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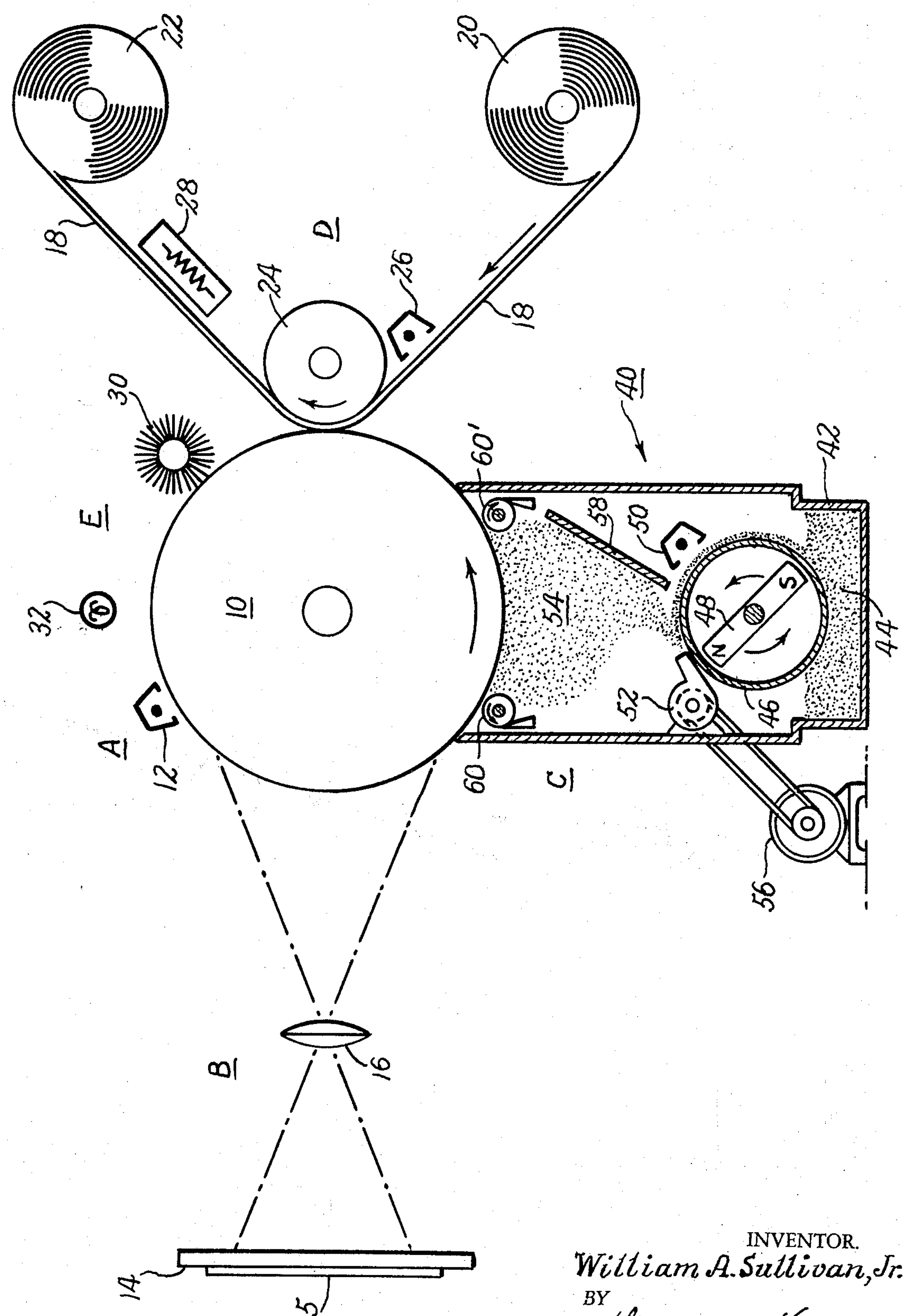

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METHOD FOR DEVELOPING ELECTROSTATIC LATENT IMAGES

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ABSTRACT OF THE DISCLOSURE

A method is provided for the development of electrostatic latent images formed on a support member. Magnetic toner particles are magnetically drawn over a non-magnetic surface, while on said surface a charge is applied to the toner particles which is opposite in polarity to that of the electrostatic latent image. A stream of gaseous material is directed against the charged toner particles carried on the non-magnetic surface to form a suspension of said particles in said gaseous material. This suspension, or powder cloud, is contacted with said electrostatic latent image to thereby develop said image with said toner particles.

