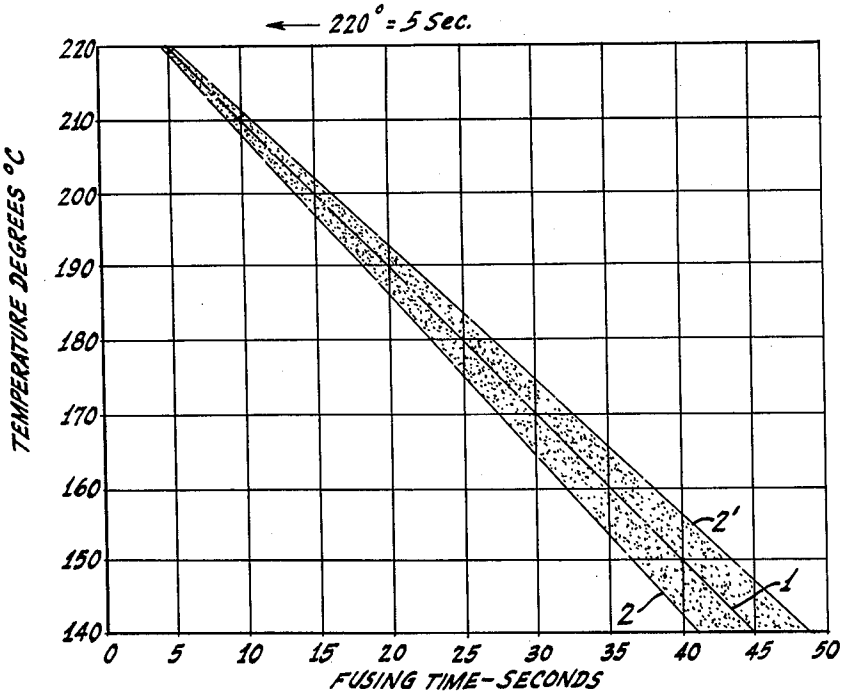
Oct. 23, 1962 S. W. JOHNSON ETAL 3,060,051

METHOD OF FUSING POWDER IMAGES

Filed Nov. 25, 1958



INVENTORS
SIGURD W. JOHNSON &
JOHN P. LAURIELLO

BY

W.S. Hill

AGENT

United States Patent Office 3,060,051 Patented Oct. 23, 1962

3,060,051

METHOD OF FUSING POWDER IMAGES

Sigurd W. Johnson, Oaklyn, and John P. Lauriello, Westmont, N.J., assignors to Radio Corporation of America, a corporation of Delaware

Filed Nov. 25, 1958, Ser. No. 776,221
6 Claims. (Cl. 117—17.5)

This invention relates to printing processes employed in the graphic arts and particularly, but not exclusively, to improved methods for fusing powder images.

In the graphic arts, powder images are frequently produced by depositing finely-divided particles in a desired configuration on a surface and then fusing the particles thereon to provide a permanent visible image. Images in a plurality of colors are produced by repeating the above procedure employing powders of different colors. During each subsequent fusing step, the different colored powders become intermixed in all areas wherein they overlap one another.

Electrostatic printing comprises one method for producing plural color images. Briefly, this method comprises the steps of: producing a substantially uniform electrostatic charge on the surface of a photoconductive insulating layer, exposing the layer through appropriate filters to a light image to produce an electrostatic image corresponding to one color of an original plural color image, developing the electrostatic image with a photoconductive developer powder having substantially the same color as the one color of the original image, and fusing the developer powder to the photoconductive layer. These steps are repeated as many times as desired employing a different color developer powder in each successive development step. The developer powders employed may comprise particles of photoconductive material coated with a low-melting theremoplastic material which includes a suitable coloring agent. Due to the photoconductive nature of the developer powders, overlapping of developed images is made possible in all areas wherein such overlapping is desired. During each successive fusing step, color mixing occurs in all areas wherein one developed image overlaps another. In this manner, a plural color copy can be produced which is a substantially true reproduction of an original colored image. This method of electrostatic printing is more fully described in a copending application for Letters Patent of H. G. Greig, Serial No. 722,707, filed March 30, 1958, and assigned to the instant assignee.

