

March 10, 1959

E. F. MAYER

2,877,133

ELECTROSTATIC PHOTOGRAPHY

Filed Oct. 22, 1956

FIG. 1.

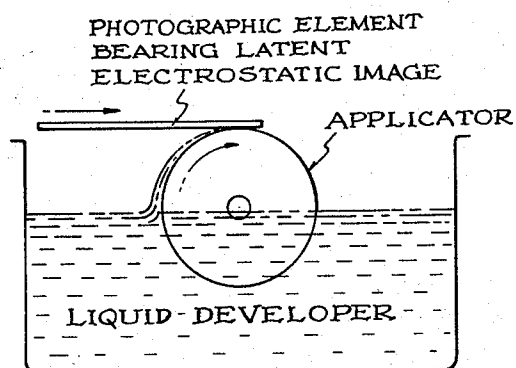
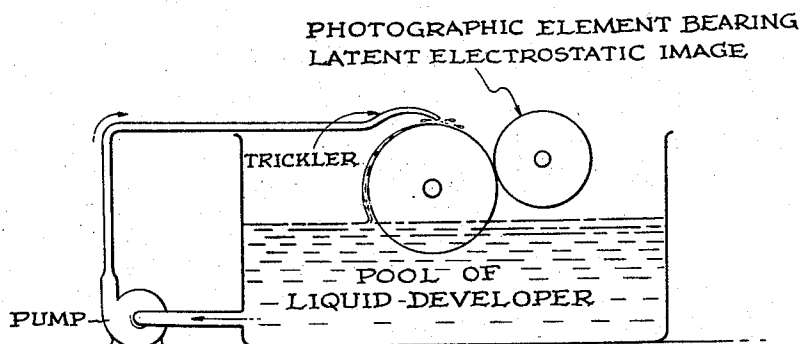


FIG. 2.



INVENTOR

EDWARD F. MAYER

BY *Lawrence J. Field*

ATTORNEY

1

2,877,133

ELECTROSTATIC PHOTOGRAPHY

Edward F. Mayer, Cleveland, Ohio, assignor, by mesne assignments, to General Dynamics Corporation, San Diego, Calif., a corporation of Delaware

Application October 22, 1956, Serial No. 617,246

6 Claims. (Cl. 117—37)

This invention relates to the development of visual images in electrophotographic processes and to a novel composition of matter which has been found to be particularly suitable for the development of a visible image from a latent electrostatic image existing as a charge pattern in a layer of a material having a high resistance.

Among the prior art processes in which latent electrostatic images are formed on or in such layers and subsequently converted into a visual image by application of a finely divided opaque solid material suspended in air either as a dry powder or as a liquid mist are those described by C. F. Carlson in Patents 2,297,691 and 2,551,582 respectively. In other copending applications, Serial No. 380,285 filed September 15, 1953, and Serial No. 484,215 filed January 26, 1955, I have disclosed electrophotographic processes in which a latent electrostatic image is converted into a visual image by means of a suspension of solid opaque particles in a liquid. The present application is a continuation-in-part of a copending application, Serial No. 486,995, filed February 8, 1955, disclosing one type of developer formulation.

The present invention is specifically directed to a method of developing visible images from the electrostatic image produced by any of the aforesaid electrophotographic processes or by any other suitable electrophotographic process, and particularly to the developer composition itself.

Dry granular electroscopic powders have in the past been cascaded over latent electrostatic images, or brought in the form of powder clouds into intimate contact with the charge image to be rendered visible. Such developers are described in Walkup Patent 2,618,551; Wise Patent 2,618,552; Walkup Patent 2,638,416; Copely Patent 2,659,670; and Landrigan Patent 2,753,308, and consist essentially of pigmented resin particles based on specific resins. Other electroscopic powders known in the art are disclosed in Patent 2,297,691, and these include finely pulverized synthetic resins and natural gums and waxes as well as inorganic powdered materials such as aluminum bronze, talcum powder, minium, sulfur and carbon dust.

I have found that development based on liquid media instead of the above described "dry" processes offers important advantages. The time required for development of a visible image can be materially diminished and this is of importance in the design of apparatus which is to continuously produce legible copy. In addition, the use of liquid borne developers permits of a greater control in the developing process.