This invention relates to a method for developing electrostatic latent images. More particularly, this invention relates to an improved method and apparatus for developing electrostatic latent images by the so-called "powder cloud" technique.

The formation and development of images on photoconductive surfaces by electrostatic means is well known. The basic xerographic process, as taught by C. F. Carlson in U.S. Pat. 2,297,691, involves depositing a uniform electrostatic charge on a photoconductive insulating layer, exposing the layer to a light-and-shadow image to dissipate the charge on the areas of the layer exposed to the light and developing the resulting electrostatic latent image by depositing on the image a finely-divided electroscopic imaging material referred to in the art as "toner." The toner will normally be attracted to those areas of the layer which retain a charge, thereby forming a toner image corresponding to the electrostatic latent image. This powder image may then be transferred to a receiving surface such as paper. The transferred image may subsequently be permanently affixed to the receiving surface by fusing with heat. Instead of latent image formation by uniformly charging the photoconductive layer and then exposing the layer to a light-and-shadow image, one may form the latent image by directly charging the layer in image configuration. The powder image may be fixed to the photoconductive layer if elimination of the powder image transfer step is desired. Other suitable fixing means such as solvent or overcoating treatment may be substituted for the foregoing heat fixing step.

If desired, an electrostatic latent image can also be formed on an insulating medium by charge transfer between at least two electrodes. This electrostatic latent image can then be developed in the manner described above with respect to xerography. The electrostatic latent image is formed on an insulating recording web such as a plastic-coated paper by the creation of an intense electric field. As the potential between the metal character electrode and the base electrode is increased, an electric field is produced in the printing gap with lines of force emanating from the positive electrode and terminating in the negative electrode. As the potential is increased, a current will carry electric charge through the bulk of the paper to the plastic-paper interface. This moves the actual base electrode from the back of the recording medium to the

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interface and increases the electric field in the printing gap. Free electrons which are present in the printing gap due to natural ionization are accelerated toward the plastic surface thereby forming an electrostatic latent image directly on the insulating surface.

Many times, it is desirable to transfer the electrostatic latent image from a photoconductive or insulating surface to an insulating surface. This transfer process has been termed "TESI," an acronym for Transfer of ElectroStatic Images. This transfer may be carried out for either of two purposes. The electrostatic latent image may be transferred to the surface of an electrically insulating material, upon which it will be stored for later readout by a scanning device, or it may be intended for xerographic development to produce a visible image. The transfer process is advantageous in that it permits a delicate photoreceptor to be used solely to record the electrostatic image, leaving the development, transfer and cleaning steps to take place on a more rugged insulating surface. Or, since an image can be transferred quickly to an insulator for later development or readout, transfer makes practical the use of photoconductors with high dark decay rates in the xerographic process.

A more detailed description of electrography and TESI can be found in British Pat. No. 734,909 to C. F. Carlson and U.S. Pats. 2,825,814; 2,833,648; 2,934,649 and 2,937,943 to L. E. Walkup.

Once the electrostatic latent image is formed by such techniques as described above, it can be developed by a variety of known methods for applying the electroscopic toner particles to the latent image. For example, the following development methods can be employed: the "cascade" development technique disclosed by E. N. Wise in U.S. Pat. 2,618,552; the "magnetic brush" process as disclosed, for example, in U.S. Pat. 2,874,063; and the "powder cloud" technique disclosed by C. F. Carlson in U.S. Pat. 2,221,776.

The present invention is directed to improvements in the "powder cloud" technique for development of electrostatic latent images as formed on a support member, whether photoconductive or insulating by the methods described hereinabove.

