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L. E. WALKUP ET AL
RAISED XEROGRAPHIC IMAGES

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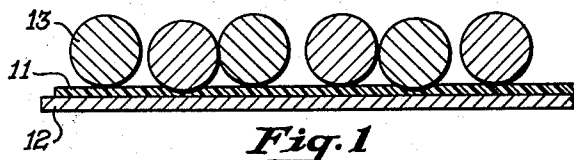


Fig. 1

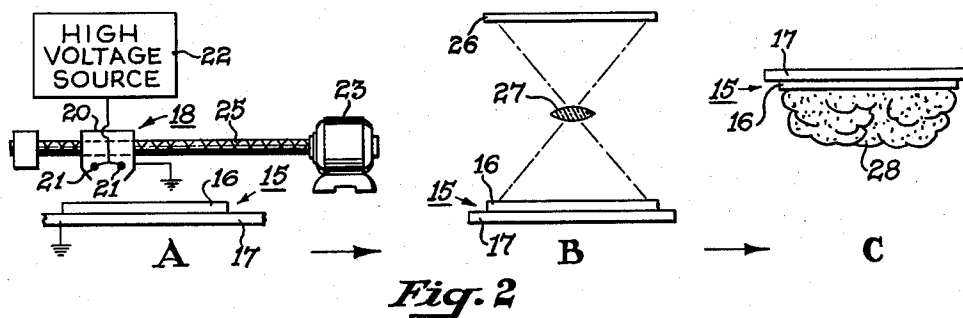


Fig. 2

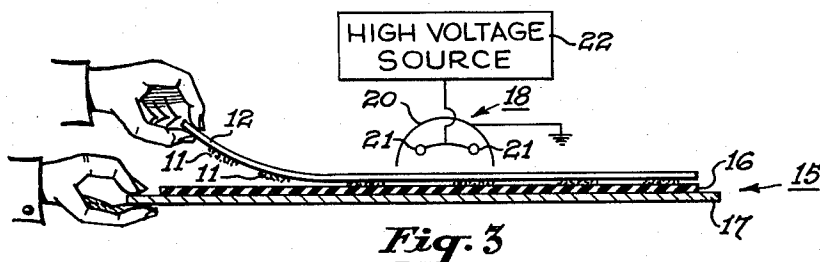


Fig. 3

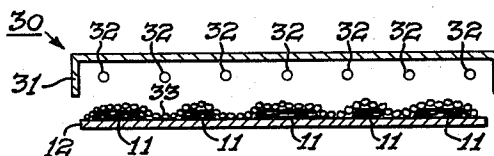


Fig. 5

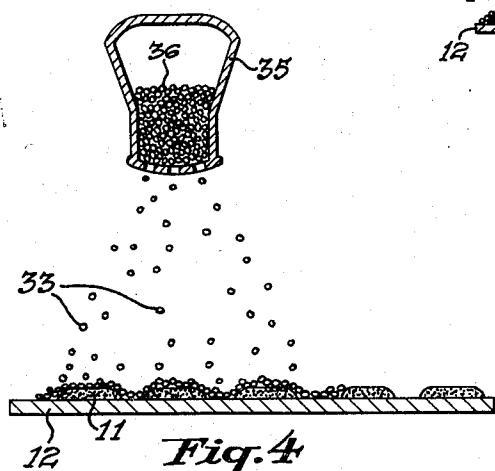


Fig. 4

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RAISED XEROGRAPHIC IMAGES

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6 Claims. (Cl. 96—1)

This invention relates in general to xerography and in particular to producing relief and intaglio images, characters, designs, and the like.

In the art of xerography or electrophotography, images are reproduced by forming and developing a latent image on a plate member which includes a photoconductive insulating layer. A plate is prepared for image formation by placing a substantially uniform electrostatic charge on the surface of the photoconductive insulating layer. This layer is characterized by its ability to rapidly dissipate charge on exposure to activating radiation such as light, penetrating radiation, or the like due to a change in the insulating characteristics of the photoconductive insulating material. This layer is also characterized by its ability to retain charge in areas not in the path of the activating energy. Thus, following exposure of a sensitive xerographic plate, a latent image of electrostatic charges is formed on the plate's surface. This latent image may be developed through the deposition of finely divided electrostatically charged powder particles which, when presented to the plate, will adhere to the electrostatic image bearing surface in conformity with the electrostatic charge pattern thereon. Although a particular technique of image formation has been described, techniques generally known to the art may be used and are intended to be encompassed herein.

