Nov. 20, 1962 W. B. THOMPSON 3,064,622

IMMERSION DEVELOPMENT

Filed June 20, 1960

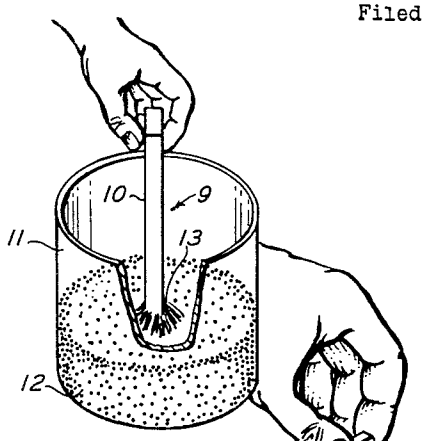


FIG. 1

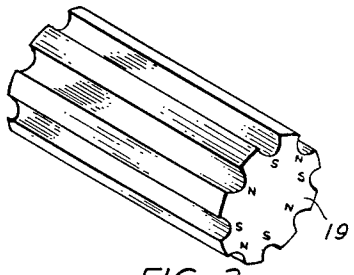


FIG. 3

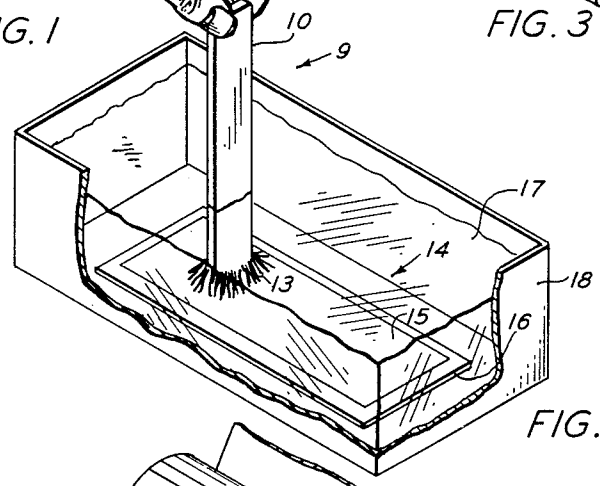


FIG. 2

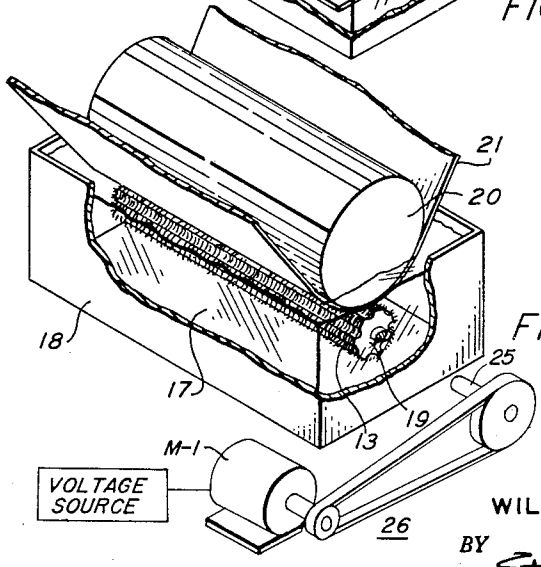


FIG. 4

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IMMERSION DEVELOPMENT

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This application deals with electrostatics and more particularly with image development in the art of xerography.

In the art of xerography it is customary to form a latent electrostatic charge pattern on the surface of a xerographic plate including an insulating, generally photoconductive insulating layer. The latent charge pattern is then generally utilized by being made visible through the electrostatically controlled deposition of finely divided marking particles. Various different xerographic development techniques are known in the art. The present invention is concerned with an improvement of liquid immersion development.

According to this invention the xerographic plate is developed by being immersed in a dielectric liquid medium. Fine particles in a liquid characteristically acquire an electrostatic charge depending on their composition, and are selectively attracted to charged or uncharged portions of the xerographic plate. It is obvious that a xerographic plate can be developed equally well by contacting the surface to be developed with a film of liquid or by pouring a stream of liquid developer across the surface, and such modifications are intended to be included in the term "immersion" as used in this specification and claims.