Essentially, the developer in my process comprises a liquid combination of mutually compatible ingredients, which when brought into contact with an element bearing an electrostatic charge pattern corresponding to the image to be reproduced, previously referred to as a latent electrostatic image, will deposit by electrostatic attraction a visible light and shadow pattern corresponding to the

2

latent electrostatic image. In its simplest form, the composition comprises three essential ingredients as follows:

- (1) A finely divided opaque powder.
- (2) A high resistance liquid, and
- (3) An ingredient which functions to prevent agglomeration.

Any of the finely divided opaque solid materials known in this art may be employed in the developer. Thus talcum powder, carbon black and other pigments disclosed in Carlson above noted or any pigment which forms a dispersion with the other constituents of the developer may be used. The particle size of the specific opaque material will influence both the rate at which the image is developed and the density of the image. Particles between 0.1 and 10 microns are satisfactory for most purposes, with about 2 microns being preferred. Of the many pigments available, I prefer hardwood charcoal the particle size of which has been reduced sufficiently, to, for example, 2 microns or less by ball milling. Up to about 25% by weight of the finely divided opaque powder may be incorporated in the composition, with between 10% and 20% by weight being a preferred range and 15% by weight producing particularly good results. The particle size and concentration chosen for any specific application is necessarily related to the sharpness or definition desired in the ultimate image.

The opaque solid particles are dispersed or suspended in a liquid vehicle possessing a high resistance. In order to avoid discharge of the latent electrostatic image, a liquid with a resistivity of about at least 10^9 ohm centimeters is necessary. Liquids which I have found suitable include carbon tetrachloride, kerosene, benzene, toluene, and other hydrocarbons and substituted hydrocarbons having a boiling point between about 70° C. and 200 C.

In order to minimize settling or clumping or agglomeration of the particles, a third ingredient is included in the developer composition. I have found that a silica aerogel (Santocel No. 54, a product of Monsanto Chemical Company) formed by dehydrating normal silica gel and replacing the water of hydration with air, without destruction of the gel structure, is particularly suitable. Amounts of up to about 20% by weight of the gel have been found satisfactory, between about 5 and 15% by weight being preferred.

The several ingredients may be formed into the desired suspension in various ways. For example, the high resistance liquid and the opaque powder may be mixed during the ball milling of the powdered material and the silica aerogel added to the mixture. Alternatively the ingredients may merely be blended by mixing them at one time in a Waring type blender. Once the finely divided powder is dispersed in the high resistance liquid it may be readily maintained uniformly suspended by occasional hand-stirring, since the aerogel functions as a suspending agent in the mixture.

Compositions comprehended within the above description have been found to be particularly useful in the roller electrophotographic process described in my aforesaid copending patent applications. One difficulty encountered in forming the latent electrostatic image into a visual image has been the tendency of the liquid developer heretofore employed to ride up on the developer roll in insufficient amounts and as a result to produce low contrast images. By employing the combination of ingredients herein disclosed I have found that a developer of suitable viscosity results, free from the difficulties previously encountered.

The following examples will further illustrate the preparation and use of developers in accordance with my invention.

Example I

A developer was prepared by ball milling for 7 hours, 1 part by weight of charcoal and 1 part by weight of Solvesso 150, a mixture of polyalkyl benzenes boiling at 365° F. to 415° F. and having a flash point of 150° F., manufactured by The Standard Oil Company of Ohio. At the end of this time the particle size of the charcoal was reduced to between 1 and 5 microns and the average particle size was 2 microns. The contents of the ball mill were discharged and any adherent pigment was rinsed from the balls by flushing them with additional Solvesso. The dispersion of solid particles was diluted with additional Solvesso until the relative proportions by weight of charcoal:vehicle was about 1:8. One part by weight of silica aerogel was added to each 15 parts by weight of the mixture and the resulting composition was charged into a Waring type blender and mixed for 10 minutes. The developer when applied to a plate bearing an electrostatic image produced a sharp image after 2 seconds' contact and was readily transferred to a newsprint web which served as a permanent record medium.