The developed image comprising powder particles held in position by electrostatic lines of force may be examined, photographed, or the like on the plate surface, or the developed image may be transferred to another support base for viewing, photographing, or the like. Whether on the plate surface or on another support base, the powder image may be made permanent using known xerographic techniques such as heating, vapor fusing, covering the image with a protective transparent coating, or the like.

This invention is concerned with the deposition of additional material on the developed and visible image, again in image configuration, to form relief or intaglio characters, images, designs, or the like. Relief and intaglio characters, images, designs, or the like formed according to the techniques of this invention may be used in the various known printing processes, either directly or indirectly. Thus, they may be used to form stereomats; they may be used as a printed Braille sheet or as an intermediate to make a number of Braille copies, or the like.

It is therefore an object of this invention to devise novel methods to improve upon the art of xerography.

It is another object of this invention to devise novel processes to xerographically form relief or intaglio images, characters, designs, or the like.

It is another object of this invention to devise a novel process to xerographically form Braille images.

It is a still further object of this invention to devise a new product in which individual particles deposit to form substantially an additional layer on xerographic images.

Additional objects of this invention will in part be

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obvious and will in part become apparent from the following specification and drawings in which:

Figure 1 is a side cross sectional view, substantially enlarged, of a fused image according to this invention;

Figures 2A, B, and C illustrate an embodiment of steps which may be used to form a powdered image corresponding to copy being reproduced;

Figure 3 illustrates one embodiment of a technique of transferring a powder image;

Figure 4 illustrates an embodiment of additional material deposition on a developed loose powder image; and,

Figure 5 illustrates fusing of a powder image carrying additional material.

For a better understanding of this invention, reference is now had to Figure 1 wherein there is illustrated an enlarged cross sectional view of a fused xerographic image carrying a particulate layer of material formed according to the techniques of this invention. In this figure a normally fused xerographic toner image 11 is shown on a support surface such as sheet or web 12. Positioned on and to some extent in the fused xerographic image 11 is a substantially uniform layer of particulate material 13. The particulate material 13 remains in position due to the adhering and/or holding power of the fused xerographic image 11, which adheres and holds to both the particulate material 13 and the support sheet or web 12. Although there is no intent to be limited to any particular size, proportion, or shape, the particulate material in this figure is represented as beads or balls of material having a diameter equal to approximately five times the thickness of the sheet or web 12 and about ten times the thickness of the fused xerographic image 11. It is to be realized that the xerographic image may be fused to substantially any surface; for example, the image may be transferred to paper, cardboard, metals, plastics, glass, or the like, and the transferred image may be fused to cause the powdered image to adhere to its transfer base. Thus, although the sheet or web 12 is, in this figure, illustrated as a thin layer of material, it is to be realized that the sheet or web may have substantial thickness and that various thicknesses of transfer material are intended to be encompassed by this invention.

It is also to be realized that, although the particulate material 13 is represented in this figure as comprising beads or balls of material, the particulate material may take various sizes, forms, or shapes. In fact, although it appears desirable in carrying out this invention to use particulate material which is uniform in shape and size, often available particulate material will not be as uniform as the illustration in this figure indicates, and it is of course possible in carrying out this invention to use particulate material which is not uniform in shape and size. Accordingly, it is to be realized that rectangular shaped particles, diamond shaped particles, tree shaped particles, circular shaped particles, square shaped particles, or the like, may be used and are intended to be encompassed by this invention.