Liquid immersion development, in common with most other forms of xerographic development, is better adapted for the development of line copy images than for the development of continuous tone images. Where large areas of charge are found on a xerographic plate, or where the gradations of charge from one point to another are slight, as with continuous tone images, the electrostatic lines of force bend back into the plate rather than extend outwardly adjacent to the plate. Since it is the attraction of developer particles by external lines of force that causes development, the absence of such lines leads to no development or inadequate development. Accordingly, most xerographic development techniques fail in some degree to deposit developer particles in a faithful relation to the electrostatic charge pattern on the xerographic plate. In accordance with the present invention, however, these problems are eliminated, and improved image quality is obtained through the use of a magnetic member in a liquid immersion system.

It is accordingly an object of the present invention to improve liquid immersion development.

It is a further object to provide methods and apparatus for improving continuous tone reproduction and solid area coverage in liquid immersion development.

It is a still further object to provide a liquid immersion development method employing a magnetic member.

These and further objects will become apparent from the following specification and drawings, in which:

FIG. 1 shows the formation of a magnetic brush;

FIG. 2 shows xerographic development being carried out according to the invention;

FIG. 3 shows an embodiment of a suitable form of magnet; and,

FIG. 4 shows an embodiment of automatic development apparatus according to this invention.

FIG. 1 shows a magnet **10** being inserted in a container **11** partially filled with magnetic particles **12**. Particles **12** are attracted by magnet **10** and form a brush-like structure **13** about the end thereof. This structure persists as magnet **10** is removed from container **11**

and the composite is generally referred to as magnetic brush **9**.

Magnetic particles **12** should be magnetically attractable and at least sufficiently conductive so that they are incapable of retaining an electrostatic charge for any appreciable time. Virtually all magnetic particles are sufficiently conductive to meet this requirement, and accordingly, various powdered magnetic metals and metal alloys, as well as metal oxides, ferrites and the like may be employed. In addition, the particle size employed should be small, but at least an order of magnitude larger than that of the developer particles which, as will be discussed later, are preferably a few microns in diameter or less. A particularly suitable, inexpensive, and readily available material for magnetic particles **12** is about 200 mesh iron filings.

FIG. 2 shows how the magnetic brush of FIG. 1 is employed in a development process. As shown, a xerographic plate **14** comprising an insulating layer **15** overlying a support layer **16** is immersed in a liquid developer **17** which is contained in tray **18**. The nature of plate **14** and liquid developer **17** will be discussed at a later point. As shown, magnetic brush **9** is also immersed in liquid developer **17** and the end bearing brush-like structure **13** is brushed over the surface of plate **14**. Since brush-like structure **13** is soft and flexible, it may be drawn across plate **14** without damaging the plate and without requiring magnetic brush **9** to be held at any critical distance from plate **14**. The magnetic brush **9** constitutes a substantially equipotential member which during development is in virtual contact with plate **14**, and there results image development of a high quality. It has been found that in the presence of developer liquid **17**, magnetic brush **9** does not discharge the electrostatic charge pattern on plate **14**, even though the particles comprising brush **13** are themselves conductive. Presumably, the liquid forms a thin insulating film separating brush **13** from plate **14**. The liquid may also infiltrate brush **13**, thus insulating the individual particles from each other. If this occurs, the capacitance between the individual particles comprising the brush is still sufficiently high so that the brush is still effectively an equipotential body.

Xerographic plate **14** used in this invention may comprise any of the forms known in the art. Thus, insulating layer **14** may comprise any insulating material, such as polystyrene, capable of retaining a charge pattern for a reasonable period of time, or it may comprise a photoconductive insulating material such as vitreous selenium, a dispersion of zinc oxide in an insulating binder, or various other materials known in xerography. Support layer **16** may comprise any suitable mechanical support, whether rigid or flexible, such as metal, paper or the like. Layer **16** may also be dispensed with where layer **15** itself has adequate strength.

Liquid developer **17** comprises a suspension of finely divided particles in a dielectric liquid. The liquid itself must be sufficiently insulating to prevent dissipation of the electrostatic charge pattern on plate **14**. This generally requires a volume resistivity in the order 10^{13} to 10^{14} ohm-centimeters or greater. Suitable liquids include among others normal heptane, normal hexane, petroleum ether and various commercial petroleum solvents having volatility in the kerosene to gasoline range. Suitable liquids of this latter type include Sohio Odorless Solvent #3440, available from the Standard Oil Company of Ohio; commercial kerosene; Shell 140 solvent and Shell 8230 insecticide base, both available from the Shell Chemical Corporation; and, Soltrol 130, available from the Phillips Petroleum Company. Where non-flammable liquids are desired, use can be made of carbon tetrachloride, tetrachloro-ethylene, trichloro-ethylene, and tri-

chloro-trifluoro-ethane generally known as Freon 113. Various other liquids having the necessary resistivity can also be used as the liquid component of liquid developer **17**.