Example II

The process of Example I was repeated except that the developer composition prepared contained 2 micron particle-size charcoal, Solvesso 150, and silica aerogel (Santocel No. 54) in the relative proportion by weight of 1:7:2. The image was developed by flowing the liquid developer over an applicator roller which lightly contacted a rotating cylinder bearing an electrostatic image. The image formed rapidly and reproduced the details of the original object electrostatically photographed.

While I have disclosed specific examples in which the finely divided solid opaque material is charcoal and the liquid vehicle in which it was dispersed was an alkyl benzene mixture, it will be understood that many other media and pigments may be used in combination without departing from the spirit and scope of my invention.

In the single sheet of drawing accompanying this application, I have shown by way of illustration two of the possible ways of applying developer compositions to a surface bearing a latent electrostatic image. Figure 1 illustrates the method of Example I in which developer is applied by a roller applicator to a plate bearing a latent electrostatic image. Figure 2 is a showing of one method of applying the liquid developer compositions to a rotating cylinder bearing a latent electrostatic image as described in Example II, above. It will be readily apparent to others skilled in the art that the liquid may be brought into physical contact with surfaces bearing latent electrostatic images in many other ways, including: immersion of the surface in a pool of developer, or flowing of developer over the image-bearing surface, in addition to the two methods illustrated.

Having now described my invention in accordance with the patent statutes, I claim:

1. A process for developing a visible image of a latent electrostatic charge image in a high resistance material which comprises: applying a liquid developer consisting essentially of a finely divided opaque solid electrostatically attractable powder of which the particle size is not greater than 10 microns dispersed in a liquid having a specific resistivity of at least about 10^9 ohm centimeters and containing up to about 20% by weight of a silica aerogel suspended therein, to the material bearing the electrostatic charge image for a time sufficient to develop the desired visible image.

2. A process for developing a visible image of a latent electrostatic charge image in a high resistance material which comprises: applying a liquid developer consisting essentially of a finely divided opaque solid electrostatically attractable powder of which the particle size is not greater than 10 microns dispersed in a liquid having a specific resistivity of at least about 10^9 ohm centimeters and containing up to about 20% by weight of a silica aerogel suspended therein, to the material bearing the electrostatic charge image for a time sufficient to develop the desired visible image, and transferring the visible image to a permanent record medium.

3. A process for developing a visible image of a latent electrostatic charge image in a high resistance material which comprises: applying a liquid developer consisting essentially of finely divided charcoal particles up to 10 microns in size dispersed in a liquid having a specific resistivity of at least about 10^9 ohm centimeters and containing up to about 20% by weight of a silica aerogel suspended therein, to the material bearing the electrostatic charge image for a time sufficient to develop the desired visible image.

4. A process for developing a visible image of a latent electrostatic charge image in a high resistance material which comprises: applying to the material bearing the electrostatic charge image a liquid developer consisting essentially of a charcoal powder approximately 2 microns in size, dispersed in a liquid having a specific resistivity of at least about 10^9 ohm centimeters and containing up to about 20% by weight of a silica aerogel suspended therein, for a time sufficient to develop the desired visible image.

5. A process for developing a visible image of a latent electrostatic charge image in a high resistance material which comprises: preparing a liquid developer consisting essentially of a finely divided opaque solid electrostatically attractable powder of which the particle size is not greater than 10 microns dispersed in a liquid having a specific resistivity of at least about 10^9 ohm centimeters and containing up to about 20% by weight of a silica aerogel suspended therein, and applying the liquid developer to a material bearing a latent electrostatic charge image for a time sufficient to develop the desired visible image.

6. A process for developing a visible image of a latent electrostatic charge image in a high resistance material which comprises: preparing a liquid developer consisting essentially of between 10 and 20% by weight of a finely divided opaque solid electrostatically attractable powder of which the particle size is not greater than 10 microns dispersed in a liquid having a specific resistivity of at least about 10^9 ohm centimeters and containing up to about 25% by weight of the dispersion of a silica aerogel suspended therein and applying the liquid developer to a material bearing a latent electrostatic charge image for a time sufficient to develop the desired visible image.

References Cited in the file of this patent**UNITED STATES PATENTS**

2,682,478	Howse	June 29, 1954
2,784,109	Walkup	Mar. 5, 1957

OTHER REFERENCES

Industrial and Engineering Chemistry, vol. 33, No. 9, September 1941, pp. 1169-1173.