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ELECTROPHOTOGRAPHIC PROCESS FOR MAKING STENCIL SCREENS

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EXPOSE ELECTROSTATICALLY CHARGED
PHOTOCONDUCTIVE SURFACE TO PRODUCE
A LATENT ELECTROSTATIC IMAGE

DEVELOP LATENT IMAGE WITH
ELECTROSTATICALLY ATTRACTABLE
DEVELOPER POWDER

TRANSFER POWDER IMAGE TO LIGHT
SENSITIZED CARBON TISSUE SHEET

AFFIX EMULSION SIDE OF CARBON TISSUE
SHEET TO A TRANSPARENT SHEET

EXPOSE TO LIGHT THROUGH THE
TRANSPARENT SHEET

DEVELOP IN HOT WATER

ADHERE CARBON TISSUE TO SILK SCREEN

DRY

REMOVE TRANSPARENT SHEET

CLEAR OUT REMAINING POWDER

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1

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ELECTROPHOTOGRAPHIC PROCESS FOR MAKING STENCIL SCREENS

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6 Claims. (Cl. 96—1)

This invention relates generally to an improved method of preparing stencil screens, and more particularly to an improved method of preparing silk screen stencils utilizing electrostatic printing techniques.

Screens of silk mesh or the like having outlines or designs set out in pervious portions and the remainder of the screen produced in impervious portions are used as stencils for transferring paints, ink, or the like to the surfaces of various articles to which a design is to be applied, such as "printed circuit boards" for example, which are often used in electronic equipment.

In one method of preparing silk screens, the design to be reproduced is first either photographed or drawn on transparent paper. A gelatin coating is then prepared, sensitized to light, and attached to a transparent supporting sheet. The sensitized gelatin has the property of becoming hard and insoluble when exposed to light. The light-sensitized gelatin is then exposed to the photographic transparency or the drawing copy. Light transmitted to the sensitized gelatin through the light-transmitting portions of the design render the portions of the gelatin which the light reaches relatively hard and insoluble, and remaining portions relatively unhardened and soluble. After exposure, the soluble or unhardened gelatin is washed away. The supporting sheet then contains a layer of hardened gelatin having thereon the design to be reproduced as a transparency. A silk screen or the like is then affixed to the gelatin and the supporting sheet is discarded. After drying, a completed silk screen is obtained.

This technique has a number of disadvantages, especially when it is desired to reproduce designs in which accuracy of reproduction is important. For example, when the original design is projected onto the gelatin it often becomes undercut. Undercutting means that images reproduced on the gelatin appear smaller than their actual size because the edges disappear or are much fainter than the remainder of the original projected image. In addition, since the transparency which may be used for projecting the design onto the sensitized gelatin is often made by a wet process, it is subject to shrinkage or expansion which may cause further errors in reproduction.

A principal object of the invention is to provide improved methods of making silk screens.

Another object of the invention is to provide an improved method of making silk screens in which the printed design is a faithful reproduction of the original.

Yet another object of the invention is to provide an improved method of making silk screens which minimizes undercutting.

Generally, the foregoing objects are accomplished by producing a powder image of predetermined configuration on a recording member, transferring said powder image from said recording member to another member having a surface comprising a photohardenable composition, for example a photosensitive gelatin, and exposing the photohardenable composition to light within its spectral sensitivity and within the spectral range in which the

2

powder image is opaque. Following the exposure, the powder image is removed and the exposed photosensitive gelatin treated in the usual way for making gelatin silk screen stencils.

The powder image is preferably produced electrically on a recording member and then transferred directly to the gelatin surface. In one method of producing this image, a thin layer of an electrically insulating material is provided on a member such as a paper sheet. A latent electrostatic charge pattern of desired configuration is produced on the layer and then the latent electrostatic image is developed with an electrostatically attractable powder to produce the temporary powder image.

A preferred method for producing the latent electrostatic image comprises coating a backing sheet with a thin layer of a photoconducting insulating material consisting essentially of a particular photoconductor dispersed in an electrically insulating, film-forming vehicle. The photoconducting coating is uniformly electrostatically charged and then exposed to a visible light image. The electrostatic charge is dissipated in the illuminated areas but remains on the non-illuminated areas, thereby producing a latent electrostatic image of a predetermined configuration with a relatively brief and convenient exposure.