In "powder cloud" development, a suspension of electrically charged electroscopic toner particles in a gaseous material is blown into contact with a support member having a previously formed electrostatic latent image on the surface thereof. The toner particles attracted by the image are drawn out of the cloud and develop the image. Generally, the powder cloud has heretofore been generated by conventional paint aerosol generation techniques. It has been found, however, that these techniques result in non-uniform powder-to-air ratios, require larger quantities of the gaseous material, e.g., air, and generally present difficulties with respect to preventing leakage and escape of the air-borne toner particles and in reclaiming the toner.

Accordingly, it is an object to the present invention to overcome the above-noted difficulties.

It is another object of the present invention to provide an improved "powder cloud" development method.

It is still another object of the present invention to provide an improved "powder cloud" generating apparatus.

It is a further object to the present invention to provide improved means for creating and controlling the powder cloud.

It is still a further object of the present invention to provide a means for developing latent images with toner particles alone thereby dispensing with the need for carrier materials.

These as well as other objects are accomplished by the present invention which, in one embodiment, provides a method for developing electrostatic latent images comprising:

(i) Forming an electrostatic latent image on a support member;

(ii) Magnetically drawing magnetic toner particles over a non-magnetic surface;

(iii) Imposing a charge upon said toner particles of a polarity opposite to that of the electrostatic latent image;

(iv) Blowing the charged particles from the non-magnetic surface with a stream of gaseous material forming a suspension of said particles in said gaseous material; and

(v) Contacting said electrostatic latent image with said suspension thereby developing said image with said toner particles.

In another embodiment of the present invention, there is provided an apparatus for developing electrostatic latent images previously formed on a support member comprising:

(i) A chamber adapted to receive an electrostatic latent image-bearing support member at one end thereof and terminating at the opposed end thereof in a reservoir adapted to contain magnetic toner particles;

(ii) A drum positioned partially within said reservoir adapted to contact the magnetic toner particles therein;

(iii) Means for producing a rotating magnetic field situated within said drum adapted to cause said magnetic toner particles to be attracted from said reservoir and travel circumferentially across the surface of said drum;

(iv) Means for imposing a charge upon said magnetic particles of opposite polarity to the electrostatic latent image; and

(v) Blower means within said chamber adapted to direct a jet of gaseous material across the surface of said drum to dislodge the magnetic particles from the surface thereof forming a suspension of said magnetic particles in said gaseous material,

Whereby development of said electrostatic latent image is effected upon contact of said magnetic toner particles in said suspension with said latent image.

The present invention will become more apparent to those skilled in the art upon reading the following detailed description in connection with the accompanying drawing which schematically illustrates a typical xerographic apparatus adapted to be employed in accordance with the present invention.

Referring now to the drawing, an automatic xerographic reproducing apparatus is shown generally comprising a plate **10** including a photoconductive layer on a conductive backing formed in the shape of a drum, which is mounted on a shaft journaled in a frame to rotate in the direction indicated by the arrow to cause the drum surface to pass a plurality of xerographic processing stations during the reproduction cycle.

For purposes of the present disclosure, the several xerographic processing stations in the path of movement of the drum surface involved in the reproduction cycle may be described functionally as follows:

A charging station at which a uniform electrostatic charge is deposited on the photoconductive layer of the drum;

An exposure station, at which a light or radiation pattern is projected onto the drum surface to dissipate the drum charge in the exposed areas thereof thereby forming an electrostatic latent image of the copy to be reproduced;

A developing station, in accordance with the present invention, at which a cloud of electroscopic magnetic toner particles having an electrostatic charge of opposite polarity to that of the electrostatic latent image is brought into contact with said latent image, whereby the toner particles adhere to the latent image to form a powder image in the configuration of the copy being reproduced;

A transfer station at which the powder image is transferred from the drum surface to a transfer material or support surface and permanently fixed thereto;

A drum cleaning and discharge station at which the drum surface is brushed to remove residual toner particles remaining thereon after image transfer and at which the drum surface is exposed to a light source to effect substantially complete discharge of any residual electrostatic charge remaining thereon prior to recycling.

