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METHOD OF LIQUID REVERSAL DEVELOPMENT FOR ELECTROGRAPHY

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FIG. 1

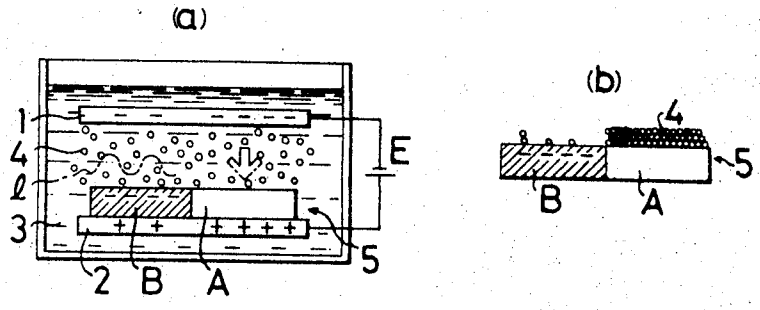
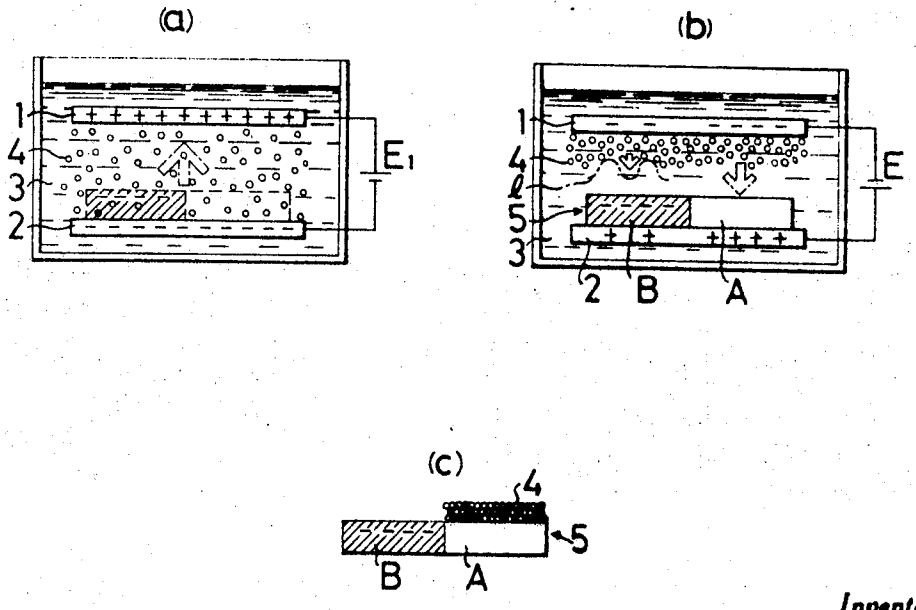


FIG. 2



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METHOD OF LIQUID REVERSAL DEVELOPMENT FOR ELECTROGRAPHY

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ABSTRACT OF THE DISCLOSURE

A bias voltage having an opposite polarity relative to toner is first applied to a developer liquid to thereby cause the toner to move toward a development electrode, and a bias voltage having the same polarity as the toner is then applied to the developer liquid. This method insures improved reproductivity of contrast and halftone of images on electrographic paper.

BACKGROUND OF THE INVENTION

The present invention relates to a method of liquid reversal development for electrography.

Liquid reversal development in which toner is deposited on the uncharged portion of an electrographic paper unlike in normal development employs a method wherein a bias voltage E having the same polarity as toner **4** dispersed in an insulating liquid **3** is applied between a base electrode **2** and a development electrode **1** so as to force the toner **4** to deposit on the uncharged portion A of an electrographic paper **5**.

In accordance with such bias method, however, the charged portion B of the electrographic paper **5** is not always charged perfectly uniformly, but due to uneven size of fine particles of semi-photoconductor on the electrographic paper or uneven distribution of fine particles of semi-photoconductor on resin-dispersed electrographic copying paper, there arises a delicate uneven charge density, giving rise to local electric field disorder in many cases. As a result, the bias voltage E, when increased to the same level as the surface potential of the charged portion B, produces deposition of toner **4** also on the charged portion B and exerts an adverse effect on the image obtained.

FIG. 1 schematically illustrates such situation. The charged portion B of electrographic paper **5** is negatively charged, and toner **4** in the developer liquid is of a negative polarity. When a negative voltage which is equal to the surface potential of the charged portion B is applied as the bias voltage E, the toner **4** which is dispersed uniformly in the insulating liquid **3**, in the area of uncharged portion A, is moved toward and deposited on electrographic paper **5** under the influence of the bias voltage E as shown in FIG. 1*b*. On the charged portion B, a weak electric field is produced where the surface potential of the charged portion B is lower than the bias voltage E due to delicate uneven charge density, the electric field causing the toner **4** to move toward the electrographic paper **5**. Consequently, the toner **4** positioned under the chain line *l* shown FIG. 1*a*, for instance, is deposited on the electrographic paper **5** as seen in FIG. 1*b*.

Whereas it is possible, in the foregoing bias method, to effect deposition of the toner **4** on the uncharged portion A to an extent as high as is achieved by normal development, the deposition of toner **4**, formation of so-called foggy background, is inevitable in the charged portion B due to the presence of delicate uneven charge density. For this reason, it is usually necessary to consider such

uneven charge density and to set the bias voltage at a negative voltage which is determined paying due consideration to the lowest value of the surface potential of the charged portion B.