The powder image is cheaply and easily produced. After transfer of the powder image to the photohardenable substance, special means of hold down during exposure of the photohardenable composition are not required. By virtue of the powder image being directly contacted to the photohardenable composition, the resolution of the ultimate image is improved and undercutting thereby eliminated.

The foregoing objects and other advantages are described in greater detail in the following detailed description and by reference to the accompanying drawing in which the sole figure is a flow chart describing the steps in the complete process.

In the preparation of silk screens in accordance with the invention, a latent electrostatic image of the design to be reproduced is first prepared. This may be achieved by well known electrostatic printing techniques such as are described by C. J. Young and H. G. Greig in "Electrofax—Direct Electrophotographic Printing on Paper," RCA Review, December 1954, vol. 15, No. 4, pages 469—484. To produce the latent electrostatic image, a suitable member having a photoconducting insulating layer or surface is sensitized by charging the surface, or in other words depositing electrostatic charge on the photoconductive surface. The photosensitive member preferably is placed on a grounded metal backing plate during charging. The photosensitive member may comprise a paper backing coated with a photoconductive variety of zinc oxide in a silicone resin, and it is sensitized immediately prior to use by passing across the surface a corona discharge electrode adapted to deposit on the surface a charge in the order of several hundred volts. The corona discharge member may comprise a plurality of 3 mil corona discharge wires disposed one-half inch from each other and from the photoconducting coating. The corona discharge wires are connected to a voltage source. As an example, a negative voltage of 6000 volts produces a corona discharge which will deposit a negative electrostatic charge upon the surface of the photoconducting coating. As the photoconducting coating passes beneath the wires, a corona discharge issuing therefrom is attracted to the grounded backing plate placed beneath the paper backing surface of the coating.

The electrostatically charged or sensitized photoconductive coating is then exposed to an incident electromagnetic radiation image, for example a light image from a projector. The electronic charge is lost or reduced in the illuminated areas and retained in the non-illuminated

3

areas to form a residual pattern of electrostatically charged areas on the photoconductive surface. Any type of electromagnetic radiation may be used depending upon the spectral sensitivity of the photoconductive coating. For example, visible light, infra red or ultraviolet rays may be used.

The electrostatic image may be stored for a time if desired. Ordinarily the next step is to develop the electrostatic image with a material which will subsequently prevent light from reaching the gelatin surface. Development may be accomplished by maintaining the photoconducting coating in darkness and passing a developer brush containing a developer powder across the surface of the photoconducting coating bearing the electrostatic image. Areas of developer powder are deposited on those areas of the surface retaining an electrostatic charge. The developer brush preferably comprises a mixture of magnetic carrier particles, for example, powdered iron and the developer powder. The mixture is secured in a magnetic field by a magnet to form a developer brush.

A preferred carrier material for the developer mix consists of "alcoholized iron," that is, iron particles free from grease and other impurities soluble in alcohol. These iron particles are preferably relatively small in size, being in their largest dimension about .002 to .008 inch. Satisfactory results are also obtained using a carrier consisting of iron particles of a somewhat wider range of sizes up to about .001 to .020 inch.

A preferred developer powder may be prepared as follows. A mixture comprising 200 grams of 200 mesh Piccolastic resin 4358 (an elastic thermoplastic resin composed of polymers of styrene, substituted styrene and its homologs) marketed by the Pennsylvania Industrial Co., Clairton, Pa.; 12 grams of Carbon Black 6, marketed by the Eimer and Amend Co., New York, N.Y.; 12 grams of spirit Nigrosine SSB, marketed by the Allied Chemical and Dye Co., New York, N.Y., and 8 grams of Iosol Black, marketed by the Allied Chemical and Dye Co., New York, N.Y., are thoroughly mixed in a stainless steel beaker at about 200° C. The mixing and heating should be done in as short a time as possible. The melt is poured onto a brass tray and allowed to cool and harden. The hardened mix is then broken up and ball milled for about 20 hours. The melted powder is screened through a 200 mesh screen and is then ready for use as a developer powder. This powder takes on a positive electrostatic charge when mixed with glass beads or iron powder. It therefore develops an electrostatic image composed of negative charges. 2-4 grams of the developer powder and 100 grams of the magnetic carrier material are blended together giving the completed developer mix. Other ratios may be used.