The charging station is preferably located as indicated by reference character A. As shown, the charging arrangement includes a corona charging device **12** which includes a corona discharge array of one or more corona discharge electrodes that extend transversely across the drum surface and are energized from a high potential source (not shown). The electrodes are preferably substantially enclosed within a shielding member.

Next subsequent thereto in the path of motion of the drum is an exposure station B. An optical scanning or projection system is provided to project an image onto the surface of the drum from a stationary original.

The optical scanning or projection of a transparent a stationary copyboard which consists of a transparent plate **14** such as, for example, a glass plate or the like, which is adapted to support a document **15** to be reproduced. The document is uniformly illuminated and arranged in light projecting relation to the rotating photoconductive surface of the drum. The reflected image of the document is projected through lens **16** onto the drum surface.

Adjacent to the exposure station is a developing station C which will be described in more detail below.

Positioned next and adjacent to the developing station is the image transfer station D which includes a web of transfer material **18** which is passed from take off roll **20** to windup roll **22** in timed relation to the movement of the drum, whereby the transfer web is advanced into contact with the developed image on the drum in the nip formed between the drum **10** and pressure roll **24**. Although a continuous web of transfer material is shown, a plurality of sheets fed into contact with the drum by an appropriate sheet-feeding mechanism can be employed with equal facility.

The transfer of the toner image from the drum surface to the transfer web is effected by means of pressure exerted by pressure roll **24** and/or a corona transfer device **26** that is located at or immediately before or after the line of contact between the transfer web and the rotating drum. In operation, the electrostatic field created by the corona transfer device is effective to tack the transfer web **18** electrostatically to the drum surface, whereby the transfer web moves synchronously with the drum while in contact therewith. Simultaneously, with the tacking action, the electrostatic field is effective to attract the toner particles comprising the powder image from the drum surface and cause them to adhere electrostatically in image configuration to the surface of the transfer web. The transferred powder image on the transfer web **18** then passes a fixing device **28** where the powder image is permanently fixed or fused to the transfer web as by radiant heating. After fusing, the permanent copy is passed to take off roll **22**.

The next and final station is the drum cleaning station E having positioned therein a drum cleaning device such as rotating brush **30** adapted to remove any toner remaining on the drum after transfer and a discharge lamp **32** adapted to flood the photoconductive surface of the drum with light thereby dissipating any residual electrical charge remaining on the drum.

Referring now specifically to developing station C, there is shown an improved "powder cloud" developing chamber **40** in accordance with the present invention. The electrostatic latent-image bearing surface of plate **10** is rotated into the upper portion of developing chamber **40** which extends substantially coextensively with the width of plate **10**. Chamber **40** terminates at the opposed end thereof in a reservoir **42** or sump portion adapted to contain the magnetically attractable toner particles **44**. A stationary drum **46**, preferably of a conducting, non-magnetic material, is positioned partially within said reservoir and is adapted to contact the magnetic toner particles therein. Drum **46** extends within chamber **40** substantially coextensively with plate **10**. Situated within the stationary drum is a magnet **48** having at least two poles. The magnet extends within said drum **46** substantially coextensively with the width thereof although having sufficient clearance for rotational freedom. The magnet **48** is mounted on a shaft which is journaled for rotation in sleeves in the opposed faces of the drum and at least one wall of the chamber **40**. Rotation of the magnet is effected by means of a motor (not shown), the output shaft of which is appropriately connected through gearing or pulleys and belts or the like to the shaft upon which the magnet is mounted. Although the rotating magnet **48** has been shown as a permanent bar magnet having two poles, any means for suitably producing a rotating magnetic field can be employed. For example, a plurality of bar magnets mounted on a common shaft or a generally cylindrical magnet with an even number of alternating longitudinal flutes and ribs, each rib comprising a magnetic pole of polarity opposite to that of the next adjacent rib, can be suitably employed.