A second method which may be employed for producing plural color images includes the use of stencils. A plurality of stencils are prepared, each having a configuration corresponding to a single color to be reproduced. An electrically-insulating surface is provided with a uniform electrostatic charge. A first stencil is superimposed upon the charged surface and colored developer powder applied to the surface through the stencil to form a visible image corresponding to a first color. This first image is then fused to the surface. These steps are repeated as many times as desired to produce a plural color image. The developer powders used in this method conveniently comprise inert carrier particles coated with a low-melting thermoplastic material which includes suitable coloring agents.

Ferromagnetography is also well adapted to the production of plural color images. This process may include the steps of: producing a latent magnetic image in a magnetizable sheet, developing the magnetic image with a developer powder comprising magnetic carrier particles coated with a low-melting thermoplastic material, and fusing the developed powder image to the magnetizable sheet. Again, these steps may be repeated as many times as desired, employing a different color developer powder in each successive development step, to produce plural color visible images.

While the developer powders employed in the above processes are admirably suited for many applications, yet, for certain applications, they have inherent properties which can result in deleterious effects. For example, when coated carrier particles are fused to a surface, the resultant visible image generally presents a matte surface. This is disadvantageous when it is desired to produce smooth glossy prints. The carrier particles employed generally are opaque. When color mixing occurs during a fusing step, the opaque carrier particles tend to mask underlying color thereby resulting in color dilution to a degree which is often objectionable.

Accordingly, it is a general object of this invention to provide improved methods for fusing powder images.

Another object is to provide a fused powder image having a relatively smooth surface.

Still another object is to provide improved methods for fusing powder images, which methods substantially eliminate color masking by opaque carrier particles.

Yet another object is to provide improved fusing methods to be employed in the production of plural color powder images, which methods enhance color mixing and minimize color dilution.

In general, the foregoing objects and other advantages may be accomplished in accordance with this invention by careful control of fusing time and temperature. The invention contemplates that carrier particles coated with thermoplastic material shall be deposited on a surface by conventional methods to produce a visible powder image. Fusing of the visible image is accomplished by heating at a temperature at least equal to the melting point of the thermoplastic coating material for a time sufficient to melt only that portion of the material in contact with the surface. Upon cooling, only a thin layer of the thermoplastic material is fused to the surface and excess powder, including substantially all the carrier particles, may be removed as, for example, by brushing, wiping, or with a jet of air. The image produced in this manner contains a minimum of masking particles and presents a smooth surface. If desired, the glossy appearance of the fused image may be enhanced by rubbing.

When the methods of this invention are employed in plural color printing processes, the advantages thereof become readily apparent. As each successive color image is fused as heretofore described, mixing of colors is improved, masking substantially eliminated and the resultant composite color image is a much truer rendition of an original image.

Other objects and advantages of this invention are more fully described in the following detailed description when read in conjunction with the accompanying drawing which is a graph illustrating fusing temperatures and related fusing times required for a typical developer powder in accordance with this invention.

DEVELOPER POWDERS

The selection of appropriate developer powders is an important feature of this invention. As described heretofore, the developer powders contemplated herein comprise finely-divided carrier particles coated with a low-melting thermoplastic material. The properties of the carrier particles will differ according to the printing methods employed. Thus, in electrostatic printing, carrier particles preferably comprise photoconductive material, such as for example, photoconductive zinc oxide. For stencilling onto a charged surface it is preferred that the carrier particles have a relatively high electrical resistivity and that they be chemically inert with respect

to the coating material. In ferromagnetography, it is necessary that the particles have magnetic properties.

Coating materials also must have specific properties for use in the fusing methods of this invention. Where the developer powders are to be deposited on surfaces such as paper, it is important that the coating material have a melting point less than that at which paper will char. A preferred temperture range is between 60° C. and 250° C. In all cases, the viscosity of the coating material comprises another important criterion. The viscosity must be low enough so that, upon melting, coating material will flow and adhere to the surface in a thin film with at least portions of the carrier particles being exposed or protruding above that film. It is also necessary that the coating should not be so free-flowing as to allow it to migrate into unwanted areas of the surface upon which it is to be fused. A preferred viscosity range is from 45 c.p.s. to 10,000 c.p.s. as measured with a direct reading Brookfield viscosimeter with a spindle speed of 60 r.p.m. at a temperature just slightly above the melting point of the material.