The developer powder may be chosen from a large class of electrostatically-attractable materials. It may be either fusible or non-fusible, because it is preferred not to fix the developer image. The developer powder should be opaque to light to which the gelatin is sensitive. The developer powder is preferably electrically-charged to aid in the development of the electrostatic latent image. The powder may be electrically-charged because the powder (1) is electroscopic, or (2) has interacted with other particles with which it is triboelectrically active or (3) has been charged from an electric source such as a corona discharge. Examples of other suitable developer powders are powdered zinc, powdered copper, carbon, sulphur, natural and synthetic resins or mixtures thereof.

The developer powder may be applied to the electrostatic image as described heretofore or in other ways. For example, it may be dusted on the electrostatic image, or it may be mixed with glass beads or other suitable carrier particles and the mixture cascaded across the surface to be developed. The beads serve merely as a temporary carrier, releasing the powder particles upon contact with the charged surface.

The developed powdered image is now ready to be

4

affixed to a gelatin layer. Commercially available pigmented, gelatin-coated paper tissue provides gelatin in convenient form for use, and is sold under the name of carbon tissue. Carbon tissue may be obtained from George Murphy Inc., 57 E. 9th Street, New York City. As it comes in rolls of sheet form, the gelatin is not light sensitive. A required operation is therefore to sensitize the carbon tissue to light. A piece of tissue is cut to desired size, and a sensitizing solution is prepared in a container sufficiently large to hold the carbon tissue sheet. A suitable sensitizing solution comprises ammonium bichromate mixed with water in the proportions of approximately 3 ounces of ammonium bichromate to a gallon of water. The temperature of the water should not exceed 60° F.

The carbon tissue is immersed in the sensitizing solution for about 2 minutes and then withdrawn and spread out flat on a glass or copper plate with the gelatin side in contact with the plate. Entrapped air bubbles and excess sensitizing solution are removed with a squeegee. Any surplus fluid should be carefully blotted from the surface. The carbon tissue on the plate is then placed in a dark room to dry. At this time particular precautions need be observed to protect the carbon tissue from light since it is now light sensitive. When the carbon tissue is dry it is moistened with water, and spread on a flat surface. The member bearing the powder image is then placed in direct contact with the moistened, light sensitive gelatin surface, and pressure is exerted firmly over the surface areas of the two members, by use of a roller, for example. The wet gelatin surface discharges the electrostatically charged sheet bearing the powder image and causes the powder image to be transferred directly to the gelatin surface. Because of this direct contact of the powder image with the gelatin surface, undercutting is eliminated as will be explained hereinafter.

The two sheets are now separated. During the further processing, the carbon tissue sheet is placed emulsion side down on a sheet of transparent material such as Mylar, clear vinyl or glass and pressure is applied uniformly over the two sheets to cause them to adhere, to thereby prevent the carbon tissue sheet from wrinkling or curling. The powder image is now sandwiched between the carbon tissue sheet and the transparent sheet.

The light sensitized gelatin surface with the powder image thereon is now exposed to light, for example, a No. 2 photo-flood or a white fluorescent light spaced about 5 inches from the plastic sheet for about 12-14 minutes. Because the powder image is in direct contact with the gelatin, undercutting or the disappearance of the edges of the image during exposure is prevented. In some prior art methods the image to be reproduced is placed on the transparent sheet, and light is projected past the image, through the transparent sheet and onto the gelatin surface. This is a major cause of undercutting.

Exposure to light causes the gelatin to harden in the exposed areas, and in those areas rendered opaque by the presence of the powder image the gelatin remains unhardened and water soluble.

After exposure, the carbon tissue sheet and the transparent covering sheet are immersed in a hot water bath at a temperature of approximately 110° F. Here a backing sheet on the carbon tissue is removed and both the developer powder and unhardened gelatin are washed from the hardened gelatin. Immersion in the hot water bath is continued until developer powder no longer washes away. The transparent covering sheet and the attached gelatin layer are then immersed in a bath of cold water to aid in hardening the gelatin. What then remains is a sheet of hardened gelatin attached to a transparent covering sheet, with the gelatin now having thereon in stencil form a design corresponding to the original powder image.

The hardened gelatin sheet may now be attached to a silk screen. Several types of screen material may be

5

used and are well known in the "silk" screen printing art. For example, organdy, silk, or wire mesh may be used. The screen should be stretched tightly and securely over a wooden frame. The gelatin sheet and its attached transparent covering sheet are now removed from the cold water bath and placed on a flat surface with the hardened gelatin surface facing upwards. The screen is placed on the gelatin surface and weights are attached to the wooden frame. The combination is then allowed to dry. When dry, the transparent covering sheet is peeled free from the gelatin, to leave a screen with the gelatin design attached thereto.