Thus, liquid reversal development is generally inferior to normal development in the reproductivity of contrast and halftone of images.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a method of liquid reversal development for electrographs which insures reproductivity of contrast and halftone of images equal or superior to that achieved by normal development, more particularly to provide a method of liquid reversal development which does not produce deposition of toner on the charged portion of electrographic paper due to delicate uneven charge density even when the bias voltage E in the foregoing bias method is set at a level equal to the surface potential of the charged portion of electrographic paper.

The bias method for liquid reversal development of this invention is characterized in that a bias voltage of an opposite polarity relative to toner is first applied to a developer liquid to thereby cause the toner to move toward a development electrode, a bias voltage of the same polarity as the toner thereafter being applied to the developer liquid for removal development of an electrographic paper to obtain a desired electrograph. Thus, by bringing the toner in the developer liquid to the development electrode at the first stage as described above, reversal development can be effected under a bias voltage which is equal to the surface potential of the charged portion even where there exists delicate uneven charge density on the charged portion of electrographic paper, thereby making it possible to obtain satisfactory reproductivity of contrast and halftone of images which is equal or superior to that obtained by normal liquid development. In accordance with this invention, it is further possible to obtain high contrast images easily by overcharging electrographic paper. Thus the present invention has these and various other advantages which can not be obtained with conventional method of liquid reversal development.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view illustrating a situation in accordance with a conventional bias method for liquid reversal development in which fogging takes place; and

FIG. 2 is a view illustrating the principle of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference of FIG. 2, the present invention will be described below. FIG. 2*a* shows a step of this invention for moving toner **4** in a developer liquid away from electrographic paper **5**. This procedure is effected by applying a bias voltage E_1 of a polarity opposite to that of toner **4** between a development electrode **1** and a base electrode **2**. In the figure, toner **4** is of a negative polarity, while the bias voltage E_1 is of a positive polarity. Due to the application of the bias voltage E_1, the toner **4** is brought close to the development electrode **1**, with the result that the developer liquid is divided into a layer of toner **4** and a layer of insulating liquid **3** as shown in FIG. 2*b*. Since no toner **4** deposits on the electrographic paper **5** during this step, the above procedure may be conducted without placing the electrographic paper on the base electrode **2**. Further because the bias voltage E_1 serves merely to move the toner **4** in the developer liquid toward the development electrode **1**, the voltage may suitably be selected, but preferably, it may usually be set

at the same value as the bias voltage E to be applied in the subsequent step of development.

FIG. 2*b* shows a procedure of reversal development in accordance with the aforementioned bias method which is conducted after the toner **4** has been concentrically brought to the development electrode **1** in the above step. When the bias voltage E equal to the surface potential of the electrographic paper **5** and having the same polarity as the toner **4** is applied, the toner **4**, under the influence of the bias voltage E, is moved toward and deposited on the electrographic paper **5** at the uncharged portion A as shown in FIG. 2*c*, while at charged portion B, a weak electric field produced by delicate uneven charge density acts to move the toner toward the electrographic paper. However, since no toner **4** is dispersed in the area under the chain line *l* in FIG. 2*b*, no deposition of the toner takes place on the charged portion B as seen in FIG. 2*c*. The above developing step insures uniform deposition of toner **4** on the uncharged portion A, which results in good reproductivity of contrast and halftone of images.

The method of this invention will now be described with reference to an example as it was actually practiced.

Electrofax paper was negatively charged in the dark by corona discharge until blue white light spot was observed on the charged surface, and an exposure was made, whereby an electrostatic image having surface potentials of —400 v. at dark portion and 0 v. at bright portion was formed. The electrofax paper was then placed on a base plate, and a bias voltage of +400 v. was first applied to a development electrode for 0.1 to 1 second. A bias voltage of —400 v. was thereafter applied to the development electrode for 0.5 to 2 seconds. When the electrofax paper was finally taken out, a visual image having high contrast and free of fogging was obtained.

In the case where a negative bias voltage alone is applied to the development electrode under the same conditions as above but without conducting the first step, fogging with numerous black spots were produced in the dark portions of the image on the electrofax paper taken out.

Further in accordance with the reversal development of this invention, no fogging was seen to take place in the background even where electrofax paper was overcharged at —600 v.

We claim:

1. The method of developing an electrostatic latent image of a first polarity on a substrate comprising establishing, in a liquid having dispersed therein a toner of said first polarity, a first electric field in a first direction to effect the flow of said toner from a predetermined zone along and adjacent the face of said substrate bearing said latent image to deplete said zone of said toner, and thereafter establishing a second electric field in said liquid opposite to said first direction to effect the flow of said toner toward said substrate positioned in said zone and to deposit said toner on the uncharged areas of said substrate.

2. The method of claim **1** wherein said electric fields are established by positioning a pair of first and second electrodes in said liquid and applying corresponding voltages between said electrodes, said first field being effected by applying a potential to said first electrode relative to said second electrode of a polarity opposite to that of said toner to establish said depleted zone proximate said second electrode and said second field being effected by applying a potential to said first electrode relative to said second electrode of the same polarity as said toner.

3. The method of claim **2** wherein said voltages producing said first and second fields are substantially equal and opposite and of substantially the same value as the potential level of said electrostatic image.

4. The method of claim **1** wherein said substrate is positioned in said zone following the depletion thereof of said toner.

5. The method of claim **1** wherein said substrate is positioned in said zone prior to the depletion thereof of said toner.

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