostatographic surface is a photoconductor and the latent image is discharged to below its development threshold by exposure of said surface to light after development of step (b).

3. The method of claim 1 wherein the liquid developer of step (b) is highly conductive and the latent image is discharged to below its development threshold during the development of step (b).

4. The method of claim 1 wherein the latent image is discharged to below its development threshold by dark decay.

5. A method for the production of a plurality of copies as defined in claim 1 wherein said electrostatic latent image is initially developed by contacting said latent image with a liquid developer dispensing member, said liquid developer being selectively attracted from said dispensing member in response to said electrostatic image with substantially no particle migration or separation out of said liquid developer.

6. A method for the production of a plurality of copies as defined in claim 1 wherein the developed and redeveloped images contact the transfer web under pressure in an electrostatic field created by a corona discharge device situated at or immediately before the line of contact between the transfer web and the electrostatographic surface thereby partially transferring said developer in image configuration to said web to obtain a plurality of electrostatographic copies.

7. A method for the production of a plurality of copies as defined in claim 1 wherein the electrostatographic surface comprises a selenium coating on an electrically conductive support base.

8. A method for the production of a plurality of copies as defined in claim 1 wherein the electrostatographic surface comprises paper coated with a zinc oxide binder layer.

9. A method for the production of a plurality of copies as defined in claim 1 wherein the electrostatographic sur-

face is paper coated with a phthalocyanine binder composition.

10. A method for the production of a plurality of copies as defined in claim **1** wherein the electrostatographic surface comprises paper coated with a cadmium sulfide binder layer.

11. A method for the production of a plurality of copies as defined in claim **1** wherein the electrostatographic surface comprises paper coated with a cadmium sulfo selenide binder layer.

12. A method for the production of a plurality of copies as defined in claim **1** wherein the liquid developer is applied to said electrostatic latent image with a substantially uniformly patterned or grooved applicator.

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96—1 LY; 117—37 LE; 101—426; 355—10