Aug. 28, 1962 E. K. KAPRELIAN 3,051,568

OFFSET ELECTROPHOTOGRAPHY

Filed Dec. 6, 1955 2 Sheets-Sheet 1

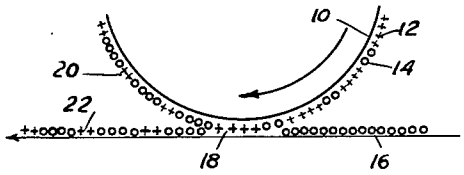


FIG. 1

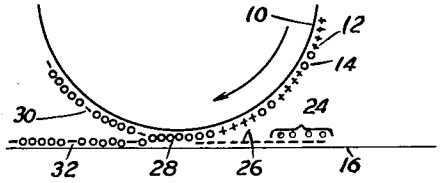


FIG. 2

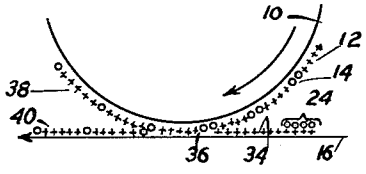


FIG. 3

FIG. 7

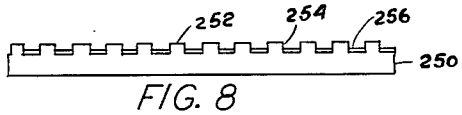


FIG. 8

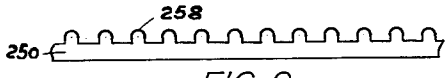


FIG. 9

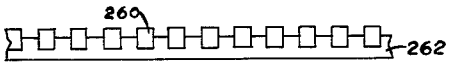


FIG. 10



FIG. 11

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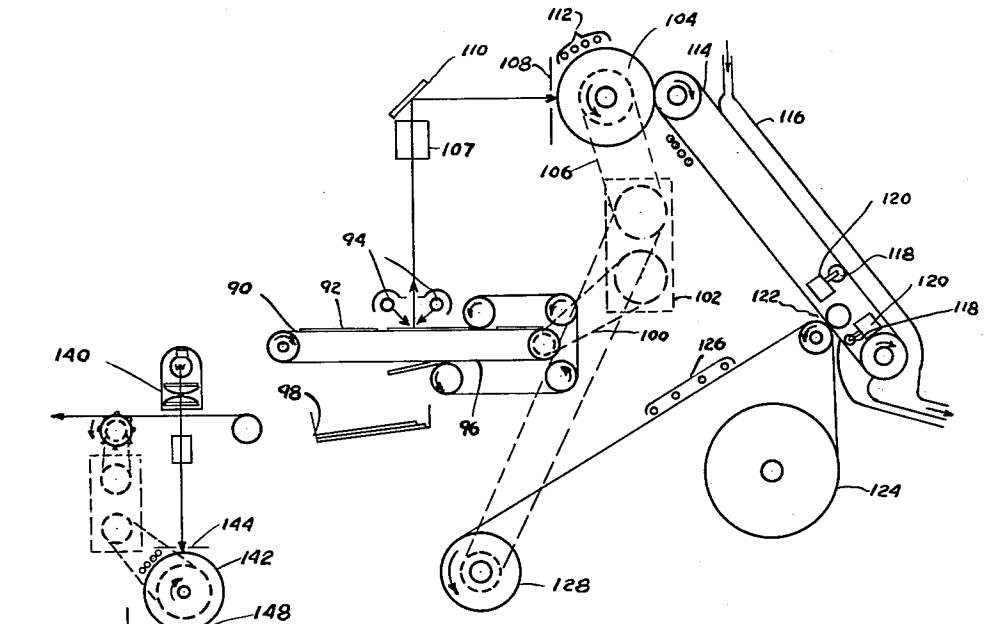


FIG. 5

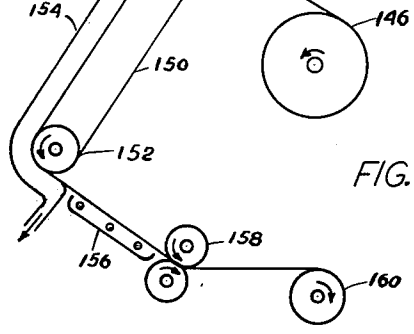


FIG. 6

FIG. 4

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OFFSET ELECTROPHOTOGRAPHY

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3 Claims. (Cl. 96—1)

This invention relates to electrophotography of the type whereby photographs are produced by the action of light on an electrostatically charged photoconductive insulator.

