

[54] **METHOD FOR TRANSFERRING A DYE IMAGE AND ELECTROPHOTOGRAPHIC COPY PROCESS EMBODYING SAME**

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[56]

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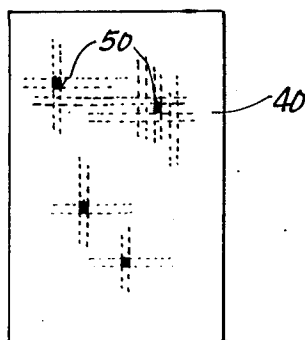
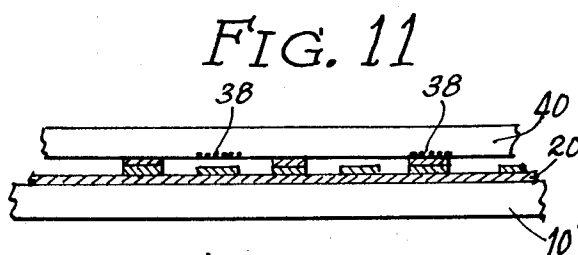
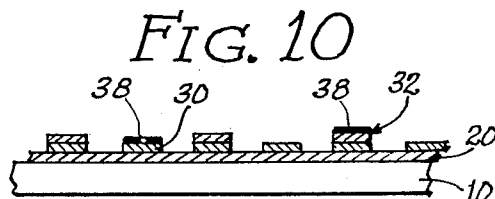
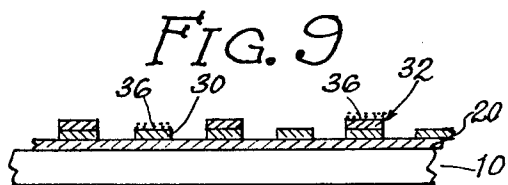
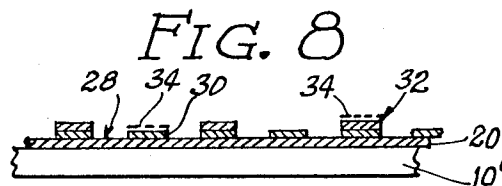
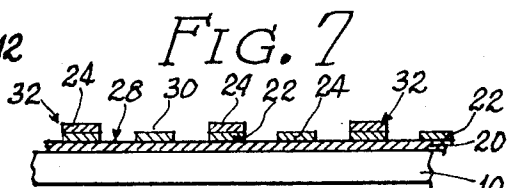
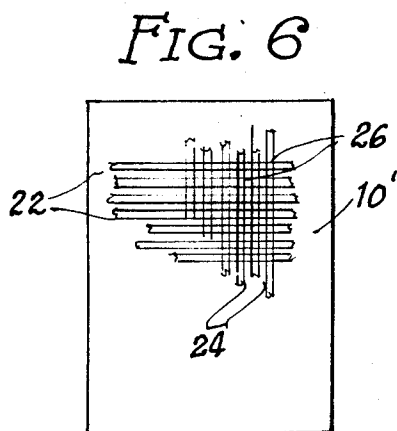
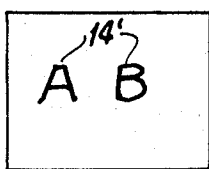
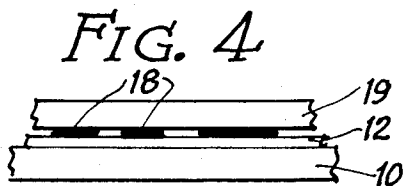
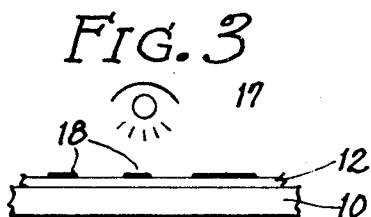
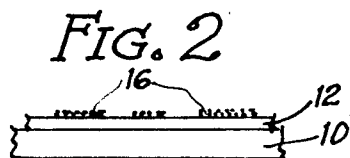
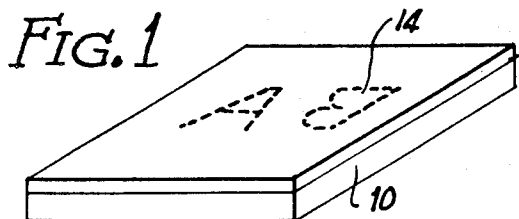
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ABSTRACT

This invention is addressed to a method for transferring a dye image from an imaged receptor sheet having at least one photoconductive composition of the face thereof containing a photoconductor, a resinous binder, a sensitizer for the photoconductor and a dispersed dye which has been developed with a solid toner in the form of a material which, when heated to a molten state, is a solvent for the dispersed dye in the photoconductive composition, in which the dispersed dye is transferred from the receptor sheet to the copy sheet by pre-fusing the toner particles on the receptor sheet and then placing the receptor sheet in surface contact with the face of a copy sheet whereby the dispersed dye is transferred to the copy sheet.

22 Claims, 12 Drawing Figures



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METHOD FOR TRANSFERRING A DYE IMAGE AND ELECTROPHOTOGRAPHIC COPY PROCESS EMBODYING SAME

This invention relates to an improved electrophotographic process for the production of copies, including true color copies, from originals.

