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DEVELOPER FOR ELECTROSTATIC PRINTING

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This invention relates to electrostatic printing. More particularly it relates to an improved liquid developer composition for converting a latent electrostatic image into a visible image and to an improved process for converting the visual image into a permanent visual record.

Processes for forming a latent electrostatic image existing as an electrostatic charge pattern in a layer of material having a high resistance and for subsequently converting the latent electrostatic image into a visual image are known. One such process involves the use of a finely divided opaque solid in the form of a suspension in air as described in United States Patent 2,221,776. Another type of process in which a finely divided opaque solid is employed in the form of a dispersion in a high resistance liquid is disclosed in copending applications Serial No. 380,285, filed September 16, 1953, Serial No. 484,215, filed January 26, 1955, and Serial No. 486,995, filed February 8, 1955, by one of the present applicants. More recently, a similar liquid developer has been described by Metcalfe in the Journal of Scientific Instruments published by the Institute of Physics (London), volume 32, Number 2, February 1955, on pages 74 and 75.

Prior art dry powder methods require complicated equipment for suspending the powder and are considerably slower than the more recent wet methods. Although the wet developers constitute an improvement over earlier dry developers for the conversion of a latent electrostatic image to a visual image, none of the prior art developers is entirely satisfactory from the standpoint of producing a permanent visual record which does not smear or blur when rubbed. One attempted solution involves the use of adhesive coated or impregnated transfer media for transferring the pattern of the solid opaque particles constituting the visual image developed from the latent electrostatic image to a permanent recording means. The use of such transfer media constitutes a severe economic disadvantage in the prior art processes.

To overcome this, other prior art efforts have been directed to the transfer of the powder image onto an inexpensive absorbent transfer medium. The ultimate image so obtained was generally satisfactory for interpretation at the time of transfer but was found to blur and smear when rubbed. It was therefore found necessary to fix such images in an additional operation and one common technique was to spray an adhesive lacquer on the permanent record medium.

The present invention constitutes an improvement over prior art liquid developers previously described. Instead of requiring the use of specially prepared adhesive containing strips or of relying on the absorbency of the transfer media, coupled with a separate aftertreatment to fix the image, we have now found that a suitable temporary visual image of the latent electrostatic image may be produced and then transferred to and fixed on a permanent record medium in a simple and direct manner.

In accordance with our invention, we provide a liquid developer composition to be used in the development of

a visual image from a latent electrostatic image comprised essentially of the following ingredients:

(1) A finely divided opaque powder,

(2) A high resistance liquid, and

(3) An ingredient which fixes the finely divided opaque powder image onto a permanent record medium when the particles constituting the temporary image are brought into contact with a permanent record medium under suitable conditions.

Virtually any opaque powdered solid material may be employed in our developer composition. It is merely required that the powder remain insoluble in the liquid components and that it be chemically inert with respect to them. Suitable powders are known in the art and we have found that carbon particles with a size between about .01 micron and 50 microns to be suitable. The particle size selected for any specific application is necessarily related to the sharpness of definition desired in the ultimate visual image. In one specific application we have found an average particle size of 12 microns satisfactory from the standpoint of definition of the image produced, while in others, carbon black of about 0.1 micron particle size have produced the desired result.

The high resistance liquid component of our composition is generally a hydrocarbon or substituted hydrocarbon such as carbon tetrachloride, kerosene, benzene, or toluene or indeed any other high resistance liquid hydrocarbon having a boiling point between about 70° C. and 200° C.

The third essential ingredient in our developer composition performs a variety of functions. It serves to disperse the finely divided opaque powder and also acts to fix the opaque powder particles onto the permanent record medium when the transfer to such medium is effected in the manner to be described. Accordingly, the third essential ingredient is chosen from materials which are non-adhesive, non-thermosetting and which soften without depolymerization on heating. Furthermore, it must be a material which maintains its film-forming properties on cooling and must be one which melts at a reasonable temperature, that is, one which melts below the charring point of the permanent transfer medium. It is further required that the third constituent be chosen from materials which do not react to any substantial extent with either the finely divided opaque powder or the high resistance liquid. We have found that one class of materials possessing the desired combination of properties are those straight chain hydrocarbon polymers or chlorinated straight chain hydrocarbon polymers which are generally designated as polyethylenes and more particularly those polyethylenes having an average molecular weight in the range of 1500–5000, or chlorinated polyethylenes of the same molecular weight range.

Other ingredients may be incorporated into our developer liquid in order to achieve additional advantages. Thus, we have found, that small amounts of the various waxes which form compatible mixtures with polyethylenes may be employed to assist in wetting the opaque finely divided solid material by the polyethylene. Typical compatible waxes have been found to include paraffin wax, beeswax, carnauba wax, and microcrystalline wax. Numerous other compatible waxes may be employed. We have also found that silica aerogel may be added to the composition to improve the viscosity of the liquid.

The several ingredients may be combined in various proportions and we have found that amounts of opaque powder, e.g., charcoal or carbon black, up to 25% by weight; and amounts of polyethylene up to 20% by weight of the composition have produced entirely satisfactory images. Obviously, the proportions may be varied to

suit any specific application and actually, we have obtained satisfactory images with as little as 5% by weight of the finely divided opaque powder.