To prevent contamination of coloring agents which might be used with the screen, any toner powder remaining may be cleared out by washing the screen with a solvent such as toluene. By blocking and taping up of unused areas of the screen, a completed screen is obtained.

What is claimed is:

1. A process comprising electrophotographically producing a loose powder image of a predetermined configuration on an electrophotographic recording member, transferring said powder image to a surface of a photohardenable composition by bringing said recording member and said surface into contact with each other, exposing said photohardenable composition with said powder image thereon to light within the spectral sensitivity of said photohardenable composition and within the spectral range to which the powder image is opaque, and removing unhardened portions of said photohardenable composition along with said powder image to leave a pattern of hardened areas of said photohardenable composition on said surface.

2. A process comprising coating an electrically-insulating material upon a supporting sheet, producing a latent electrostatic image in a predetermined configuration upon said electrically-insulating coating, developing said latent electrostatic image with a powdered electrostatically-attractable material, transferring said developed image to a surface of a photohardenable composition by bringing said supporting sheet and said surface into contact with each other, exposing said photohardenable layer with said developed image thereon to light within the spectral sensitivity of said photohardenable composition and within the spectral range to which said powdered material is opaque, and removing unhardened portions of said photohardenable composition along with said powdered material to leave a pattern of hardened areas of said photohardenable composition on said layer.

3. A process comprising coating a supporting member with a photoconducting composition comprising a particulate photoconductor dispersed in an electrically-insulating, film-forming vehicle, electrophotographically producing upon said photoconducting coating an electrostatic image in a predetermined configuration, applying an electrostatically-attractable powder to said photoconducting coating, whereby said powder adheres to said coating to form a powder image in a configuration substantially corresponding to said electrostatic image, transferring said powder image to a surface of a recording member comprising a photohardenable gelatin by pressing said supporting member against said surface, exposing said photohardenable gelatin with the powder thereon to light for sufficient duration to harden said gelatin coating in areas not covered by said powder, removing said powder and said gelatin in areas covered by said powder.

4. A process for making stencil screens comprising

6

the steps of: producing a substantially uniform electrostatic charge on a photoconductive insulating surface; exposing said surface to a light image to produce a latent electrostatic image, developing said latent electrostatic image with electroscopic developer powder to produce a powder image on said surface; transferring said powder image to the emulsion side of a light sensitized carbon tissue sheet by contacting said photoconductive surface to said emulsion; applying a thin sheet of transparent material over said powder image and said emulsion; exposing said emulsion to light passing through said thin sheet to harden areas of said emulsion not covered by said powder image; immersing said carbon tissue sheet bearing said powder image and said thin sheet in hot water to remove said powder image and unhardened emulsion underlying said powder image; separating said carbon tissue sheet and said thin sheet to leave an image of hardened emulsion on said thin sheet, applying a taut screen to said hardened gelatin while still damp, removing said thin sheet to leave said hardened emulsion on said taut screen, removing any remaining developer powder from said taut screen by applying thereto a reagent which is a solvent for said developer powder but not for said emulsion.

5. A process for making stencil screens which includes the steps of electrophotographically producing a powder image on an electrophotographic recording member, transferring said powder image to the gelatin side of a gelatin-coated tissue by bringing said electrophotographic recording member into contact with said gelatin surface, applying a thin sheet of a transparent material over the powder image, exposing the gelatin through the transparent material to a light source for a predetermined period, removing the tissue while the gelatin remains adhering to the transparent material, washing out the powder image and unexposed portions of the gelatin, applying a screen to the gelatin while damp, and peeling away the transparent material.

6. A process for making stencil screens which includes the steps of photosensitizing the gelatin of a gelatin-coated tissue, electrophotographically producing a powder image on an electrophotographic recording member, transferring said powder image to the gelatin while still wet with sensitizing solution by bringing said electrophotographic recording member into contact with said gelatin, applying a sheet of thin transparent plastic material to the gelatin sheet with the powder image affixed thereto, exposing the plastic covered gelatin to light through the transparent sheet, wetting the gelatin and tissue with warm water, removing the tissue, washing away the powder image and unexposed portions of the gelatin, applying a taut screen to the gelatin while it is still damp, drying the gelatin, and removing the transparent plastic sheet.

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