Reference is now had to Figure 2 wherein there is illustrated an embodiment of xerographic image formation. The steps illustrated in this figure are: Figure 2-A, charging or plate sensitization; Figure 2-B, exposure of a plate previously sensitized; and, Figure 2-C, development of the plate following exposure. The plate in this figure is generally designated 15 and comprises a photoconductive insulating layer 16 overlying a conductive backing member 17. The photoconductive insulating layer may comprise any of a number of photoconductive insulating materials, as, for example, sulphur, vitreous or amorphous selenium, zinc oxide in a resin binder, or the like. Functionally, the material should be one able to retain an electrostatic charge on its surface for a sufficiently long period to allow exposure and development or other utilization

of a formed electrostatic charge pattern on its surface and one which, on exposure to activating radiation, rapidly dissipates charge.

In Figure 2-A the charging or sensitizing step is illustrated using a corona discharge electrode, generally designated 18, comprising a grounded shield 20 and corona discharge wires 21. The corona discharge wires 21 are connected to a high voltage source 22 which supplies a corona generating potential to discharge wires 21, the potential being in the order of 6,000 to 10,000 volts. The voltage may be direct, positive or negative, or alternating current. Generally, it is desirable to charge the surface of the photoconductive insulating layer 16 from 100 to 800 volts either positive or negative for image formation in xerography.

The corona electrode 18 is driven by motor 23 along screw 25 connected to motor 23 and corona discharge electrode 18. Relative movement between the corona discharge electrode and the surface of the plate being charged is desirable when the discharge electrode covers only a small portion of the plate surface. In this figure, movement of the electrode takes place; whereas, it is sometimes desirable to move the plate while holding the electrode stationary. When the electrode substantially encompasses and is able to sensitize substantially the entire image bearing area a stationary electrode with a stationary plate may be used.

During charging, backing member 17 of plate 15 is generally maintained at ground potential, and when a charged plate is sensitive to light, charging is carried out in darkness.

Figure 2-B illustrates the exposure of a sensitive plate. In this figure, copy 26 to be reproduced is projected through lens 27 to the surface of charged photoconductive insulating layer 16 overlying backing member 17 of plate 15. The backing member 17 of plate 15 need not be grounded during exposure but may, if desired, be held at ground potential. Exposure causes dissipation of charge in those areas struck by light or other activating radiation resulting in a charge pattern of electrostatic charges on the surface of photoconductive insulating layer 16.

Figure 2-C illustrates one possible development technique which may be used to make visible an electrostatic charge pattern on the surface of the photoconductive insulating layer 16 overlying backing member 17 of the xerographic plate generally designated 15. The particular type of development illustrated is generally known in the art as "powder cloud development." In powder cloud development a cloud 28 of developer particles in gas is presented to the image bearing surface. The particles are electrostatically charged through the use of corona charging, frictional charging, or the like, and the electrostatic fields of force which exist between the charges on the particles and the charges on the surface of the plate cause particle deposition in conformity with the electrostatic charge pattern on the image bearing surface. There is thus formed following the steps in Figures 2A, B, and C, a powder image reproduction of the original copy.

It is to be realized that the steps in Figure 2 are included herein for illustrative purposes and that there is no desire to limit this invention to the particular technique of image formation shown. For example, although corona charging is illustrated in Figure 2-A, there is also intended to be included herein other techniques of charging such as radioactive charging, frictional charging, or the like. Also, although in Figure 2-B projection exposure to a light image is shown, there is intended to be included herein X-ray exposure, contact exposure, reflex exposure, or the like. Similarly, in Figure 2-C powder cloud development is illustrated but it is intended to include herein other known development techniques such as magnetic development, cascade development, liquid spray development, or the like. Various other

modifications which will readily occur to those skilled in the art are also intended to be included herein.

Reference is now had to Figure 3 wherein there is illustrated transfer of a developed visible image from the surface of the plate to a new support base. The plate generally designated 15, comprising photoconductive insulating layer 16 overlying plate base 17, has on its surface, following development, for example, as illustrated in Figure 2-C, a powder image corresponding to the original copy to which the sensitive plate was exposed. To transfer this visible image to a new support base, such as sheet or web 12, sheet or web 12 may be positioned against the developed image on the surface of the plate member 15 thereby sandwiching the developed image between sheet 12 and plate 15. The assembly is then moved beneath corona discharge electrode 18 comprising corona discharge wires 21 and grounded shield 20. Corona discharge wires 21 are connected to high voltage source 22 which supplies a corona generating potential to the corona discharge wires 21. The assembly illustrated in this figure is being moved from right to left beneath the discharge electrode by manually moving the plate carrying the image and sheet 12. Following passage of the assembly beneath discharge electrode 18 sheet or web 12 may be separated from the plate and will carry on its surface transferred image 11.

