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DEVELOPMENT OF LATENT ELECTROSTATIC IMAGES WITH
CRESTED WAVES OF LIQUID DEVELOPER
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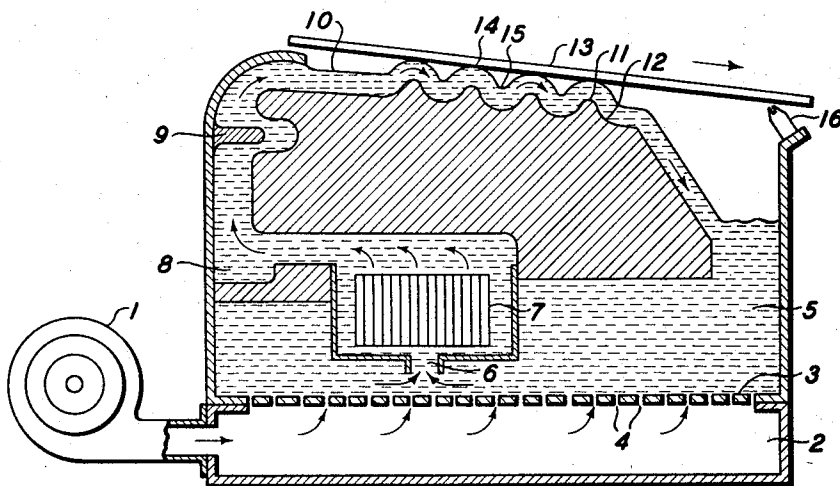


FIG. 1

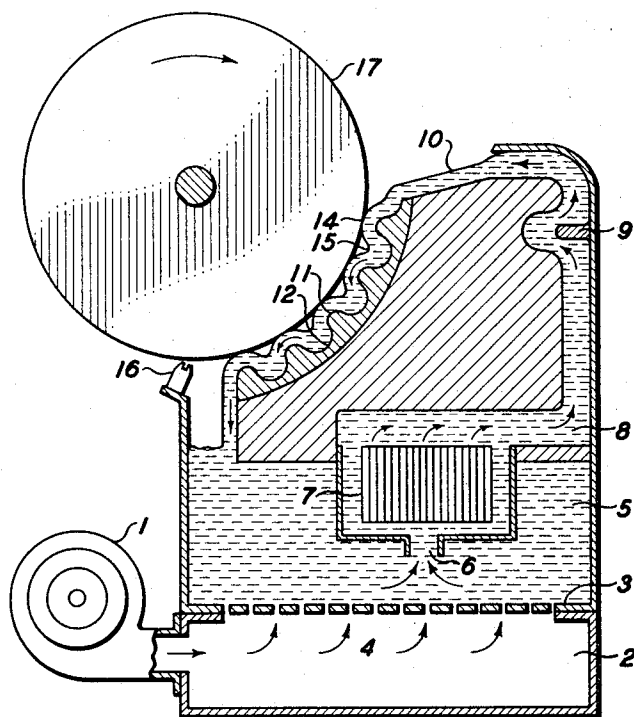


FIG. 2

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DEVELOPMENT OF LATENT ELECTROSTATIC IMAGES WITH CRESTED WAVES OF LIQUID DEVELOPER**James E. Young, Pittsford, N.Y., assignor to Xerox Corporation, Rochester, N.Y., a corporation of New York****Original application Oct. 28, 1964, Ser. No. 407,095. Divided and this application July 13, 1966, Ser. No. 578,911****2 Claims. (Cl. 117—37)**

This is a division of application Ser. No. 407,095, filed Oct. 28, 1964, and now U.S. Patent No. 3,334,613.

This invention relates generally to development of latent electrostatic images and more particularly, to development of such images by contact with liquid developers.

In the process of xerography, it is usual at one or another point to subject a latent electrostatic image to development. This step commonly involves contacting the latent image with a suitable pigment, usually referred to as toner. Such toner may be brought into contact with the latent image in a number of different ways. The toner may, for example, be dusted as a dry powder directly upon the latent image. In another technique, the toner particles may be first dispersed throughout a liquid medium. Quantities of the pigment-carrying liquid are here brought into contact with the latent image. This latter type of process is known as liquid development.

Liquid development has a number of advantages over dry techniques. In most dry techniques, for example, the toner particles are electrostatically bound to a carrier. As a result, a minimum of force must be overcome before it is even possible for the toner particles to be attracted to the electrostatic image. This minimum value, which is called a threshold value is not present in the case of liquid developers where the particles, of course, are freely suspended. Another obvious advantage of liquid developers arises by virtue of the fact that very minute toner particles can be readily suspended in the liquid medium while they are not so readily handled and distributed in dry form.

As a result of these and other advantages, it is theoretically possible to obtain higher image resolutions with liquid developers than can be accomplished by dry methods. In practice, however, liquid developers have not proved so ideal. In particular, it has been found that when a xerographic plate or other latent image bearing surface is brought into contact with a stationary volume of liquid developer portions of the developer in immediate contact with the latent image areas tend to become depleted of toner particles, thereby depriving more weakly charged areas of sufficient development. If in an attempt to overcome this depletion, turbulence or general motion is introduced into the developer, there occurs, on the other hand, a tendency to mechanically and triboelectrically destroy the very delicate latent image.

It is accordingly, an object of the present invention to provide apparatus whereby liquid development of xerographic plates, films and the like can be accomplished in a highly efficient and yet gentle manner.

It is a further object of the present invention to provide apparatus whereby turbulent agitation may be introduced into the liquid developer in order to maintain suspension of toner particles, and yet such agitation is so introduced that the sensitive latent electrostatic image is not thereby damaged.