In copending application, Ser. No. 836,415, filed June 25, 1969, now U.S. Pat. No. 3630729, and entitled "Electrophotographic Multi-Color Copy Process and Elements," description is made of a color electrophotographic copy process in which an electrostatic charge is applied onto the face of a receptor formed of a substrate having on its face interspersed sections of two or more photoconductive coatings, each of which contain a photoconductor, a sensitizer for the photoconductor and a dispersed, solubilizable dye. In each coating, which may or may not be coplanar, the sensitizer sensitizes the photoconductor to a particular segment of the visible light range for absorption of light within that particular range and reflection of light outside that particular range, and the solubilizable dye has a color corresponding to the color of the reflected light.

The separate coatings on the face of the receptor, taken together, cover the entire spectrum of visible light, and preferably include three separate coatings sensitized to each of the primary additive colors of red, green and blue, respectively.

Thus, upon application of an electrostatic charge by known means, each of the separate photoconductive coatings retain an electrostatic charge. Thereafter, the charged receptor is exposed to, for example, a multi-color original, whereby certain of the separate coatings on the receptor are discharged in response to exposure to color in corresponding areas of the original to which the particular coatings have been sensitized, thereby leaving an electrostatic charge on the photoconductive coatings from which light has been reflected.

After certain of the coatings have been discharged as described above, the receptor is developed with a developer containing a toner in the form of finely divided particles of a material which is a solvent for the solubilizable dye whereby the toner particles are retained on the photoconductive coatings retaining an electrostatic charge. Copy is thus produced by bringing a copy sheet in surface contact with the receptor with the toner in an activated stage whereby the solubilizable dye is transferred to the copy sheet from the receptor in a color pattern corresponding to the color pattern of the original to produce a multi-color copy.

While the process defined in the aforementioned copending application briefly described above represents a significant advance in the art of producing multi-color copies by electrophotographic copy techniques, one of the problems which remains is that of the relatively low intensity of the solubilizable dye which is transferred to the copy sheet on development of the electrostatic image. In order to obtain acceptable color intensity on the copy sheet, it is frequently necessary to contact a copy sheet with the toned receptor under conditions of high contact pressure and temperature and at slow speeds.

It is accordingly an object of the present invention to provide a new and improved process for the preparation of copy from an electrophotographic receptor having one or more photoconductive coatings on the face

thereof containing a solubilizable dye which overcomes the aforementioned disadvantages.

It is a more specific object of the invention to provide a new and improved process for the preparation of copy from an electrophotographic receptor having one or more photoconductive coatings, at least one of which has been developed with a toner in the form of a material which, when in a molten state, is a solvent for a solubilizable dye dispersed in one or more of the photoconductive coatings in which copy is produced with improved image intensity at low contact pressures and temperatures and at higher speeds.

These and other objects and advantages of the invention will appear more fully hereinafter, and for purposes of illustration, but not of limitation, embodiments of the invention are shown in the drawings in which:

FIG. 1 is a perspective view of a receptor sheet having a latent electrostatic image thereon;

FIG. 2 is a sectional view of the receptor sheet shown in FIG. 1 after treatment with a developer composition;

FIG. 3 is a schematic illustration of the receptor sheet shown in FIG. 1 in which the toner particles have been prefused in accordance with the practice of this invention;

FIG. 4 is a schematic illustration of the transfer of the image formed on the receptor sheet to a copy sheet;

FIG. 5 is a top plan view of the copy sheet after transfer of the image;

FIG. 6 is a top plan view of another receptor sheet employed in the practice of this invention;

FIG. 7 is an enlarged sectional view through a portion of the receptor sheet shown in FIG. 6;

FIG. 8 is a schematic sectional view similar to that of FIG. 7, illustrating the conditions existing in response to exposure to a multi-color original;

FIG. 9 is a schematic sectional view of the exposed receptor of FIG. 8 after treatment with a developer composition;

FIG. 10 is a schematic sectional view of the toned receptor sheet of FIG. 9 after pre-fusion of the toner particles in accordance with the present invention;

FIG. 11 is a schematic diagram showing the transfer of the multi-color image from the receptor to a copy sheet; and

FIG. 12 is a top plan view of the multi-color copy produced from the exposed receptor of FIG. 11.

The concepts of the present invention reside in a new and improved method for the transfer of a dispersed dye from the imaged areas of an electrophotographic receptor sheet to a copy sheet in which a receptor sheet having at least one photoconductive coating formulated to contain (1) an organic insulating binder, (2) a photoconductor, (3) a sensitizing component to sensitize the photoconductor, and (4) a dye component which is dispersed in the coating, is provided with an electrostatic charge and exposed in a conventional manner, developed with a developer composition containing a toner in the form of a material which, when in a molten state, is a solvent for the dispersed dye.

In accordance with the practice of this invention, after the latent electrostatic image on the receptor sheet is developed, the toner particles are pre-fused to the imaged portions of the receptor sheet by melting the toner particles electrostatically attracted to the imaged portions, and then the receptor sheet is placed in contact with a copy sheet with the application of heat and pressure whereby the dye is transferred to the copy

sheet to form an image thereon corresponding to the image on the original.

It has been found that the step of pre-fusing the toner prior to transfer of the dispersed dye to the copy sheet provides improved copy intensity while permitting the use of higher transfer speeds and lower contact pressures and temperatures during transfer of the dye from the photoconductive coating to the copy sheet.

