METHOD FOR DEVELOPING AN ELECTROSTATIC LATENT IMAGE

Filed March 17, 1972

FIG. 1

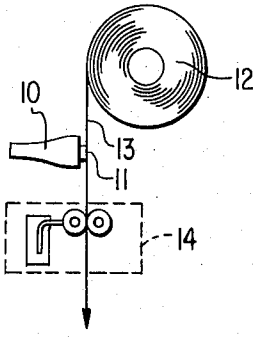


FIG. 2A

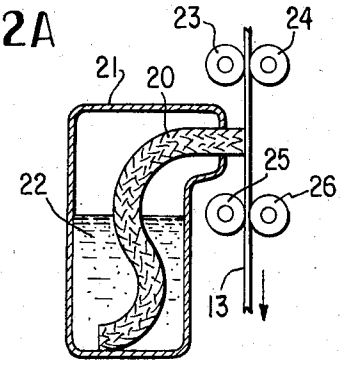


FIG. 2B

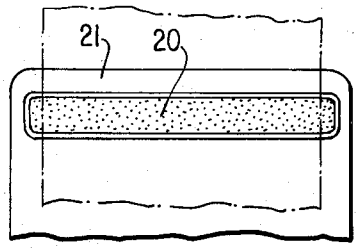


FIG. 3

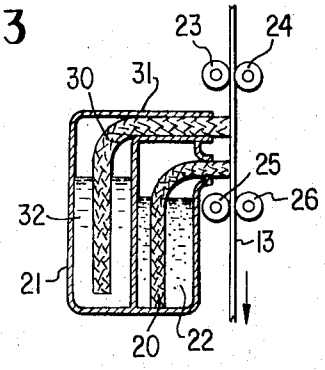


FIG. 4

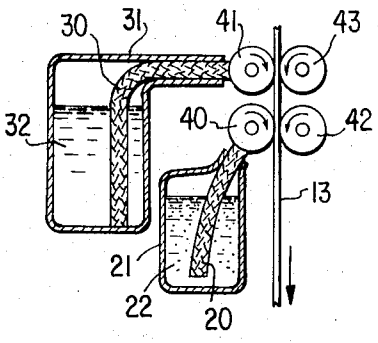
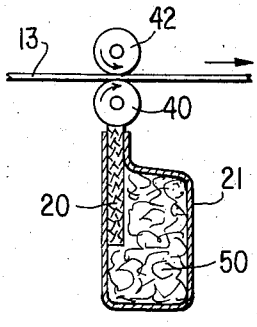


FIG. 5



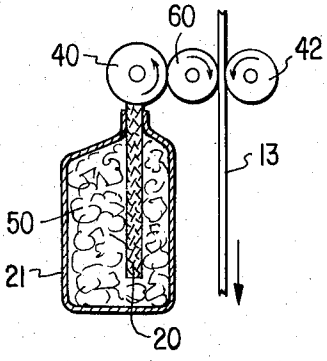


FIG. 6

United States Patent Office 3,827,906
Patented Aug. 6, 1974

3,827,906

METHOD FOR DEVELOPING AN ELECTROSTATIC LATENT IMAGE

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Filed Mar. 17, 1972, Ser. No. 235,480
Claims priority, application Japan, Mar. 17, 1971, 46/14,843
Int. Cl. G03g 13/10
U.S. Cl. 117—37 LE 5 Claims

ABSTRACT OF THE DISCLOSURE

A method for developing an electrostatic latent image on a photoconductive surface comprising applying a liquid developer material using a porous material to said electrostatic latent image on said photoconductive surface, the improvement comprising applying said liquid developer material to said photoconductive surface using said porous material by keeping at least a portion of said porous material in contact with a reservoir of said liquid developer material and contacting said photoconductive surface containing said electrostatic latent image thereon with another portion of said porous material and the improvement further comprising said liquid developer being a suspension of a graft pigment in an insulating liquid is disclosed.

BACKGROUND OF THE INVENTION

(1) Field of the Invention

This invention relates to a xerographic development process wherein an improved easily handled liquid developer is employed.

(2) Description of the Prior Art

One of the disadvantages with prior art xerographic developing systems using a liquid developer is that the liquid developer material utilized in well known developing machines is extremely volatile and combustible and, therefore, cannot be handled in the machines without encountering the danger of contamination or fire due to a portion of the developer material splashing out of the machine.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view of equipment for facsimile incorporating a xerographic developing apparatus.