The use of such certain photoconductive insulators as selenium, anthracene, zinc oxide, etc. to produce photographs through the practice of such methods of electrophotography as Xerography and Electrofax is well known. In the usual method a thin layer of the photoconductive insulator is given an electrostatic charge and the charged plate or sheet is exposed in a camera or printer. Wherever the light strikes the surface the charge leaks off in proportion to the amount of light, with the result that a latent image of varying electrostatic potentials is produced on the plate surface. This latent image is next developed through the use of a finely divided, usually pigmented, material which by selective attraction to the plate produces a visible powder image, which, in turn, may be transferred to another surface, or fixed on the plate or sheet by various means well known in the art.

One typical method of electrostatic electrophotography utilizes a rotating drum which, as it rotates, receives the following treatment at successive stations:

(1) The photconductive insulator surface, usually selenium, receives an electrostatic charge.

(2) The charged surface receives light in the pattern of the desired image, and the charge leaks off selectively to produce an electrostatic latent image.

(3) The electrostatic latent image is developed into visible form by the application of a suitable finely divided powder.

(4) The powder is transferred to a paper or similar base.

(5) The transferred powder image is fixed through the application of heat or a solvent.

(6) The plate surface is cleaned preparatory to repetition of the cycle.

By contrast with this method the present invention employs an intermediate step of transferring the electrostatic image to an insulating surface on which the image is developed. The developed image is then fixed on this insulating surface, or it may be transferred to another surface and fixed there.

One of the objects of this invention is to permit the use of a smaller photoconductive insulator surface for a given capacity or speed of operation; or conversely to increase the capacity or speed of operation for a given size of photoconductive insulator surface.

Another object is to prolong the useful life of photoconductive insulator surfaces by eliminating the deteriorating effect of developing and cleaning operations.

Still another object is to provide such gentle action on the surface during cycling as to permit the use of softer, frailer photoconductive insulator layers which cannot withstand repeated developing and cleaning operations.

Still another object is to permit simple and direct control of image contrast.

Still another object is to permit ready reversal of the final image, i.e. from a positive to a negative.

Still another object is to permit the steps of powder transfer and plate cleaning, usually performed in the dark in drum machines, to occur in light where observation, servicing and adjustment is readily accomplished.

Still another object is to improve the quality of line images to permit the production of half tone images.

These and other objects of the invention can be determined from the specification and drawings in which:

FIG. 1 shows the action of transferring a charge to an uncharged surface,

FIG. 2 shows the action of transferring a charge to a surface of opposite charge,

FIG. 3 shows the action of transferring a charge to a surface of similar charge,

FIG. 4 shows in schematic elevation an electrophotographic printer employing a charge transfer belt for producing multiple copies,

FIG. 5 shows in schematic elevation an electrophotographic printer employing a charge transfer belt for producing reproductions of opaque copy,

FIG. 6 shows in schematic elevation an electrophotographic printer in which the latent electrophotographic image is transferred directly to the paper on which the copy is to be made,

FIG. 7 shows a printer in which each unit of opaque copy is reproduced on an individual sheet of paper through direct image charge transfer,

FIG. 8 shows in cross section one form of image transfer belt which can be used,

FIG. 9 shows in cross section another form of image transfer belt which can be used,

FIG. 10 shows in cross section still another form of image transfer belt which can be used.

FIG. 11 shows in cross section still another form of image transfer belt which can be used.

The action of image charge transfer is shown in FIG. 1 in which an electrophotographic drum **10** having the usual photoconductive insulator coating of selenium or other suitable material carries a positive image charge, or electrostatic latent image, consisting of alternately charged and uncharged areas **12** and **14** respectively as indicated by the plus symbols and the zeros. Transfer of the image charge to an electrostatically neutral insulating surface **16** takes place at the point of contact **18**, the drum and surface moving in the direction of the arrows. After transfer, the original image on the drum and the transferred image on the sheet have shared the initial charge pattern, as shown at **20** and **22**, respectively.

In FIG. 2 there is shown the corresponding action when the insulating sheet **16** receives a negative charge **26** from corona wires **24** prior to transfer at point **28**. The charges resulting on the drum and sheet after transfer are shown at **30** and **32**, respectively. In addition to sharing the charge it is clear that reversal has occurred.

In FIG. 3 the plate **16** is positively charged by wires **24** as at **34**. After transfer at point of contact **36** the charges finally remaining on the drum and plate at **38** and **40**, respectively, show that the charge has again been shared. Obviously, corresponding transfers of opposite sign would result if the drum were initially given a negatively charged electrostatic image instead of one of positive sign. It is also possible to produce a charge on the insulating transfer belt or sheet by induction rather than by contact. In this case the belt or sheet would be brought close to the drum, and the back of the belt or sheet grounded to induce a charge on the belt in a manner well known in electrostatics.

FIG. 4 shows an electrostatic latent image transfer printer for producing multiple copies from transparent originals. In this modification an electrophotographic drum **42** receives, through slit **44** and projection lens **46**, an image of film **48**. A suitable light source is provided above the film by head **50**. The film is driven by a sprocket **52** in the direction shown through suitable gearing, or equivalent, at the proper speed relative to that of the drum to insure that the image is stationary on the drum, i.e. at a speed ratio equal to that of the conjugate foci of the lens.

Drum 42, rotating in the direction shown, receives a charge at charging station 54 and is exposed as it passes slit 44. It contacts an endless belt 56 at 58 where the electrostatic image or image charge is transferred to the belt in the manner shown in FIGS. 1 to 3. The belt, rotating in the direction shown may or may not receive a modifying charge from electrodes 60 for the purpose of controlling image contrast or otherwise modifying the image. A developing station 62 of the type which cascades a carrier type developer over the drum produces a powder image which is then transferred, at transfer station 64, to a suitable base, such as paper from a roll 66. This transfer station includes a first point 68 at which an initial heavy transfer of powder occurs and a second point 70 at which all powder in excess of that necessary to form an acceptable image is returned to the belt electrostatically in a manner already known in the art. The image on the paper is permanently fused to the base at a fixing station 72. The belt progresses to succeeding transfer stations 74, 76 and 78 and is thereafter cleaned at a cleaning station 80 for the purpose of removing residual powder. The belt continues past a charging station 82 and the cycle is repeated. Belt 56 is made of a suitable flexible dielectric material such as rubber or some synthetic resin as polyethylene or various polyesters and vinyls. While shown as a belt for convenience the transfer surface may be in the form of a cylinder, for example, if such shape is desirable of the geometry of the printing machine. The surface of the belt may be smooth or provided with a texture as described below.

FIG. 5 shows a charge transfer printer for opaque copy. A conveying belt 90 carries the sheets 92 of material to be copied past suitable light sources such as mercury vapor tubes 94 and against an enveloping belt 96 which reverses the direction of the copy material and guides it to a receiving tray 98. Belt 90 is suitably driven through gears or toothed belt 100 from a speed change transmission 102. The transmission is in turn connected to drive electrophotographic drum 104 through similar positive drive means 106. The transmission ratio can be changed to accommodate various magnifications or reductions.

Copy 92 is imaged by lens 107 past slit 108 onto the drum. A mirror 110 may be employed to fold the path for reasons of compactness and also for the purpose of producing rectified (unreversed) prints. The usual charging station 112 is associated with the drum at a point near the slit. After exposure at the slit the charge is transferred to a moving belt 114 and the transferred electrostatic image is developed at station 116. Two vibrating rollers 118 in contact with the belt and driven by suitable motors or vibrators 120 remove excess or unwanted powder from the belt prior to reaching transfer station 122 where the powder image is transferred to paper from roll 124. The printed copies are fixed at station 126 and are wound on reel 128. The belt is charged at charging station 130 to control contact or type of the final image or may be left uncharged as desired.

In FIG. 6 the latent electrostatic image is transferred directly to the paper base. In this modification a projection head generally indicated at 140 moves the film synchronously with an electrophotographic drum 142 in a manner similar to that shown and described in connection with FIG. 4. After exposure is accomplished at slit 144, the drum transfers the image charge to a sheet of paper or other suitable material from a roll 146 at a transfer station 148. The paper is carried on a belt supported by pulleys 152. The paper enters a developing station 154 which may employ cascading carrier beads or a powder cloud and separates from the belt 150 at the bottom pulley 152. The image is fixed at station 156 and passes through rollers 158 to a take-up reel 160.

FIG. 7 shows a printer which accepts opaque copy and transfers the electrostatic latent image directly to the paper base. In this modification opaque copy 180 is fed by a synchronously driven endless belt 182 of transparent or translucent woven plastic webbing or plastic sheet past a slit 184 where it is illuminated by suitable lamps 186. A tray 188 receives the processed copy after passage through the projection head. A lens 190 images the copy on electrophotographic drum 192 behind slit 194. The drum is charged and exposed, the electrostatic latent image reaching a transfer station 196 comprising an endless belt 198 carried on pulleys 200. Print paper from a roll 202 is fed between the drum and belt 198 where it receives the electrostatic latent image. Feeding is accomplished through metering rollers 204 and feed rollers 206 in accordance with signals provided by a control system.

The control system for feeding the print paper includes a sensing head 208 which can consist, for example, of either a photocell for detecting the passage of the front edge of a piece of copy, or a sensitive switch actuated by passage of the front edge of the piece of copy. The resulting signal is passed through an amplifier or relay 210 into a control box 212 which selectively times the operation of (1) solenoid 214 for controlling drive rollers 204, (2) solenoid 216 for controlling rollers 206, and (3) solenoid 218 which operates a paper cutting knife 220.

The operation of the control is as follows. When a piece of copy 180 enters slit 184 sensing head 208 responds, solenoids 214 and 216 are actuated, and rolls 204 begin to feed paper toward roll 206. After the following edge of copy 180 passes the slit sensing head 208 again responds, solenoid 214 is deenergized, and rollers 204 are stopped. Solenoid 218 is then operated, cutting the paper sufficiently long to receive the complete transferred image with such additional border as is required. Rollers 206, which may or may not have been stopped during the cutting operation, continue to feed the cut piece of paper past a charging station 222 and into the transfer station, after which solenoid 216 is deenergized, thereby stopping rollers 206, or permitting them to overrun if such is desirable. Belt 198 drops the piece of paper on to a second endless belt which is preferably of porous rubber or plastic construction and which carries the paper through a developing station 226 preferably of the powder cloud type. A pair of suction heads 228 serve to hold the paper against the belt as the latter enters the developing station and to entrain and remove any of the developer cloud which escapes between the lip of the station and the belt. The sheet is dropped from the lower end of belt 224 onto an endless conveyor belt 230 which carries the sheet under a fixing chamber 232 and discharges it into a receiving tray 234.

The transfer belts 56 and 114 used in the modifications of FIGS. 4 and 5 respectively can be of solid cross section for most applications. It is sometimes desirable, however, to provide the transfer surface with a texture or pattern for the purpose of improving the rendition of half-tones, for improving the "fill-in" of large solid black areas in the copy, or for the otherwise breaking up the electrostatic latent image into a number of minute charge areas. In normal electrophotography large solid black areas do not fill in well with developer because of characteristics of electric fields. By breaking up the single charge at these large solid areas into a multiplicity of smaller ones the developer can produce a uniform density in these areas.

Four modifications of belt surfaces are shown in FIGS. 8 to 11. FIG. 8 shows a plastic or rubber belt body 250 provided with uniformly or randomly spaced flat topped projections 252 the width of which may vary from 0.3 mm. to 0.03 mm. The tops of these projections may be from 1 to 0.1 mm. above the bottom of the depressed surface 254 between the projections. The depressed surface is provided with a conducting layer 256 of evaporated metal or metal foil. This belt is readily produced by heating the plastic surface, embossing it with a roller or die plate, coating the surface with evaporated aluminum, and removing the aluminum at the top of the projections by polishing against an abrasive surface. Alter-

natively a piece of adhesive-backed metal foil can be placed on the heated plastic surface, pressed with a patterned roller or die to obtain bonding and to simultaneously produce the projections, and the unwanted foil removed from the tops of the projections by abrasion or by roller coating the tops of the projections with an acid.

In the arrangement shown in FIG. 9 the plastic or rubber base is embossed to produce a series of rounded projections **258** having dimensions similar to those of projections **252** of FIG. 8 and a radius of curvature between .015 mm. to 1.5 mm.

FIG. 10 shows a belt having alternately raised insulating portions **260** and depressed conducting portions **262**. The latter may be of rubber or plastic containing electrically conductive ingredients for lowering the resistivity of these portions. Such a belt may be made by studding a plain belt of low resistivity material with small beads or bits of high resistivity material and vulcanizing or polymerizing the two materials to each other.

In FIG. 11 a belt base **264**, which may be of high or low conductivity flexible material or webbing, is covered with a layer of high resistivity material of sponge-like or cellular construction and which may or may not contain low resistivity particles.

It is also possible to provide paper having surface characteristics generally similar to those of the belts shown in FIGS. 8 to 11 to thereby obtain the same advantages without requiring the use of a transfer belt as in the printers shown in FIGS. 6 and 7.

Obviously the transfer of the electrostatic latent image can be employed in electrophotographic cameras as well as printers. The rotating drum can be used in aerial strip cameras for example. Charges can of course be transferred from flat electrophotographic plates into intermediate electrostatic image blankets which can be developed and the powder image transferred to a suitable base on which it is fixed. Also, transfer of the electrostatic latent image from a flat plate directly onto the final base where it is developed and fixed is feasible.

I claim:

1. A method of electrophotography employing an electrophotographic plate comprising a photoconductive insulating layer overlying a conductive backing layer and in electrically conductive contact therewith, said method comprising the steps of uniformly charging said photoconductive insulating layer by subjecting the latter to a charging potential, exposing said charged photoconductive insulating layer to a light image pattern to increase its conductivity selectively, allowing current flow selectively from the charged photoconductive insulating layer to the conductive backing layer in accordance with the light image pattern to produce a corresponding electrostatic latent image on said layer, bringing an insulating surface into juxtaposition on top of said photoconductive insulating layer, applying pressure to force said insulating surface and said photoconductive insulating layer into intimate contact to cause transfer of the charges comprising the electrostatic latent image from said photoconductive insulating layer to said insulating surface, lifting said insulating surface off said photoconductive insulating layer to thereby carry off said transferred electrostatic image, and modifying the contrast characteristics of said transferred electrostatic latent image on said insulating surface by subjecting said image to the electrostatic field of a charged electrode, said insulating surface being provided with a uniform pattern of protuberant and depressed areas.

2. A method of electrophotography employing an electrophotographic plate comprising a photoconductive insulating layer overlying a conductive backing layer and in electrically conductive contact therewith, said method comprising the steps of uniformly charging said photoconductive insulating layer by subjecting the latter to a charging potential, exposing said charged photoconductive insulating layer to a light image pattern to increase its conductivity selectively, allowing current flow selectively from the charged photoconductive insulating layer to the conductive backing layer in accordance with the light image pattern to produce a corresponding electrostatic latent image on said layer, bringing an insulating surface into juxtaposition on top of said photoconductive insulating layer, applying pressure to force said insulating surface and said photoconductive insulating layer into intimate contact to cause transfer of the charges comprising the electrostatic latent image from said photoconductive insulating layer to said insulating surface, lifting said insulating surface off said photoconductive insulating layer to thereby carry off said transferred electrostatic image, and modifying the contrast characteristics of said transferred electrostatic latent image on said insulating surface by subjecting said image to the electrostatic field of a charged electrode, said insulating surface being provided with a uniform pattern of discrete protuberant and depressed areas said areas having average linear dimensions in the range from 0.3 mm. to 0.03 mm.

3. A method of electrophotography as claimed in claim 2 said depressed areas comprising discrete isolated electrically conducting spots.

References Cited in the file of this patent

UNITED STATES PATENTS

2,277,013	Carlson	Mar. 17, 1942
2,297,691	Carlson	Oct. 6, 1942
2,558,900	Hooper	July 3, 1951
2,588,675	Walkup et al.	Mar. 11, 1952
2,599,542	Carlson	June 10, 1952
2,600,580	Sabel et al.	June 17, 1952
2,618,551	Walkup	Nov. 18, 1952
2,637,651	Copley	May 5, 1953
2,693,416	Butterfield	Nov. 2, 1954
2,756,676	Steinhilper	July 31, 1956
2,758,524	Sugarman	Aug. 14, 1956
2,764,693	Jacobs	Sept. 25, 1956
2,808,329	Jacob	Oct. 1, 1957
2,817,277	Bogdonoff	Dec. 24, 1957
2,817,765	Hayford et al.	Dec. 24, 1957
2,825,814	Walkup	Mar. 4, 1958
2,833,648	Walkup	May 6, 1958
2,868,642	Hayford et al.	Jan. 13, 1959
2,895,847	Mayo	July 21, 1959
2,914,403	Sugarman	Nov. 24, 1959
2,937,943	Walkup	May 24, 1960
2,937,944	Van Dorn et al.	May 24, 1960

FOREIGN PATENTS

168,181	Australia	Dec. 7, 1956
529,234	Belgium	June 15, 1954