The effect of the rotating magnetic field thus obtained is to cause the magnetic toner particles **44** to be attracted to the surface of drum **46** and due to the continuing reversal of magnetic polarity undergo translation circumferentially across the surface of the drum. In effect, the magnetic toner particles undergo a continuous advancing "flip-flop" motion thereby traveling from the reservoir up and over the drum surface. This translational motion imparted to the toner provides a means of metering the toner while preventing particle agglomeration.

As the toner particles advance across the drum surface, a charge of the requisite polarity for development of the electrostatic latent image can be imposed upon the toner particles by charging means such as a corona charging device **50** situated within chamber **40** proximate the surface of drum **46** at a point prior to toner removal as described hereinbelow. The charging device can include a corona discharge array of one or more corona discharge electrodes that extend transversely across the drum surface and are energized by a high potential source (not shown).

Once the toner particles reach the top of the drum **46**, they encounter a jet of gaseous material such as air directed across the surface of drum **46**, preferably in an upward tangential direction, by a blower **52** which dislodges the toner particles from said drum forming a "powder cloud" or suspension **54** of said magnetic particles is said gaseous material. The drawing shows the jet of gaseous material being blown countercurrent to the direction of movement of the toner particles across the non-magnetic surface. The blower **52** can be any recirculary type blower such as a high speed turbine driven by an external motor **56**. Rotary blowers, centrifugal blowers and the like can similarly be employed. If desired, by proper coupling and gear reduction, motor **56** can be employed to activate both blower **52** and magnet **48**.

A deflector **58** can be positioned in chamber **40** in the air space above the drum **46**. The deflector **58** directs the suspension **54** upwardly towards the image-bearing plate **10**. Once the suspension **54** contacts the electrostatic latent image, the charged toner particles deposit thereon in image configuration thereby developing said latent image. Magnetic seals **60** and **60'** situated in the upper portion of the chamber **40** in the regions thereof wherein the plate **10** enters and exits the chamber are employed to prevent leakage of the air-borne toner particles through the clearance between plate **10** and chamber **40** required for rotational freedom of said plate. The magnetic seals are adapted to rotate past doctor blades or pick off blades whereby the attracted toner particles are removed from the seals and returned by gravity to the toner reservoir.

The toner particles employed in the present invention can be any electroscopic magnetically attractable particles such as magnetic ferrites, iron carbonyls, alcoholized iron and the like. Generally, these particles can range in size from about 1 to about 30 microns. Preferably, the particles range in size from about 1 to about 10 microns.

The drum **46** is non-magnetic, i.e., it is made from a material which does not interfere with the lines of force of the magnetic field. Preferably, however, the drum is not only non-magnetic, but also electrically conducting. Thus, materials such as aluminum, brass and the like are preferably employed.

Other modifications of the present invention will occur to those skilled in the art upon a reading of the present disclosure. For example, although use of a permanent magnet was illustrated, electro-magnets can similarly be employed. Moreover, although the powder-cloud development system of the present invention was illustrated as applied to a xerographic process, it is equally applicable to electrography, TESI and any other process wherein development is sought of an electrostatic latent image. Such modifications are intended to be included within the scope of this invention.

What is claimed is:

1. A method for developing electrostatic latent images comprising:

(i) forming an electrostatic latent image on a support member;

(ii) magnetically imparting translational motion to said magnetic toner particles over a non-magnetic surface thereby providing a means for metering said toner particles while preventing particle agglomeration.;

(iii) imposing a charge upon said toner particles of a polarity opposite to that of the electrostatic latent image;

(iv) blowing the charged magnetic particles from the non-magnetic surface with a stream of gaseous material forming a suspension of said particles in said gaseous material; and

(v) contacting said electrostatic latent image with said suspension thereby developing said image with said toner particles.

2. The method of claim **1** wherein the stream of gaseous material is directed tangentially across the non-magnetic surface.

3. The method of claim **2** wherein the stream of gaseous material is blown countercurrent to the direction of movement of the toner particles across the non-magnetic surfaces.

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