Coating materials having the foregoing properties may comprise certain natural or synthetic resins, waxes, or other low-melting materials or mixtures thereof. For example, any of the following materials or combinations of materials may be used:

(1) Acrawax C (a synthetic wax-octedecenamide, the Glycol Products Co., Brooklyn, N.Y.)—the melting point between 133 and 140° C.

(2) Carnauba wax—melting point about 80° C.

(3) Polymekon wax (a commercially modified microcrystalline wax of the Warwick Wax Co., New York, N.Y.)—melting point about 93 to 127° C.

(4) Ultracera Amber Wax (a microcrystalline petroleum wax of the Bareco Oil Co., Barnsdall, Oklahoma)—melting point about 108 to 112° C.

(5) BE Square Wax White (a microcrystalline petroleum wax of the Bareco Oil Co., Barnsdall, Oklahoma)—melting point between 105 and 109° C.

(6) Petronauba D wax (a microcrystalline petroleum wax of the Bareco Oil Co., Barnsdall, Oklahoma)—melting point about 103° C.

(7) Piccolyte S–135 (a thermoplastic hydrocarbon terpene resin of the Pennsylvania Industrial Chemical Co., Clairton, Pa.)—melting point about 135° C.

Coating materials, such as those above-identified, may also include modifying agents such as plasticizers, toughening agents, hardening agents, dispersing agents, etc. which are added to obtain desired physical, chemical and electrical properties.

A preferred developer powder includes a ratio of carrier particles to coating material within a range of from 1 to 7 parts by weight of carrier particles to one part by weight of coating material. Such a powder is generally prepared by first melting the coating material and then dispersing the finely-divided carrier particles in the melt. The melt is allowed to cool and harden after which it is broken up and reduced to the desired powder form. The exact ratio of carrier particles to coating material will depend to a large extent on particle size and the method of printing in which the developer powder is to be used.

Coloring agents such as dyes, stains or pigments can be added to the melt to produce developer powders of desirable colors. Examples of suitable coloring agents include:

(1) Cyan Blue Toner GT (described in U.S. Patent 2,486,351 to Richard H. Wiswall, Jr.)

(2) Benzidene Yellow

(3) Brilliant Oil Blue BMA (Color Index No. CI–61555)

(4) Condensation Blue

(5) Sudan III Red (Color Index No. 26100)

(6) Oil Yellow 2G (Color Index No. 11020)

(7) Safranin Y (Color Index No. 50240)

These and other suitable coloring agents may be employed singly or in combination to impart to the developer powder the desired color.

ELECTROSTATIC PRINTING

The improved fusing methods of this invention are admirably suited for electrostatic printing processes such as those described in the Greig application, op. cit. As described heretofore, the Greig application contemplates development of electrostatic images with photoconductive developer powders. The developed image, when fused, presents a surface capable of being overprinted in subsequent electrostatic printing steps. Specific examples of suitable developer powders include the following:

Example I

BLUE DEVELOPER POWDER

	Parts by weight
Polymekon wax	15
Piccolyte S–115	5
Photoconductive zinc oxide	50
Condensation Blue	1

The wax is melted and particles of the zinc oxide having a particle size of from .025 to .5 micron mean diameter are added to the melt. Particle size and shape of the zinc oxide determine to some extent the ratio of zinc oxide to coating material. Due to the bulking characteristic of zinc oxide, finer particles usually require more coating material since there is more total surface to be covered. Continuous stirring from 15 to 30 minutes is sufficient to thoroughly disperse the zinc oxide in the wax when the batch weighs about 100 grams. During stirring, the condensation blue is added to the melt. When mixing is completed, the mixture is allowed to cool and harden after which it is reduced to a fine powder. This is accomplished by ball milling the mixture for about 3 hours and then classifying it as to particle size. For most purposes, the fraction below 200 mesh (74 microns) is suitable.

Example II

YELLOW DEVELOPER POWDER

	Parts by weight
Piccolyte S–135	20
Photoconductive zinc oxide	30
Benzidine Yellow	1.5

Preparation as in Example I.

Example III

RED DEVELOPER POWDER

	Parts by weight
Acrawax C	36
Polyethylene (melting point about 130° C.)	4
Photoconductive zinc oxide	80
Sudan III Red (CI 26100)	2
Safranin Y (CI 50240)	2

Preparation the same as Example I.