The technique of transfer illustrated in this figure is generally known in the art as "electrostatic transfer." To accomplish transfer an electrostatic charge is deposited on the surface of sheet 12 facing the discharge electrode by the electrode. The direction or polarity of charge is generally opposite to the direction or polarity of charge on the electrostatically charged particles and thus acts to electrostatically bind the charged particles to sheet 12. On separation, the particles which form the image separate with sheet 12 and remain adhering electrostatically to the surface of the new support base.

The corona discharge technique of electrostatic transfer illustrated in this figure may of course be modified, and such modifications as are generally known to those in the art are intended to be encompassed by this invention. Thus, for example, other techniques of deposition of electrostatic charge for transfer purposes, such as frictional charging or the like, may be used to accomplish transfer. Also, techniques which involve the use of electrostatic fields which cause transfer as, for example, positioning a field generating electrode above and in contact with the rear surface of the new transfer base or the like are intended to be included herein.

Although electrostatic transfer is shown and described in this figure, there is no intent to limit this invention thereby. Instead, all techniques of transfer presently known to the art which will allow the formation of the relief or intaglio image pattern being described in this invention are intended to be included herein. Thus, techniques in which the powdered image on the plate surface is transferred using pressure alone, or pressure combined with electrostatics or using a transfer material which is adhesive during the transfer step but not adhesive subsequently, or the like may be used in carrying out the formation of the novel images of this invention, and, accordingly, are intended to be encompassed within the scope of this invention.

It is also to be realized that the transfer step described in connection with Figure 3 may be omitted entirely in carrying out this invention. The transfer step in Figure 3 is to place the image on a final surface. Transfer of the image is desirable in the art of xerography in some instances because of the nature of the xerographic plate on which the original image is formed. The plate member is one which may be used for hundreds and thousands of cycles. Formation of the relief and intaglio images of this invention directly on the xerographic plate terminates its usefulness for additional xerographic cycles. Thus, when using plates on which it is desirable to make

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subsequent xerographic images, it is usual to transfer the developed image to a new support base such as paper or the like to thereby free the plate for the additional cycles. However, plates are known in the art of xerography which are quite inexpensive and are considered expendable with one exposure and image development. On such plates the transfer step may be omitted, and the intaglio or relief image pattern may be formed directly on the plate surface without transfer of the developed and visible image pattern.

In Figure 4 there is illustrated the deposition of additional material on image 11 resting on support base 12. In this figure, there is illustrated deposition of pellets 33 supplied from material supply reservoir 35 in which a supply of pellets 36 is positioned. Material supply reservoir 35 may take various shapes and forms. In this figure, the supply reservoir 35 is in the shape of a shaker having holes at an end thereof allowing passage of the supply of pellets 36 which fall downward as pellets 33 to the image 11 on sheet 12. Adherence of the pellets to image 11 takes place as will be described in connection with Figure 5. There is thus formed following deposition of the material substantially a layer of pellets 33 covering image and nonimage areas. The image 11 following deposition of the pellets is still in loose powder form adhering in position due to electrostatic forces.

Reference is now had to Figure 5 wherein tackification of the developed image on a support base is illustrated. In this figure the image 11 is positioned on sheet 12 within a tackifier generally designated 30. Overlying image 11 and sheet 12 is a layer of pellet material 33. Image 11 is the transferred image on the transfer base sheet 12. However, it is to be realized that if transfer is omitted then image 11 would reside on the xerographic plate surface and would be carried through the same steps being described hereinafter. The tackifier 30 of this figure is a heat tackifying device and comprises a cover member 31 and heating elements 32. Cover member 31 is provided to protect an operator from burns and to concentrate the heating in the direction of image 11 on sheet 12. A typical type of heating device which might be used to soften or tackify the image material is described in Sabel et al. United States Patent 2,586,484. Other devices as, for example, heated platens, infrared heating devices, or the like which will generally occur to those skilled in the art are also intended to be encompassed within the scope of this invention. Heating of the image will cause it to soften until it reaches a tacky state.