FIGS. 2(A) and 2(B) are a longitudinal cross sectional view and a front view, respectively, of a simplified form of the means employed in practice of the method according to the invention.

FIGS. 3 to 6 are corresponding longitudinal cross sectional views showing various forms of the means employed in practice of the method according to the present invention.

In the figures, reference numeral **10** designates a pin tube, **11** a pin matrix, **12** a recording paper supply roll, **13** an electrostatic recording paper, **14** a developing means, **20** a porous member, **21** a container, **22** a liquid developer material carrying a suspension of graft pigment, **23** and **24** feed rollers, **25** and **26** squeeze rollers, **30** a porous member, **31** a container, **32** an insulating liquid, **40** to **43** transfer and back up rollers, **50** a stuffing material, and **60** a transfer roller.

SUMMARY OF THE INVENTION

Accordingly, the present invention provides a xerographic developing process using an easily handled liquid developer material of a suspension of a graft polymer in an insulating liquid which overcomes the above mentioned problem. It should be noted that the developing process according to the present invention is particularly

suited for use in domestic or household facsimile printing systems which will come into widespread usage in the future.

DETAILED DESCRIPTION OF THE INVENTION

Referring to the drawings, and particularly to FIG. 1, there is shown a facsimile printing apparatus embodying the present invention which comprises a pin tube **10** having a pin matrix **11**, and a supply roller **12** for supplying a continuous web of electrostatic recording paper **13**. As the electrostatic recording paper is drawn past the pin tube **10** having pin electrodes **11**, electrostatic latent images are produced on the surface of the recording paper **13**. During the passage through a developing apparatus **14** encircled by a dotted box, the electrostatic latent images thus produced by the pin electrodes are developed on the recording paper.

Such a recording paper and an electrostatic recording system using a pin tube are as well known in the art that, accordingly, a detail description thereof is omitted in this specification.

The present invention is particularly concerned with a development system suited for use in an apparatus, such as the one above described.

FIGS. 2 to 6 illustrate various forms of the means employed in practice of the method according to the present invention.

Referring now to FIGS. 2(A) and 2(B), which are a longitudinal cross section and a front view, respectively, showing a corresponding essential part of a simplified form of the means employed in the practice of the method according to the present invention, an elongated member **20** of a porous material is placed within a container **21**, but with one end projecting from the top side of the container. The lowermost part of the member **20** is dipped into a liquid suspension (liquid developer) **22** within the container. A portion of the liquid suspension in the container passes through the porous member due to capillary action and oozes out of the top end of the member projecting from the container.

A recording paper **13** containing electrostatic latent images thereon is moved by a pair of feed rollers **23** and **24** in contact with the top end face of the porous member **20** and then is passed between another pair of rollers **25** and **26** whereby any excess liquid on the surface of the recording paper is squeezed out.

It will thus be appreciated from the foregoing description made in conjunction with the apparatus employed in practice of the method according to the invention that the method of the present invention includes contacting the surface containing electrostatic latent images with a porous member impregnated and saturated with a toner suspension.

However, such systems are well known in the art and are described, for example, in U.S. Pat. No. 3,343,956.

The method of the invention is entirely different from any of those conventional systems in that a liquid developer material carrying a graft pigment suspension is employed.

All of the prior art developer materials were essentially suspensions of a mixture containing pigment and polymer suspended in an insulating liquid. Such liquid suspensions, however, cannot provide stability over a long period of time in a uniformly dispersed condition.

More specifically, the toner particles in such a suspension tend to adhere to the surfaces of the porous material and the number of toner particles remaining suspended in the liquid developer is significantly reduced over a long period of storage or of use and finally becomes useless and must be discarded.

Accordingly, the developing system disclosed in the specification of the above cited U.S. patent is not suitable

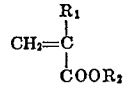
for use in domestic or household equipment because the apparatus involves the necessity of continually supplying the developer material to the developing system.

The present invention overcomes the above described problem by using a liquid developer material of a graft pigment suspension, that is one obtained by graft polymerization of an addition polymerizing monomer on the surfaces of the pigment particles.

It has been found by the inventors that the graft pigment which is suspended in an insulating liquid and is impregnated in the porous material, retains the ability to remain uniformly dispersed in the liquid suspension for a significantly longer period of time. The developer material consisting of a graft pigment suspension according to the present invention provides the ability for longer use or storage, such as, for example, over six months, as compared to the conventional liquid developer materials which, when impregnated in the porous material, normally becomes useless or inoperable in a few days.