As indicated above, the receptor is provided with at least one photoconductive coating including an insulating binder, a photoconductor, a sensitizing component and a dispersed or soluble dye. As the binder, use can be made of any of a variety of polymeric binders known to the art to be suitable for this purpose. Representative of such binders include organo-silicone resins, butadiene-styrene copolymers, modified alkyd resins, acrylic resins and a number of others.

As the photoconductor, use is preferably made of photoconductive zinc oxide, such as Photox 80 of the New Jersey Zinc Company. However, use can also be made of other photoconductors known to the art, such as those described in Middleton U.S. Pat. No. 3,121,006.

In accordance with one embodiment of the invention, the receptor is provided with at least one photoconductive coating in which the sensitizing component is a sensitizing dye or dyes which sensitize the photoconductor either to a portion of or the entire spectrum of visible light as described in copending application, Serial No. (DB-479), filed concurrently herewith. A wide variety of such sensitizers are well known to those skilled in the art, and are preferably sensitizing dyes, such as the following sensitizing dyes:

Acridine Red	CI 45000
Auramine O Conc.	CI 41000
Brilliant Blue F.C.F.	42090
Brom Phenol Blue	Indicator
Dibromofluorescein	CI 45370
Patent Blue	CI 42045
Rhodamine B. Base	CI 45170B
Rose Bengal	CI 45440

In this embodiment, the dispersed dye can be any color corresponding to the color desired on the copy sheet, such as blue, black, red, yellow, etc., as represented by Nigrosine SSB from Allied Chemical Corp., Spirit Soluble Fast Blue 6G from Allied Chemical Corp., Spirit Soluble Fast Red 3B from Allied Chemical Corp., Calcofast Spirit Yellow TG from American Cyanamid.

When it is desired to use a panchromatic sensitizing component, it is generally preferred to use combinations of sensitizing dyes of the type described above, sensitize the photoconductor to a separate portion of the visible spectrum. Taken together, the combination of all the dyes has the effect of sensitizing the photoconductor component over the spectrum of visible light.

In formulating such combinations of sensitizing dyes to panchromatically sensitize the photoconductor component, use is made of at least two sensitizing dyes, and preferably three sensitizing dyes. By way of illustration, it is possible to employ a combination of three sensitizing dyes, each of which sensitize the photoconductor to one of the three additive primary colors of red, green and blue. Thus, to provide red sensitivity, use should be made of a sensitizing dye which sensitizes the photoconductor to absorbed light within the range of about 600 to 700 nm, such as U.S. Pat. Blue (C.I. 42045)

from Allied Chemical Company, 3-ethyl-2-[5-(3-ethyl-2-benzothiazolynylidene)-1,3-pentadienyl]-benzothiazolium iodide (referred to in the art as EEBI) from Aldrich Chemical Company or Brom Phenol Blue from Allied Chemical Company.

To provide the desired blue sensitivity, use should be made of a sensitizing dye which sensitizes the photoconductor to absorbed light within the range of about 400 to 500 nm, such as Euchrysine GGA from GAF Corporation or Auramine O from Allied Chemical Corporation.

To provide the desired green sensitivity, use should be made of a sensitizing dye which sensitizes the photoconductor to absorbed light within the range of about 500 to 600 nm, such as Ethyl Red No. 2155 From Eastman Organic Chemicals, Acridine Red (C.I. 45000) from Allied Chemical Co. or Rose Bengal from Allied Chemical Co.

Thus, considering the visible spectrum to include light within the range of 400 to 700 nm, the combination of one of each of the foregoing sensitizers has the effect of sensitizing the photoconductor to the entire spectrum of visible light.

When based on the amount of photoconductive zinc oxide, the photoconductive coatings are preferably formulated to contain the components in the following proportions

	Parts by Weight
Photoconductor	100
Binder	10-200
Sensitizer component	0.001-5.0
Dispersed dye	0.5-20.0

It will be understood by those skilled in the art that the sensitizer component may be employed in quantities greater than 5.0 parts by weight per 100 parts by weight, although the costs involved become significant when greater amounts are employed.

The coating is prepared from compositions containing the foregoing components in combination with an inert diluent which is a solvent for the resinous binder. Application of the composition is generally made in amounts sufficient to provide a dry coating in a coating weight within the range of 5 to 40 pounds per 3,000 square feet of surface area, and preferably 15 to 30 pounds per 3,000 square feet of surface area.

This concept of the invention may be illustrated by reference to the following examples.

EXAMPLE 1

Coating Composition (Blue dispersed dye-Red sensitized)

Photoconductive Zinc oxide	100.0 g.
Modified alkyd resin (DeSoto E-104-13A)	25.0 g.
Red sensitizing dye (Patent Blue)	0.05g.
Dispersed dye (Spirit Soluble Fast Blue 6G-Allied Chemical)	1.5 g.
Solvent (Toluene)	60 ml.

EXAMPLE 2

Coating Composition (Red dispersed dye-green sensitized)

Photoconductive zinc oxide	100.0 g.
Modified alkyd resin (DeSoto E-104-13A)	25.0 g.
Green sensitizing dye (Rhodamine B Base)	0.05g.
Dispersed dye (Spirit Soluble Fast Red 3B-Allied Chemical)	1.5 g.

Solvent(toluene)

60 ml.