IMAGE FUSING

Fusing temperatures and times are illustrated in the single FIGURE of the drawing for the above described red developer powder. The red developer powder was deposited on a paper-backed photoconductive surface (photoconductive white zinc oxide dispersed in a resinous polysiloxane binder) employing conventional electrostatic printing techniques. The paper was then placed in a conventional oven wherein temperature was carefully controlled. It was found that proper fusing could be accomplished in as short a time as 5 seconds at a temperature of 220° C., and in 45 seconds at 140° C. It was also found that between these limits the time-temperature relationship was linear, as illustrated by the solid line 1 of the graph. It was further noted that at

45 seconds and 140° C., the time of fusing could vary as much as ±4 seconds and that as time was decreased and temperature increased the allowable time variation correspondingly decreased. The allowable time variation is illustrated by the shaded area on the graph between the dashed lines 2, 2' for various temperatures. When a blue developer powder, comprising substantially the same coating material and zinc oxide but having a blue coloring agent therein, fusing times increased about 10%. With similar yellow developer powder, fusing times increased about 15% over the times depicted in the graph. When photoconductive developer powders are fused in this manner, coating material adheres to the photoconductive layer in a very thin film and overprinting of one color image with another so as to obtain optimum color mixing is readily accomplished. After each image is fused to the photoconductive surface the zinc oxide particles and excess coating material are removed. This is done, for example, by brushing with a stiff bristle brush which removes substantially all the zinc oxide particles and excess coating material. Alternatively, a soft cloth or air jet may be used for the same purpose. When a completed composite image is produced in this manner the gloss thereof can be enhanced by a light polishing as, for example, by rubbing with a soft cloth.

Since substantially all the photoconductive zinc oxide carrier particles are removed in the above process, other carrier materials may be substituted therefor. Some of these include, high melting point resins, ordinary sand, ceramics or metals. It is preferred that such materials have a particle size not less than .025 micron and not more than 40 microns mean diameter. Carrier particles having too small a size are difficult to remove after fusing and those too large in size will not provide for sufficient deposition of coating material. When materials other than photoconductive particles are employed, there exists the risk that, in the final composite image, pin holes may be present. This can result because of the fact that during the removal step, something less than 100% of the carrier particles are cleaned off the photoconductive surface. Thus, if the carrier particles are of conductive material, those remaining on the surface will be incapable of retaining an electrostatic charge and cannot be overprinted. In applications where such pin holes are objectionable, it is preferred that photoconductive particles, such as white zinc oxide, be employed. Any photoconductive particles remaining on the surface will be capable of retaining an electrostatic charge, in darkness and of being discharged by the action of light thereon. Thus, such particles will function, during subsequent printing operations in a manner identical to that of the photoconductive surface on which they rest. In this way, the presence of any pin holes in the final composite image can be eliminated.

ELECTROSTATIC STENCILLING

Suitable developer powders for stencilling onto electrostatically charged sheets are similar to those employed in electrostatic printing. In this instance, since all printing operations are generally carried out in the full light, a preferred carrier material is one which is a good insulator rather than one which is a photoconductor. Admirably suited for this purpose are many high-melting point resins and ceramic materials. Such developer powders may be prepared in the same manner as those of Examples I to III by merely substituting the particles of insulative material for the zinc oxide in each example. Here again, pin holes in the final composite image are avoided if insulative carrier particles are employed. Where such pin holes are not objectionable, conductive materials such as metals may be substituted.

FERROMAGNETOGRAPHY

By substituting magnetically attractable materials for the zinc oxide carrier particles of Examples I to III, developer powders useful in ferromagnetography are provided. Suitable materials include powdered soft iron and various ferrites. Preferably materials are selected which have little or no remanance or, alternatively, materials having a Curie point below the temperature at which images are fused. When a magnetic surface, on which such powders are deposited, also has a Curie point below the temperature at which images are fused, the procedure for laying down two or more images is simplified. With such a surface, fusing automatically demagnetizes the surface eliminating the need for an additional step to accomplish the same purpose. Thus, once an image has been fused on the surface, excess developer materials removed, and the surface has cooled, it can be remagnetized in configuration with the next color image to be produced thereon.