The particles used in liquid developer **17** may also comprise various types. They may, for example, comprise finely divided pigmented resin particles of the vinyl, acrylic or other types, finely divided dry pigments, fine particles of dyes insoluble in the dielectric liquid employed, or artists' oil pigments disperse in the liquid. Other useful forms of particles include carbonyl iron powders, available from the Antara Products Division of General Aniline and Film Corporation, as well as finely divided iron oxide particles. These latter two types of materials have, of course, magnetic properties, but are nevertheless quite useful in carrying out the present invention. Apparently, when small particle sizes are employed, the electrostatic forces tending to attract the particles to the electrostatic latent image on plate **14** are greater than the magneic forces exerted by magnet **10** which might tend to remove the particles from plate **14**. All types of particles, whether magnetic or otherwise, are preferably employed in a size range of a few microns or less in order to avoid an objectionably grainy appearance in the developed image. The optimum concentration of the various types of particles is variable, but generally lies in the range of .1 to 1% by weight. A requisite for the developer material is that it be insoluble in the dielectric liquid.

FIG. 3 shows one of various other forms of magnets which may be used in carrying out the present invention. Magnet **19**, as shown, is of generally cylindrical form but with an even number of alternating longitudinal flutes and ribs. As shown, each rib constitutes a magnetic pole of polarity opposite to that of the next adjacent rib. When such a magnet is dipped in iron filings or the like, a magnetic brush is formed which extends the full length of the magnet and is nearly continuous around the circumference of the magnet. This form of brush makes magnet **19** particularly suitable for use in an automatic type of liquid immersion developing apparatus.

FIG. 4 is a schematic illustration of one form of automatic apparatus embodying the present invention. As shown, there is included a developing tank or tray **18** filled with a liquid developer **17**. A horizontal cylinder **20** is partially immersed in liquid developer **17** and is adapted to be rotated about its axis by conventional means not shown. A flexible web-like xerographic plate **21** is led around the lower portion of the circumference of cylinder **20** and is thus passed through liquid developer **17**. Magnet **19**, of the same type as shown in FIG. 3, is positioned beneath while substantially co-axial with cylinder **20**. Magnet **19** is mounted on a shaft **25** and with its adherent magnetic brush-like structure **13**, is adapted to be rotated about its axis by further drive means, provided by motor M–1 operatively connected via belt and pulley combination **26** to shaft **25**, so that brush-like structure **13** contacts the latent image bearing surface of xerographic plate **21**. Thus, as the apparatus is in operation, xerographic plate **21** is continuously led through a path of liquid developer **17** and all portions of plate **21** are contacted by the brush-like structure **13** adhering to rotating magnet **19**. There is thus provided simple apparatus for effecting high quality continuous tone development of a xerographic plate in the form of a moving flexible web. As a further modification of the apparatus of FIG. 4, plate **21** could be eliminated and cylinder **20** could be replaced by a cylindrical xerographic plate together with suitable conventional apparatus for forming an electrostatic latent image thereon.

Since this invention deals with the art of xerography, various conventional xerographic methods and apparatus for forming electrostatic latent images, transferring and fusing developed images, etc. may be combined with the invention. Similarly, various forms of magnets, not shown herein, will readily occur to those skilled in the art. These and various other modifications are intended to be encompassed within the scope of the appended claims.

What is claimed is:

1. Xerographic developing apparatus comprising a container adapted to hold a xerographic liquid developer, magnet field means positioned and disposed within said container and within the area of said container covered by the liquid developer when said container bears liquid developer, said magnet being substantially cylindrical in shape and having formed on its periphery longitudinal flutes and ribs, each of said ribs constituting a magnetic pole of polarity opposite to that of the next adjacent rib as to be adapted to maintain a brush-like structure of magnetic material on its outer surface, means to position an electrostatic image bearing surface within said container and into virtual contact with a brush-like structure on said magnet, and means to effect driven relative movement between the magnet and said image bearing surface while in said last-recited relation whereby to deposit marking material from liquid developer in said container on the electrostatic image on the image bearing surface.

2. Apparatus according to claim 1 including roller means to move the image bearing surface relative to said magnetic brush within said container.

3. Apparatus according to claim 2 including motor connected drive means to rotate said cylindrical magnet during development of the electrostatic image on the image bearing surface concomitantly with the movement of said image bearing surface.

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