EXAMPLE 3

Coating Composition(Yellow dispersed dye-Blue sensitized)

Photoconductive zinc oxide	100.0 g.
Modified alkyd resin (DeSoto E-104-13A)	25.0 g.
Blue sensitizing dye (Auramine O Conc.)	0.05g.
Dispersed dye (Calcofast Spirit)	1.5 g.
Yellow TG-American Cyanamid)	60 ml.
Solvent (toluene)	

EXAMPLE 4

Coating Composition(Black dispersed dye-Pan-chromatically sensitized)

Photoconductive zinc oxide	100.0 g.
Modified alkyd resin (DeSoto E-104-13A)	25.0 g.
Blue sensitizing dye (Auramine O Conc.)	0.02g.
Red sensitizing dye (Brom Phenol Blue)	0.02g.
Green sensitizing dye (Rose Bengal)	0.01g.
Dispersed dye(Nigrosne SSB- Allied Chemical)	1.5 g.
Solvent(toluene)	60 ml.

However, as will be appreciated by those skilled in the art, the compositions of Examples 1-3 can be pan-chromatically sensitized by the substitution of the sensitizer system described in Example 4 for the single sensitizing dye employed in Examples 1-3.

The resinous binder, the zinc oxide and solvent are first blended to obtain a uniform mixture. The sensitizing dye is then added and mixed, and finally the dispersed dye is added and mixed to form each of the above coating compositions.

One of the above compositions is then coated on a paper base sheet by use of a roller coater, a metering rod or by hand draw-down with a wire wound rod in the desired coating weight and dried.

The resulting receptor sheet is then charged as by subjecting the face of the receptor sheet to a corona spray as it is exposed to a corona discharge from wires operating at a potential of about 6,000 to 8,000 volts. The charged wires, which extend across the face of the receptor sheet are either transported over the face of the receptor sheet, or the receptor sheet is displaced beneath the wires. An electrostatic charge is deposited over the entire receptor sheet covered by the photoconductive coating of the composition of Examples 1-4.

The charged receptor sheet is then exposed to light modified by an image, such as by projection of a photographic image of an original, whereby the illuminated areas of the charged photoconductive layer on the receptor sheet, corresponding to the non-imaged areas of the original, are rendered conductive. Thus, such illuminated areas are discharged to leave on the face of the receptor sheet a latent electrostatic image on the photoconductive coating corresponding to the imaged portions of the original.

The latent electrostatic image which is formed on the face of the receptor sheet is schematically illustrated in FIG. 1 of the drawing. As shown in this figure, the receptor sheet is formed of a conductive base sheet 10 having a photoconductive coating 12 formed of the composition of Example 1, and contains a latent electrostatic image 14 on the face thereof.

The exposed receptor sheet is then developed in a conventional manner, using either a dry powder developer or a liquid developer of the type described in copending application, Ser. No. 836,415, filed June 25, 1969. As described in this copending application, use is made of a developer composition in which the conventional toner particles have been replaced by finely divided particles of a material which, when heated to a molten state, is a solvent for the dispersed dye in the photoconductive coating.

Illustrative of liquid developing compositions which can be used in the practice of this invention include the following:

EXAMPLE 5

Developer Composition

Toner (antipyrine)	5.0 g.
Liquid carrier (Isopar G)	400.0 ml.
Charge director (Fuel Oil Additive No. 2)	5.0 g.

EXAMPLE 6

Developer Composition

Toner(1-allyl-2-thiourea)	5.0 g.
Liquid carrier (Isopar G)	400.0 ml.
Charge director	5.0 g.

The liquid carrier used in the above developer compositions is Isopar G from Humble Oil and Refining Co., and is an aliphatic hydrocarbon solvent having a flash point of 104°F. In general, as the liquid carrier, use should be made of aliphatic hydrocarbon solvents in which the toner particles are insoluble.

The charge director, Fuel Oil Additive No. 2 from DuPont, is a solution in kerosene of a methylmethacrylate copolymer having an average molecular weight of about 50,000. As will be apparent to those skilled in the art, any of a variety of conventional charge directors may be used.

The antipyrine of Example 5 and the 1-allyl-2-thiourea of Example 6 are merely representative of suitable toner particles which may be used for development of the latent electrostatic image remaining on the receptor face after exposure. Other toner particles may be used which meet the requirements:

1. a solvent for the dispersed dye component in the coatings when the toner is in a liquified state;
2. capable of being reduced to a finely divided form in which it is retained in the liquid or powdered developer composition;
3. capable of taking on a charge, such as a positive charge when used with a charged photoconductive coating of zinc oxide;
4. suitably located within the triboelectric series to produce the desirable charge development. Representative of other suitable compounds which meet these requirements and can be used as toners are vanillin, 1,6-hexanediol, 1,10-decanediol, ammonium acetate, ethyl urea, acetamide, benzohydrol, 2,2-dimethyl-1, 3-propanediol, ammonium formate and pyrazine. The toner particles can be employed in various concentrations in the developer composition, such as within the range of 2-20% by weight, and preferably 3-10% by weight, in a dry powder developer and within the range of 0.2-20% by weight and preferably 2-10% by weight in a liquid developer. When use is made of a dry powdered

developer which is applied by brushing or the like, the toner concentration can range up to 100 percent by weight toner in the developer.