Tackification of a dry image is accomplished when the powder image becomes a more liquefied adhesive unit. Although it is not intended to limit this invention to a particular mode of operation, it is now thought that heat will act on the image particles to cause the viscosities and surface tensions of the image materials to decrease thereby allowing the particles to flow together as a more liquefied adhesive single image body.

Although heat tackification is illustrated in this figure, it is to be realized that vapor tackification or the like as is generally known in the art may also be used and is intended to be included herein. The use of a proper solvent vapor for the image material will similarly cause the viscosities and surface tensions of the materials comprising the image particles to decrease and thus bring about the more liquefied single adhesive image body.

Sheet 12 should be composed of a material which is not made tacky during the image tackification step. When heat is used for tackification, the tackifier is adjusted to the proper temperature range for the xerographic image developer materials. This temperature range will generally not affect paper and similar sheet material. If a plastic material is being used as sheet 12, it is desirable to choose a plastic material which is not affected by heat in the temperature range generally used for tackification of the image material to thereby avoid

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softening of the plastic material or to choose an image material which softens at a lower temperature. It is also to be realized that some base or sheet materials 12 are softened by heat more readily than by vapors. In such an instance, it may be desirable to use vapor tackification rather than heat tackification.

Following tackification, sheet 12 is removed from tackifier 30 and image 11 will fuse or solidify. The particular time in each instance to solidify or fuse will depend on such factors as the xerographic developer material, the degree of tackification of the developed image, the particular tackification technique used, atmospheric conditions, and the like.

After fusing or solidification of the xerographic developed image 11, excess pellets 33 which deposit in non-image areas may be removed from sheet 12 by shaking the sheet or by brushing it lightly. The pellets which fall from the sheet are nonadhering particles and thus are removed easily. Light brushing is desirable to avoid the removal of the adhering pellets or the pellets fused to or imbedded into the fused developed image 11.

The pellets 33 which are deposited on the developed powder image 11 may comprise any of a number of various materials as, for example, plastics, metals, glass, wood, rubber, or generally pellets of any material which does not readily flow. The desired characteristics of the material making up pellets 33 is that of material which substantially holds its shape on contact with the image and during tackification and fusing of the image. Complete deformation of the material is preferably avoided in order to assure a sufficient build-up of particulate material on the developed image 11.

Deposition of the additional material takes place substantially in a layer structure of particulate material on image areas. The particulate material will adhere to the xerographic developed image 11 where the material contacts the tacky image and there is therefore formed substantially a layer of material 33 on image 11.

Examples of material which have been used include Carborundum powder, glass beads, and the like. In experiments carried out using Carborundum, powder of 100 mesh size was deposited on a sheet carrying an image. The image was then tackified and, following fusing of the tacky image, excess powder was removed. The image carrying the adhering Carborundum powder was formed in the shape of Braille characters. When presented to a blind person the image was pronounced readable.

The particular material used as pellet material for deposition on the image 11 should be chosen to fit the particular use of the fused and finished product of this invention. Thus, in some instances it is desirable to only deposit additional material without concern as to its strength, flexibility, rigidity, or the like, and, in such instances, such materials as rubber pellets or the like may be used; whereas, in other instances a solid relief or intaglio image pattern is desired and in such instances use of solid rigid particles such as glass or metallic pellets or the like may be used. If it is desirable to deposit material to make the powdered image denser and blacker, material which will not fuse when the image is tackified but which is in the nature of black powder may be used; for example, carbon powders or pellets might be used.

Various known xerographic developers have been found to work well in this invention in forming image 11. Such materials are available under the trademark "XeroX" and are sold as "Developer" or "Toner" by The Haloid Company, of Rochester, New York. There are disclosed valuable developer materials in Walkup United States Patent 2,618,551 and Walkup and Wise United States Patent 2,638,416. Other developers and toners generally known to those in the art are also intended to be included herein.