The several components of our liquid developer composition may be brought together in various ways. One relatively simple method of forming the desired composition is to heat the three ingredients to the melting point of the polyethylene and then allow the composition to cool to room temperature. In another method of preparation, amounts up to 100% of the high resistance liquid may be added to the opaque solid material and the opaque solid material may then be ball milled to the desired degree of fineness. Any further addition of the high resistance liquid is then made and the resulting dispersion is then combined with the third essential ingredient of our composition, the thermoplastic material, for example a polyethylene having an average molecular weight in the range of 1500 to 5000. When such a material constitutes the third ingredient, it may be combined with the dispersion by heating and melting it and pouring it into the dispersion. Since the polyethylene is only slightly soluble in many of the liquid hydrocarbons possessing the required high resistance, it may be melted and poured into the mixture of opaque finely divided solid and high resistance liquid with vigorous agitation whereby a dispersion containing up to 20% by weight of polyethylene may be obtained.

Alternatively, another method of preparing the composition is to melt the polyethylene in the high resistance hydrocarbon containing the finely divided opaque solid material. Whichever method is chosen for adding heated polyethylene to the remaining components, it has been observed that the polyethylene does not separate from the hydrocarbon constituent upon cooling. At high concentrations of polyethylene a thixotropic mixture is formed, that is, one which is gel-like until it is shaken, at which point it becomes more liquid. In still another method of preparation, the thermoplastic material may be melted and to the melt the finely divided opaque solid may be added with stirring to uniformly disperse the solid throughout the thermoplastic constituent. This dispersion is added to the high resistance organic liquid, preferably in heated condition, to form a dispersion of the thermoplastic material and opaque finely divided solid in the high resistance liquid. When the specific ingredients employed are polyethylene, carbon particles and a hydrocarbon, the polyethylene appears to form a coating around the carbon particles and it is the coated particles which are dispersed in the hydrocarbon. Still another method of preparation may be employed. In this method the solid opaque particles are added to the melted thermoplastic material and to improve the coating of the particles, we add a straight chain hydrocarbon wax such as a petroleum wax to the constituent. The desired final composition is then formed by adding the high resistance organic liquid to the prepared mixture.

The following example will illustrate the preparation of one specific developed composition.

Example

A developer was prepared by heating together 100 cc. of kerosene and 20 cc. of a composition formed by suspending one part by weight of carbon black in three parts by weight of kerosene. The ingredients were heated together to a temperature of about 110° C. In a separate vessel, 10 grams of a low molecular weight polyethylene (AC Grade No. 6, average molecular weight of 2000) were heated to melting, about 110° C., and quickly poured into the first mixture with constant stirring. The resultant composition was allowed to cool to room temperature and was thereafter employed in the electrostatic process described in the above identified copending patent applications of one of the present applicants. The development of a visual image from the latent electrostatic image was found to be entirely satisfactory.

The light and shadow pattern, developed from the latent electrostatic image when transferred to a permanent record medium, was converted to a permanent image which did not blur or smear after considerable rubbing, by heating the permanent record medium to a temperature slightly above the melting point of the polyethylene, that is to a temperature below about 100° C. While we do not wish to be bound by any particular theory, it would appear that the developer composition is absorbed into the transfer medium and then fixed by the heat and that possibly the individual opaque particles are coated with a thin film of the polyethylene and bonded to the transfer medium by means of the film.

We claim:

1. In a process for developing a visible image from a latent electrostatic image the improvement which comprises: bringing a surface bearing the latent electrostatic image into contact with a body of a liquid developer composition consisting essentially of between about 5% and 25% by weight of an opaque solid electrostatically attractable particulate material, up to about 20% by weight of a solid polyethylene having a molecular weight between about 1500 and 5000 and a liquid hydrocarbon vehicle having a high electrical resistance, said particulate material having a particle size finer than about 50 microns and being present as solids in said composition.

2. The process of claim 1 in which the opaque solid is a carbonaceous solid material from the group consisting of charcoal, carbon black and lampblack.

3. The process of claim 1 in which the opaque solid has a particle size of between about .01 and 50 microns.

4. The process of claim 1 in which the hydrocarbon is selected from the group consisting of kerosene, benzene, toluene and carbon tetrachloride.

5. The method of preparing a developer composition for electrostatic printing which comprises: forming a heated mixture consisting essentially of between about 5% and 25% by weight of an opaque solid particulate material, having a particle size finer than 50 microns and insoluble in the remainder of the composition; a polyethylene having a molecular weight between 1500 and 5000 and a liquid hydrocarbon vehicle, and permitting the heated mixture to cool.

6. The process for developing a visible image from an electrostatic charge image which comprises: applying a liquid developer composition to a surface bearing an electrostatic charge image, said liquid composition consisting essentially of between about 5% and 25% by weight of finely divided opaque powder particles finer than about 50 microns insoluble in and suspended in a liquid having a high electrical resistance and containing up to about 20% by weight of a polyethylene having a molecular weight of between 1500 and 5000.

7. A method of producing a developer composition for electrostatic printing which comprises: melting a low molecular weight polyethylene in a high resistance organic liquid, and adding thereto a finely divided opaque solid powder insoluble therein and having a particle size of less than 50 microns.

8. A method producing a developer composition for electrostatic printing which comprises: heating a suspension of a finely divided solid opaque powder having a particle size of less than 50 microns in a liquid having a high electrical resistance and in which the solid powder particles are insoluble and adding thereto a molten low molecular weight polyethylene with stirring to produce a uniform composition and permitting the product to cool.

9. A method of producing a developer composition for electrostatic printing comprising mixing finely divided opaque solid powder particles finer than 50 microns with a heated thermoplastic material whereby the finely divided opaque solid powder particles become coated with the

thermoplastic material and dispersing the coated particles in liquid hydrocarbon having a high electrical resistance.

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