Upon development of the latent electrostatic image, the toner particles 16 are electrostatically attracted to the area of the face of the latent electrostatic image as schematically illustrated in FIG. 2 of the drawing.

In accordance with the practice of this invention, the toner particles electrostatically attracted to the latent electrostatic image on the face of the receptor are pre-fused to reduce the toner particles to a molten state prior to transfer of the dispersed dye in the photoconductive coating to a copy sheet. The toner particles can be pre-fused or melted using any convenient heat source, such as an infra-red source, a hot air gun, an oven, etc. The pre-fusing of the toner particles is schematically illustrated in FIG. 3 of the drawing, whereby the receptor sheet having the toner particles 16 thereon is subjected to a heat source 17 to melt the toner particles to form a thin layer 18 of pre-fused toner which contains a portion of the dispersed dye in the photoconductive coating in a pattern corresponding to the pattern of the latent electrostatic image, and thus to the pattern of the original, on the face of the receptor sheet.

The dye dissolved in the thin layer 18 of pre-fused toner on the face of the receptor sheet is then transferred to a copy sheet by pressing a copy sheet 19 (FIG. 4) in surface contact with the developed receptor sheet, as by passage of the composite assembly between compression rollers heated to a temperature near the melting point of the pre-fused toner matter. The use of the pre-fusing step of the present invention makes possible the use of lower temperatures and pressures in transferring the dispersed dye to the copy sheet. Thus, temperatures as low as room temperature can be used in the practice of the invention to obtain copy. For best results, use should be made of a temperature of 10°C. to 25°C. above the melting point. The copy sheet 19 having the image 14' as depicted in FIG. 5 is then separated from the developed receptor sheet.

The following illustrative examples will serve to illustrate the pre-fusion step of the method of this invention.

EXAMPLE 7

A receptor sheet containing a coating of the photoconductive composition of Example 1 in a coating weight of about 20 pounds per 3,000 square feet of surface area is charged by corona discharge, imaged and developed with the developing composition of Example 6.

After development of the latent electrostatic image with the 1-allyl-2-thiourea toner, the toner particles adhering to the receptor sheet are reduced to a molten state using a hot air gun. The receptor sheet is then placed with the imaged side in surface contact with a sheet of bond paper, and the sandwich assembly is passed through a pair of heated rollers.

The rollers were set at a speed of 5 feet per minute, a pressure of 60 psi and a temperature of about 160°F. A dye transfer copy having an intense color image is obtained.

The same procedure is repeated except that the 1-allyl-2-thiourea toner is not pre-fused for purposes of comparison. The dye transfer copy was noticeably less

intense as compared to the copy obtained when the toner is pre-fused.

EXAMPLE 8

The procedure and composition of Example 7 are repeated except that the heated rollers are set at room temperature.

A dye transfer image is obtained where the 1-allyl-2-thiourea toner is pre-fused, whereas no transfer image is obtained where the toner is not pre-fused prior to transfer.

EXAMPLES 9 to 11

The procedure of Example 7 is repeated using the photoconductive compositions of Examples 2, 3 and 4. Again, a more intense dye transfer image is obtained where the toner particles are pre-fused prior to transfer.

In accordance with another, and preferred, concept of the invention, the step of pre-fusion is applied in the transfer of a multi-color dye image in accordance with the method described in the aforementioned copending application, Ser. No. 836,415. With this concept of the present invention, the receptor sheet is provided with at least two, and preferably three or more, separate photoconductive coatings, each of which is sensitized to a particular portion of the spectrum of visible light.

In this embodiment of the invention, each photoconductive coating is formulated to include (1) a resinous binder and (2) a photoconductor, as described, and (3) a sensitizing component, such as a sensitizing dye which sensitizes the photoconductor to light of a selected wave length within the visible light spectrum while reflecting wave lengths outside said range, with each coating containing a sensitizing ingredient which sensitizes the photoconductive coating to a different portion of the visible light range, whereby the total of the coating provides sensitivity which covers the entire visible light range, and (4) a dispersed dye component in each coating having a color transfer value corresponding to the complement of the color for which the particular coating is sensitized, as represented by a color produced by the combination of ranges of light reflected by the sensitized photoconductor of the particular coating composition.

In this embodiment, the pre-fused toner functions as a solvent for the dispersed dye component (4) of the photoconductive coating to effect transfer of the dye color from the portions of the coating immediately underlying the pre-fused toner for transfer to copy sheets pressed into surface contact with the receptor to produce true color copies of multi-color originals in response to a single exposure.

By way of illustration, the visible spectrum may be subdivided into contiguous segments, preferably three or more segments, such as subdivision of the visible light spectrum, assumed to be included within the range of 400-700 nm, into segments of about 400-500 nm (blue sensitivity) and to reflect light within the range of 500-700 nm. This particular effect can be achieved by the use of a dyestuff corresponding to the yellow layer in the well known photographic color processes based upon the subtractive tri-pack, such as Auramine O (C.I. 41,000). The dispersed dye compo-

nent formulated into the described coating composition is selected of a dyestuff having a yellow color or a color which represents the combination of the reflected light range of 500–700 nm.

Another or second coating is formulated with a sensitizing component effective to sensitize the photoconductor in the light range of 500–600 nm (green sensitivity), while reflecting light within the range of 400–500 nm and 600–700 nm. This can be achieved by the use of a magenta coating, when reference is made to the subtractive tri-pack system, such as by formulating the coating composition to contain acridine red (C.I. 45,000). The dispersed dye component formulated into the described coating would be selected of a dyestuff having preferably a blue-red color corresponding to the combination of the reflected light within the range of 400–500 and 600–700 nm.

The third coating would be formulated to contain a sensitizing component which sensitizes the photoconductor to absorbed light within the range of 600–700 nm (red sensitivity), while reflecting light within the range of 400–600 nm. This can be achieved by a cyan coating, such as Patent Blue (CI 42045). The dispersed dye component in the third coating would be selected of a dyestuff giving a blue-green color corresponding to the range of reflected light or the combination of colors within the range of 400–600 nm.

When based upon the amount of photoconductive zinc oxide, the described coating compositions can be formulated to contain the resinous binder in an amount within the range of 10–200 parts by weight of resinous binder per 100 parts by weight of zinc oxide. The sensitizing component or dyestuff is formulated in the coating composition in an amount within the range of 0.001 to 5.0 parts by weight per 100 parts by weight zinc oxide and preferably within the range of 0.01 to 2.5 parts by weight per 100 parts by weight of zinc oxide, the amount depending somewhat upon the sensitizing dye, such as 0.13 percent by weight magenta color, as in the form of acridine red having a spectral response in the range of 495–620 nm, 0.06 percent of the cyan color, as represented by Patent Blue having a spectral response in the range of 600–700 nm, and 1.2 percent by weight of the yellow color as represented by Auramine O concentrate having a spectral response within the range of 405–500 nm. It will be understood that, except for cost, more than 5.0 parts by weight of sensitizer per 100 parts by weight zinc oxide can be used. The dispersed dye component can be formulated into each coating in an amount within the range of 0.5–20.0 parts by weight per 100 parts by weight of zinc oxide and preferably in an amount within the range of 1–5 parts by weight per 100 parts by weight of zinc oxide. The foregoing amounts of sensitizer and dispersed dye components specified in parts by weight may be taken as corresponding to the percent by weight of the photoconductive coatings formulated of photoconductive zinc oxide or a photoconductor other than zinc oxide, but in which the percentage is adjusted by the weight ratio of zinc oxide to said other photoconductive material in the coating.

The dispersed dye component is preferably formulated in the respective coating compositions as a dispersed dye but it will be understood that the soluble dye component can be incorporated in other states.

The coatings are produced from compositions containing the described components in combination with

a diluent which is a solvent for the resinous binder and application may be made to the substrate in coating weights, when formulated of a zinc oxide photoconductor, within the range of 5–40 pounds per 3,000 square feet of surface area, and preferably within the range of 15–30 pounds per 3,000 square feet of surface area.

The separate coating compositions are applied or otherwise imprinted on the surface of the substrate in various patterns. The essential requirement is that the face of the coated substrate define a final pattern of separate, small light-responsive areas of each coating interspersed one with another substantially uniformly over the surface of the substrate in closely spaced relation.

This can be accomplished by application of the separate coating compositions in a pattern of dots, circles, beads, spheres, squares, lines or the like configurations. Since it is not essential that the separate light-responsive areas be arranged coplanar, it is preferred to apply the coating compositions either in the form of lines which criss-cross one another over the surface of the substrate or more preferably to apply one coating composition as a continuous coating over the surface of the substrate and to apply the remaining coatings as lines which criss-cross over the underlying base coat as islands or dots of various configuration which overlie the base coat. Thus, the receptor sheet will be formed of a substrate having portions coated with only one layer of the first coating, other portions with two layers formed of the first and second coats and first and third coats; and still other portions formed of three layers of the first, second and third coating, etc.

Having described this concept of the invention from the standpoint of compositions and construction of the elements employed, illustration will now be made by way of examples which represent the practice of the invention. The description will hereinafter be made with respect to a system of compositions based upon the subtractive tri-pack, but it will be understood that the visible light spectrum can be otherwise divided for the selection of component identified as the sensitizing component and corresponding dispersed dye component embodied in each of the separate coating formulations.

EXAMPLE 12

Magenta coating composition: (green sensitive)

Photoconductive zinc oxide (Photox 80-New Jersey Zinc Company)	100 g.
Modified alkyd resin (DeSoto E-104-13A-DeSoto Chemical Coatings, Inc.)	25 g.
Sensitizing dye-Acridine Red-C.I. 45,000(Allied Chemical Company)	0.13 g.
Dispersed dye-Spirit soluble Fast Red 3B(Allied Chemical Corp)	1.5 g.
Toluene	60 ml.

EXAMPLE 13

Yellow coating Composition: (blue sensitive)

Photoconductive zinc oxide (Photox 80)	100 g.
Modified alkyd resin (DeSoto E-104-13A)	25 g.
Sensitizing dye-Auramine O -C.I. 41,000(Allied Chemical Corp)	0.05 g.
Dispersed dye-Calcofast Spirit Yellow TG(American Cyanamid CO.)	1.5 g.
Solvent-toluene	60 ml.

EXAMPLE 14

Cyan coating composition: (red sensitive)

Photoconductive zinc oxide (Photox 80)	100 g.
Modified alkyl resin (DeSoto E-104-13A)	25 g.
Sensitizing dye-Patent Blue- C.I.42,045 (Allied Chemical Corp.)	0.05 g.
Dispersed dye-Spirit Soluble Fast Blue 6G (Allied Chemical Corp.)	1.5 g.
Solvent-toluene	60 ml.

In each of the examples, the resinous binder, zinc oxide and solvent are first blended together by mixing for about 5 minutes. The sensitizing dye, in solution in methanol, is added and blended by mixing for about 1 minute. The dispersed dye is finally added and blended with mixing for about one to 2 minutes.

The first coating 20, which may be the magenta coat of Example 12, is applied either by a roller coater, by a metering rod, or by hand draw-down with a wire wound rod, onto Weyerhaeuser Base A paper 10 in a coating weight of about 20 pounds per 3,000 square feet, and then dried as depicted in FIGS. 6 and 7. The yellow coating composition of Example 13 is applied, as by silk screen, in a coating weight of about 15 pounds per 3,000 square feet of surface area in a pattern of closely spaced parallel lines 22 which extend crosswise over the surface of the first coating 20. It will be understood that the described coatings can be applied in various other sequences such as a first coating of the yellow coat of Example 2 followed by second and third coatings of Examples 12 and 14, or a first coat of Example 14 and second and third coatings of Examples 14 and 13 or 13 and 14, etc.

The cyan coating composition of Example 14 is also applied, as by silk screen, in a coating weight of about 15 pounds per 3,000 square feet of surface area in a pattern of closely spaced parallel lines 24 which extend lengthwise over the first and second coatings to provide cross-over points 26 having three thicknesses of coating with the third coating 24 uppermost on the face of the substrate or paper base sheet.

The final coated sheet constitutes a receptor suitable for use in the practice of this invention with separate sections 28 having a single coating thickness of the magenta coating, separate sections 30 having a double coating thickness formed of a lowermost magenta coating 20 and an uppermost yellow coating 22 and a lowermost magenta coating 20 and an uppermost cyan coating 24 and still other sections 32 having a triple coating thickness formed of a lowermost magenta coating 20, an intermediate yellow coating 22 and an uppermost cyan coating 24. Thus, the exposed face of the receptor presents separate sections of each of the coatings in substantially uniformly dispersed relation over the face of the receptor sheet.

The receptor sheet is then charged in the manner described above, and the charged receptor is next exposed to the multi-color original. Such portions of the original which are blue in color, for example, will cause discharge of the corresponding areas on the face of the receptor formed of the yellow coating which is sensitized to blue, leaving the charges in the corresponding areas on the exposed face sections of the magenta and cyan coatings for subsequent development.

The portions of the original which are green in color cause discharge of the corresponding areas 28 on the face of the receptor formed of the magenta coating, which are sensitized to green, leaving the charge 34 on the corresponding areas on the face sections 32 of cyan and sections 30 of yellow coating for subsequent development, as depicted in FIG. 8.

Similarly, the portions of the original which have the color red will cause discharge in the corresponding areas of the receptor of the cyan sections 32 on the exposed face of the receptor sheet which are sensitized to red, leaving the charges on the corresponding areas in the exposed face sections of magenta and yellow for subsequent development.

The exposed receptor sheet is then developed with a developing composition of the type described in reference to Examples 5 and 6 which contain toner particles in the form of a material which, when reduced to a molten state, serves as a solvent for the dispersed dye contained in the photoconductive coating. In response to the application of the developer composition, the toner particles 36 will be retained on the portions on the face of the receptor which remain charged to define the latent electrostatic image after exposure while the discharged sections on the face of the receptor will remain substantially free of the toner particles as illustrated in FIG. 9.

In accordance with the practice of this invention, the toner particles 36 are then pre-fused to form a thin layer 38 of pre-fused toner containing the dispersed dye from the underlying coating dissolved therein as depicted in FIG. 10. The dye is then transferred to a copy sheet by placing a copy sheet 40 in surface contact with the imaged receptor sheet in the manner described above and schematically illustrated in FIG. 11.

In the example illustrated in FIGS. 9 to 11, the cyan and yellow coatings 32 and 30, respectively, which remain charged and retain toner particles 36 on development, solubilize the Calcofast Spirit Yellow TG and the Spirit Soluble Fast Blue 6G upon pre-fusion of the toner particles 36 to form the thin layer of pre-fused toner 38 whereby these dispersed dyes are transferred to the copy sheet with resultant reproduction 50 of the green color of the original. In such areas of the original which are black, such as printed areas, none of the sections in the face of the receptor would become discharged upon exposure. As a result, each of the areas accept toner for transfer of dispersed dyes from all of the three basic color sections which together appear black on the copy sheet.

It will be apparent that the copy produced by the combination of colors transferred from the developed receptor sheet will correspond to the colored original and that the developed receptor can function in a manner of a spirit master to produce multiple copies of the multi-color original, as by the successive passage of copy sheets into pressure contact with the developed receptor until the dispersed dyestuff in the toned face segments are exhausted.

The following illustrative example will serve to illustrate the transfer of a multi-color image in accordance with the concepts of this invention.

EXAMPLE 15

A receptor sheet which is coated with the photoconductive compositions of Examples 13 to 14 in the pattern illustrated in FIG. 6 is charged by exposure to a co-

rona discharge, exposed to a multi-color original and developed with the developer composition of Example 5.

The toner particles retained on the face of the exposed receptor are pre-fused to reduce the antipyrine particles to a molten state. Thereafter, the image side of the receptor and a copy sheet are passed through a pair of heated rollers at a temperature of about 100° C. and pressure of about 50 psi to transfer the multi-color original to the copy sheet.

The same procedure is repeated, except that the toner particles are not pre-fused. The color intensity of the copy produced with pre-fusion is noticeably more intense than that produced in the control run in which no pre-fusion step is employed.

I claim:

1. In a method for transferring a dye image from an imaged receptor sheet having at least one photoconductive composition on the face thereof comprising a photoconductor, a resinous binder, a sensitizer for the photoconductor and a dispersed dye which has been developed with a solid toner in the form of a material which, when heated to a molten state, is a solvent for the dispersed dye in the photoconductive coating, the improvement comprising the steps of pre-fusing the toner to reduce the toner to a molten state and thereby solubilize the dispersed dye and then placing a copy sheet in surface contact with the face of the receptor sheet at an elevated temperature whereby the dispersed dye is transferred from the face of the receptor to the copy sheet.

2. A method as defined in claim 1 wherein the dispersed dye is transferred to the copy sheet by passing the developed receptor sheet having pre-fused toner on the face thereof in surface contact with a copy sheet through a pair of heated compression rollers.

3. A method as defined in claim 1 wherein the temperature is within the range of a temperature of 10° C. to 25° C. above the melting point of the toner.

4. A method as defined in claim 1 wherein the toner is selected from the group consisting of antipyrine and 1-allyl-2-thiourea.

5. A method as defined in claim 1 wherein the photoconductor is zinc oxide.

6. A method as defined in claim 1 wherein the receptor sheet has a single photoconductive coating.

7. A method as defined in claim 6 wherein the photoconductive coating contains a sensitizer to sensitize the photoconductor to the entire spectrum of visible light.

8. A method as defined in claim 1 wherein the receptor sheet contains at least two photoconductive coatings interspersed on the face thereof.

9. A method as defined in claim 8 wherein each photoconductive coating contains a sensitizer which sensitizes the photoconductor to a particular segment of the visible light range for absorption of light within said range and reflection of light outside said range, and wherein the receptor sheet contains separate coatings to provide a total receptor sensitivity covering substantially the entire spectrum of visible light.

10. A method as defined in claim 9 wherein the dispersed dye in each photoconductive coating corresponds with the color of the light reflected from each coating.

11. A method as defined in claim 10 wherein the in-

terspersed photoconductive coatings comprise interspersed coatings sensitized to the additive primary colors of red, green and blue, respectively.

12. In an electrostatic copy process in which a receptor sheet having at least one photoconductive coating comprising a photoconductor, a resinous binder, a sensitizer for the photoconductor and a dispersed dye is provided with an electrostatic charge, exposed to an original whereby the non-imaged portions of the original cause corresponding areas of the receptor sheet to become conductive and thereby be discharged and the electrostatic charge is retained by areas of the face of the receptor sheet corresponding to the image areas of the original an developed with a developer composition containing a toner in the form of a material which, when reduced to a molten state, is a solvent for the dispersed dye in the photoconductive coating, the improvement comprising the steps of transferring a dye image from the receptor sheet to a copy sheet comprising pre-fusing the toner to reduce the toner to a molten state and thereby solubilize the dispersed dye and then placing a copy sheet in surface contact with the face of the receptor sheet at an elevated temperature whereby the dispersed dye is transferred from the face of the receptor sheet to the copy sheet.

13. A process as defined in claim 12 wherein the dispersed dye is transferred to the copy sheet by passing the developed receptor sheet having pre-fused toner on the face thereof in surface contact with a copy sheet through a pair of heated compression rollers.

14. A process as defined in claim 12 wherein the temperature is within the range from 25° C. to a temperature of 10° C. above the melting point of the toner.

15. A process as defined in claim 12 wherein the toner is selected from the group consisting of antipyrine and 1-allyl-2-thiourea.

16. A process as defined in claim 12 wherein the photoconductor is zinc oxide.

17. A process as defined in claim 12 wherein the receptor sheet has a single photoconductive coating.

18. A process as defined in claim 17 wherein the photoconductive coating contains a sensitizer to sensitize the photoconductor to the entire spectrum of visible light.

19. A process as defined in claim 12 wherein the receptor sheet contains at least two photoconductive coatings interspersed on the face thereof.

20. A process as defined in claim 19 wherein each photoconductive coating contains a sensitizer which sensitizes the photoconductor to a particular segment of the visible light range for absorption of light within said range and reflection of light outside said range, and wherein the receptor sheet contains separate coatings to provide a total receptor sensitivity covering substantially the entire spectrum of visible light.

21. A process as defined in claim 20 wherein the dispersed dye in each photoconductive coating corresponds with the color of the light reflected from each coating.

22. A process as defined in claim 21 wherein the interspersed photoconductive coatings comprise interspersed coatings sensitized to the additive primary colors of red, green and blue, respectively.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,754,907

Dated August 28, 1973

Inventor(s) Leo N. Chapin

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 13, line 46, after "coating." delete "cm 7."

Column 13, line 47, before "A" please insert -- 7. --

Signed and sealed this 18th day of December 1973.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

RENE D. TEGTMEYER
Acting Commissioner of Patents