The method of producing graft pigments is disclosed in "Journal of the Society of Rubber Industry Japan," vol. 28, pp. 57–60 (1965).

Suitable such pigment-resin copolymers, are, for example, those described in U.S. Pat. No. 3,503,881. For example, a graft-copolymer obtained by the graft-copolymerization of carbon black and a monomer such as an acrylate represented by the following formula:



wherein R_1 represents H, CH_3 or C_2H_5, and R_2 represents an alkyl group having from 6 to 19 carbon atoms, is described therein. This monomer component is capable of combining with carbon black and thereby dispersing carbon black grains in a carrier liquid.

Thus far the situation has been that, in a practical developer, sufficient charging characteristics cannot be provided by the graft-polymer alone in which the monomer (oleophilic) as described above is used.

Usually, a small amount of polar monomer is used in combination therewith so as to improve the charging characteristics, and thus, copolymerization of carbon black and an oleophilic monomer and a polar monomer is conducted.

As such polar monomers, there are illustrated, e.g., acrylic acid, N,N - diethylaminomethyl methacrylate, acrylonitrile, acrylamide, hydroxyethyl methacrylate, alpha-cyanomethyl acrylic acid, methacrylonitrile, N,N-diphenyl methacrylamide, zinc methacrylate, potassium maleate, etc.

When carbon black, the above-described monomers and a small amount of a polymerization initiator are added to a solvent and heated while stirring, polymerization occurs, and thus, the carbon black is graft-copolymerized with said monomers to obtain the so-called grafted carbon wherein carbon black and the resin components are combined with each other.

A preferred graft pigment for the purposes of the present invention is Graft Carbon trade name of the Mitsubishi Gas Chemical Company, Incorporated, although other graft pigments produced from organic pigments may be used as developer materials in color reproduction. Those graft pigments are normally produced through a well-known process as disclosed in "High Polymers Japan," The Society of Polymer Science, Japan, vol. 14, pp. 746–749 (1965).

The use of graft carbon in conventional xerographic developer materials is now well known in the art and disclosed, for example, in Japanese Pat. 19,196/1969.

In accordance with the present invention, the liquid developer material carrying a suspension of a graft pigment in a solvent is supplied through a porous material to the photoconductive surface containing electrostatic latent images therein.

It is believed that the stability over a long period of time of the graft pigment suspension impregnated in the porous material depends upon the dispersibility as well as the antiadhesion and absorption characteristics of the graft pigment to the porous material.

This will be more readily understood by considering that when a liquid developer material of a conventional pigment suspension is impregnated in the porous material, the solvent in the developer material tends to vaporize as well as diffuse into the atmosphere. At the same time, some of the pigment particles in the developer material adhere to the surface of the porous member, with the result that the permeability of the pigment through the porous material is significantly reduced after a certain time period, due to such pigment particles intefering with the transfer of the remainder of the pigment through the porous material.

Furthermore, the pigment permeability of the porous material cannot be recovered even were a fresh and new pigment suspension supplied and added to the porous material.

However, it has been found that the graft pigment suspension in accordance with this invention maintains a sufficiently high degree of permeability in the porous material for a significantly longer time period. It has been found that when the porous material has been dried, the pigment transfer can be recovered by supplying a fresh developer liquid to the porous member.

The porous member used in the process of this invention can be made of any desired porous material, such as felt, flannelet, cloth, sponge, or bundle or fabric cloth of glass fibers.

Referring now to FIG. 3, another form of the means employed in practice of the method according to the invention is shown, which overcomes the problem described in the apparatus of FIG. 1, that is, contamination as a result of some of the toner material adhering to the photoconductive surface in the peripheral areas around the electrostatic image being developed on the surface as the liquid developer comes into direct contact with the dry photoconductive surface.

In the apparatus shown in FIG. 3, an additional porous material **30** is provided to apply a film of an electrically insulating liquid over the photoconductive surface containing the electrostatic latent image thereon prior to the supply of the liquid developer to the photoconductive surface, thereby preventing the toner material from adhering to the photoconductive surface as a result of forces other than the electrostatic charges contained in the photoconductive layer.

As a result, any contamination problems are substantially eliminated.

The porous member **30** may be formed of the same material as the porous member **20** of FIG. 2. The porous member **30** is dipped into the electric insulating liquid **32** contained in a container **31**. The insulating liquid **32** may be similar to the solvent of the above described developer material, for example, materials such as cyclohexene, Decalin, benzene, kerosene, isooctane, ligroin, methylcyclohexene, xylene, toluene, and combinations thereof, as well as other insulating materials can be used.