It is yet a further object of the present invention to provide apparatus which makes possible multiple contact of large volumes of circulating liquid developer with the latent electrostatic image, but in a manner that is so

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gentle and non-abrading that the latent image is not thereby destroyed or otherwise disturbed.

The present invention accomplishes these objects by providing a series of parallel troughs and crests in the development area of the apparatus opposite the latent image bearing surface to be developed. Fluid developer flowing transversely over these troughs and crests thereby is formed into a series of successive parallel waves. The fluid velocity and spacing between the washboard-like surface and the latent image carrying surface are so chosen that the circulating developer contacts the latent image only at crests of the wavy developer surface. By thus introducing such a series of undulations into the liquid developer, turbulence is maintained within its volume which assures the continuous uniform distribution of toner particles. At the same time, the actual development contact with the latent image bearing surface is by a series of gentle kiss-like contacts. The invention is diagrammatically illustrated by way of example in the accompanying drawings in which:

FIGURE 1 shows schematically an embodiment of the present invention suitable for developing flat image bearing surfaces including webs and continuous tapes.

FIGURE 2 schematically illustrates an embodiment of the invention suitable for use with curved image bearing surfaces such as xerographic drums.

In FIGURE 1, air pump 1 maintains a continuous positive pressure within plenum chamber 2. Wall 3 which separates plenum chamber 2 from developer reservoir 5 contains numerous small perforations 4. These perforations are sufficiently minute that liquid developer contained within reservoir 5 normally cannot overcome surface tension effects to penetrate outwardly, but as a result of the pressure within plenum chamber 2, air continuously seeps through perforations 4 and into the body of liquid developer contained within reservoir 5. The resulting bubbling action maintains continuous agitation within the developer, as a consequence of which toner particles remain in uniform dispersion throughout the body of the liquid. The developer liquid is drawn into circulating pump 7 through pump inlet 6. The liquid is thereupon emitted under pressure into conduit 8 and is driven around projection 9. Projection 9 acts to break up the smooth fluid flow, improves the uniformity of flow distribution at the conduit 8 outlet, and generally agitates the solution, all of which assists in maintaining uniform toner particle distribution in the developer suspension. The developer liquid then enters developing area 10 where it will contact the latent electrostatic image. As developing area 10 is open to the atmosphere the developer liquid is no longer under positive pressure, but is flowing principally under the influence of gravity and its own inertia. Arranged transversely to the direction of flow are multiple and alternating ridges 11 and troughs 12. These ridges and troughs may be formed as an integral part of the developing area or they may be individually or collectively severable and/or removable so as to make possible ready variations in their disposition and number within the developing area. As the liquid flows over this series of hills and valleys, its surface contour assumes a shape similar to the contours over which it flows. That is to say, its surface forms into a series of crests 14 and troughs 15. The liquid developer thereafter flows from the developing area and returns to the developer reservoir 5, thus completing its cycle through the apparatus.

An electrostatic latent image bearing surface is shown in FIGURE 1 as a tape 13. This tape moves continuously through the developing area and from left to right in the sense of diagram. The flow of liquid developer through developing area 10 is so adjusted that contact with the moving tape 13 takes place only at successive crests 14

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of the developer surface. Since the tape is in motion through the developing area, it will be obvious that any particular point on the tape will come into contact with multiple and successive crests of the developer fluid. After tape 13 leaves the developing area, it is subjected to air pressure from air knife 16 which acts to wipe away surplus liquid.

In FIGURE 2, an embodiment of the invention is illustrated suitable for use with curved image bearing surfaces. The operation of the apparatus is similar to that of FIGURE 1, except that the continuous tape 13 is here replaced by a xerographic drum 17. The developing area 10 is now curved to correspond to the curvature of the drum 17. At reasonable rates of flow, the liquid developer surface within area 10 will conform to the underlying ridges 11 and troughs 12 located in this area. The velocity of liquid flow is then adjusted, for example, by varying the speed of pump 7 until contact with the xerographic drum is made only by crests 14 of the deformed developer surface.

The number, arrangement and shape of ridges 11 and troughs 12 shown in FIGURES 1 and 2 is, of course, only exemplary of the present invention. In practice, their precise arrangement and number would depend upon the rate of progression of the latent image-bearing surface through the developing area and upon the contact time/area relationship desired. Their shape would depend upon the viscosity of the particular developer used and upon the fluid velocity and surface deformation characteristics desired. In any case, the net effect of deforming the developer surface in accordance with the invention is to effectively float the image bearing surface upon the waves of the developer. This is literally true in the case of a relatively slack tape such as is shown in FIGURE 1.

As a result of the rolling flow within the developing area, a built-in agitation is maintained for the developer liquid, assuring homogeneity of the developer. At the same time, multiple contact is assured by virtue of the presence of multiple crests at the developer surface, and

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yet the force of impact between developer and image is relatively low since contact with the developing wave surface takes place at a point of inflection in the flow surface.

Having thus described the invention, it will become apparent that numerous modifications and departures may now be made by those skilled in the art, which variations will yet fall within the scope of the invention. Consequently, the invention herein disclosed is to be construed broadly and limited only by the spirit and scope of the claims now appended.

What is claimed is:

1. A method for development of latent electrostatic images by contact with liquid developer comprising forming waves upon the surface of a liquid developer and moving a latent electrostatic image bearing surface across said developer surface so that said image-bearing surface intercepts said developer surface only at the crests of said waves.

2. A method for development of latent electrostatic images by contact with flowing liquid developer containing suspended particulate material comprising forming the surface of said flowing developer into time-independent waves, providing continuous agitation to said flowing developer to maintain uniform suspension of the particulate matter contained therein, and moving a latent electrostatic image bearing surface across said developer surface so that said image-bearing surface intercepts said developer surface only at the crests of said waves.

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