It will be obvious that, in ferromagnetography, it will often be desirable to employ developer powder coating materials having considerably high melting points than those employed in electrostatic printing or stencilling. Higher melting points of coating materials provide much greater latitude in the selection of magnetically attractable carrier particles and in the selection of magnetizable recording surfaces.

Although specific examples have been provided herein of suitable developer powders and particularly with respect to the coating materials thereof, the scope of this invention is not limited thereto. Many materials whose melting points differ from those described or from those illustrated in the single figure of the drawing can be properly fused as described herein. Proper fusing times and temperatures for such materials can readily be determined with a few tests at different temperatures and times, and by optical inspection of the results of these tests. It is important that a temperature and time be selected such that only that portion of the coating material contacting the surface shall melt and adhere thereto and that substantially all the carrier particles and excess coating material can be readily removed.

What is claimed is:

1. In a process for producing powder images on a surface with a developer powder comprising carrier particles coated with a thermoplastic material, the improvement comprising heating said developer powder on said surface at a temperature at least equal to the melting point of said thermoplastic material for a time sufficient to melt that portion of said coating material in contact with said surface and, after said portion of said coating material is fused to said surface, removing said coating material not fused to said surface and substantially all of said carrier particles.

2. In a process of electrostatic printing including repeating the following steps in sequence: (1) producing a latent electrostatic image on an insulating surface, (2) producing a colored powder image on said surface in substantial configuration with said electrostatic image with a developer powder comprising carrier particles coated with a thermoplastic electroscopic material having a melting point substantially within a range of from 60° C. to 190° C., and (3) fusing said developer powder on said surface; the improvement comprising accomplishing said fusing by heating said developer powder on said surface at a temperature at least equal to said melting point for a time sufficient to melt and fuse only that portion of said coating material in contact with said surface, and including in said sequence, after said portion is fused to said surface, an additional fourth step of removing from said surface said coating material not fused thereto and substantially all of said carrier particles.

3. An electrostatic printing process comprising repeating the following steps in sequence: (1) electrophotographically producing on a photoconductive surface a developer powder image in areas on said surface corresponding to one color of an original color image, said developer powder comprising particles of photoconductive zinc ox-

ide coated with a thermoplastic electroscopic material having a melting point substantially within a range of from 60° C. to 190° C. and in which is included a coloring agent capable of imparting to said coating material a color substantially the same as said one color of said transparency, (2) heating said powder image on said surface at a temperature at least 10 degrees in excess of said melting point for a time sufficient to cause only that portion of said coating material in contact with said surface to melt and fuse thereto, and (3) after said portion is fused to said surface, removing from said surface said coating material not fused to said surface and substantially all of said particles of photoconductive zinc oxide.

4. The process of claim 3 wherein said thermoplastic electroscopic material has a melting point of about 130° C. to 140° C. and said powder image is heated at a substantially constant temperature within the range of from 140° C. to 220° C. for a time inversely linearly proportional to said range of temperatures, said time varying from between 41 seconds to 56 seconds at 140° C. down to about 5 seconds at 220° C.

5. The process of claim 4 wherein substantially all of said particles of photoconductive zinc oxide and said coating material not fused to said surface are removed therefrom by brushing.

6. The process of claim 4 wherein substantially all of said particles of photoconductive zinc oxide and said coating material not fused to said surface are removed by directing onto said surface a jet of compressed air.

References Cited in the file of this patent

UNITED STATES PATENTS

2,186,054	Weaver	Jan. 9, 1940
2,297,691	Carlson	Oct. 6, 1942
2,336,243	Hanson	Dec. 7, 1943
2,552,209	Murray	May 8, 1951
2,618,552	Wise	Nov. 18, 1952
2,701,765	Codichini et al.	Feb. 8, 1955
2,735,784	Greig et al.	Feb. 21, 1956
2,758,939	Sugarman	Aug. 14, 1956
2,808,328	Jacob	Oct. 1, 1957
2,841,078	Weaver	July 1, 1958
2,857,290	Bolton	Oct. 21, 1958
2,884,348	Kulesza	Apr. 28, 1959
2,890,968	Giaimo	June 16, 1959
2,940,934	Carlson	June 14, 1960

FOREIGN PATENTS

723,539	Great Britain	Feb. 9, 1955