Referring to FIG. 4, there is shown a further modified form of the means employed in the practice of the method according to the invention, which overcomes the disadvantage found in conjunction with the means of FIGS. 2 and 3, in that the porous member **20**, which is normally from several millimeters to ten millimeters in thickness (when measured in the direction of the advancement of the recording paper), tends to scrape or upset the powder image which is loosely held on the photoconductive surface during contact with the photoconductive surface of the recording paper moving across the end face of the porous member in development, thus resulting in an inferior reproduction.

Another problem with the second means shown in FIG. 3 is contamination due to the production of a triboelectric charge on the photoconductive surface by frictional contact with the porous member **30** prior to the development of the electrostatic latent image, which holds some of the toner material on the surface of the recording paper.

Such problems of contamination are also found in conjunction with the developing apparatus of FIG. 2 (due to friction between the porous member **20** and the photoconductive surface containing the electrostatic charge therein). In the apparatus of FIG. 4, however, these problems are overcome and eliminated by forming a liquid film on the surface of an additional member by contacting the additional member with the porous member dipping in the liquid developer and then transferring the liquid film from the surface of the additional member to the photoconductive surface without any relative motion between the member and the photoconductive layer and without direct contact with the porous member.

The means shown in FIG. 4 further includes transfer rollers **40** and **41** rotating in contact with the top end faces of the porous members **20** and **30**, respectively. These rollers are constructed of a material which is capable of carrying and retaining an amount of liquid material thereon. Preferably, the rollers are metal or plastic rollers having a rough or coarse outer surface, alternatively, having a planar outer surface covered with a rough surfaced material such as mesh, cloth, sponge, felt, flannel, or paper.

As will be understood by those skilled in the art, metal rollers also can serve as a development electrode.

Take up or feed rollers **42** and **43** formed of metal or rubber are provided in the third means.

Accordingly, any triboelectric contamination problems can be substantially eliminated by rotating the rollers **40** and **41** without relative motion or slippage between the surfaces of the rollers and the photoconductive surface containing the electric static latent image therein.

Referring to FIG. 5, a cross sectiional view of a still further means embodying the present invention is shown, which eliminates the common problem of all of the above described apparatus, that is, the tendency of the liquid developer material to seep out of the porous member and away from the container when the container is overturned.

In the apparatus of FIG. 5, the container is packed with a stuffing material **50** such as cotton, cloth, paper or fibers, which prevents the developer material from seeping out of the container.

In FIG. 6, there is shown still another means employed in the practice of the method according to the present invention, which further includes a roller **60** adapted to transfer a film of the developer material from the porous member to the photoconductive surface of the recording paper, preventing a direct contact of the porous member with the photoconductive surface. The roller **60** may be formed of a material similar to that of the roller **40** described.

The existence of the roller **60** assures a more uniform thickness of the developer liquid film formed on the photoconductive surface. Preferably, the roller **60** is adapted to rotate in the same direction as the rotation of the roller **40**. Rotation of the rollers in the same direction will facilitate a uniform distribution of the toner on the roller **60**.

What is claimed is:

1. In a method for developing an electrostatic latent image on a photoconductive surface comprising applying a liquid developer material using a porous material to said electrostatic latent image on said photoconductive surface, said liquid developer material being applied to said photoconductive surface using said porous material by keeping at least a portion of said porous material in contact with a reservoir of said liquid developer material and contacting said photoconductive surface containing said electrostatic latent image thereon with another portion of said porous material, the improvement comprising said liquid developer being a suspension of a graft pigment in an insulating liquid.

2. The method of claim **1**, wherein said contacting is by indirectly contacting said photoconductive surface with said porous material using an additional surface adapted to transfer said developer material from said porous material to said photoconductive surface.

3. The method of claim **1**, wherein said porous material is felt, flannelet, cloth, sponge, glass fiber bundle or glass fiber cloth.

4. The method of claim **1**, wherein said insulating liquid is cyclohexene, Decalin, benzene, kerosene, isooctane, ligroin, methylcylohexene, xylene, toluene or mixtures thereof.

5. The method of claim **1**, wherein said graft pigment is graft carbon.

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MICHAEL SOFOCLEOUS, Primary Examiner

U.S. Cl. X.R.

117—112; 96—1 LY