It is to be realized that in the art of xerography it is possible to develop a photographic negative or photographic positive of the copy exposed to the plate. De-

velopment of a positive copy is brought about by deposition of the developer material on areas not exposed to light. This is accomplished by using particles carrying electrostatic charges which are opposite in sign to the charge placed on the plate to sensitize the plate and thus opposite in charge to the remaining image charges after exposure. A photographic negative of the original copy may be produced by developing the electrostatic image pattern following exposure with particles carrying electrostatic charge of the same direction or polarity as the polarity of charge making up the electrostatic image. The particles during development, due to electrostatic forces, are repelled from image areas and are attracted to background areas, and a photographic negative of the copy is reproduced. Thus, it is possible using xerography to develop image areas or to develop background areas by choosing the proper developer material. It therefore follows in this invention that one is able to produce images in relief by developing a photographic positive of positive copy or a photographic negative of negative copy and then carrying out the steps of deposition of additional material and tackifying as described in this invention, or it is possible to form an intaglio image surface by developing a photographic negative of positive copy or a photographic positive of negative copy and then carrying out the steps of this invention of tackifying the developed image and fusing thereto additional previously deposited material.

Depending on the particular method of transfer of the developed image from the plate surface, or whether the image is transferred or not, developed xerographic images on their support bases will vary in thickness. Generally, the developed xerographic image will be in the order of 0.00025 inch to 0.00050 inch. The deposition of the pellet material on the image results, after solidification has taken place, in an image substantially equal to the thickness of the fused image plus the thickness of a layer of the pellet material. Thus, if the pellet material is in the order of 0.001 inch thick, the image extending above the surface will equal the thickness of the fused xerographic developed image which extends above the surface plus the thickness of the pellet material, or plus 0.001 inch. This invention therefore allows the formation of an image having a substantial height as compared to the normal xerographic image. For example, it is possible, starting with a usual xerographic image having a height in the order of 0.00030 inch, to increase its height fifty-fold by depositing on the image pellets having a thickness or diameter in the order of 0.0015 inch. This type of great increase in image thickness has not been possible heretofore.

While the present invention as to its objectives and advantages, as has been described herein, has been carried out in specific embodiments thereof, it is not desired to be limited thereby, and it is intended to cover the invention broadly within the spirit and scope of the appended claims.

What is claimed is:

1. A method of forming a relief image of an original subject comprising forming on a surface an image pattern corresponding to the original subject and being from about $\frac{1}{4}$ to about $\frac{1}{2}$ mil in thickness of finely divided powder subsequently, in a non-tacky and non-adhesive state, said powder image pattern having been formed by a xerographic process including electrically charging a photoconductive member, exposing the member to a light image of the original subject to form an electrostatic latent image thereof, and developing the latent image on said member by the application of powder thereto, covering the surface together with the powder thereon with particles having a particle size of at least about 10 times the thickness of the powder image pattern, said powder being capable of being rendered tacky and adhesive, applying a tackifying influence to said surface bearing said image and said particles to cause said image to soften, tackify and consolidate and to bond said particles to said surface in the image areas, said surface being non-tackifiable and said particles being shape-retaining under said tackifying influence, removing said tackifying influence from said surface to cause said image to solidify and lose its tackiness, and removing from said surface all free particles.

2. The method according to claim 1 in which the tackifying influence is heat.

3. The method according to claim 1 in which the tackifying influence is a solvent vapor.

4. The method according to claim 1 wherein said xerographic process further includes transferring the powder image from said member to another surface prior to covering the powder image with said particles and prior to applying a tackifying influence to said powder image.

5. The method according to claim 4 in which the tackifying influence is heat.

6. The method according to claim 4 in which the tackifying influence is a solvent vapor.

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UNITED STATES PATENT OFFICE
CERTIFICATION OF CORRECTION

Patent No. 2,955,035

October 4, 1960

Lewis E. Walkup et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 6, line 63, for "xerogrpahic" read -- xerographic --; column 8, line 6, strike out "subsequently," and insert the same after "thereto," in line 12, same column 8.

Signed and sealed this 30th day of May 1961.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents