

Oct. 4, 1960

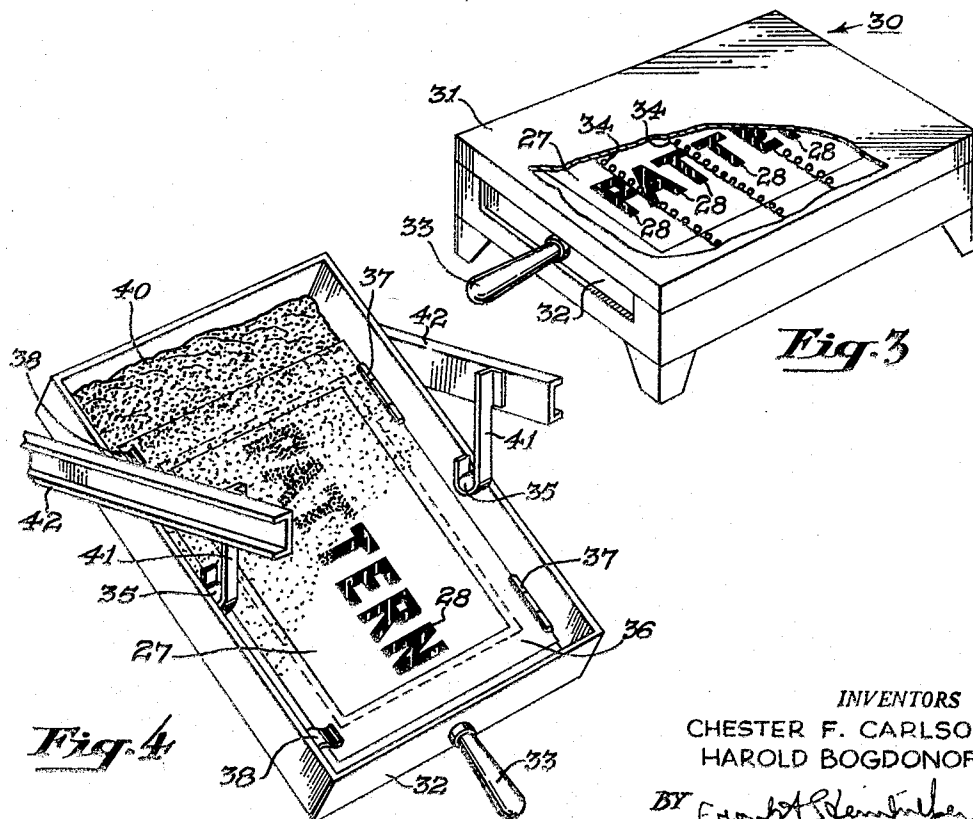
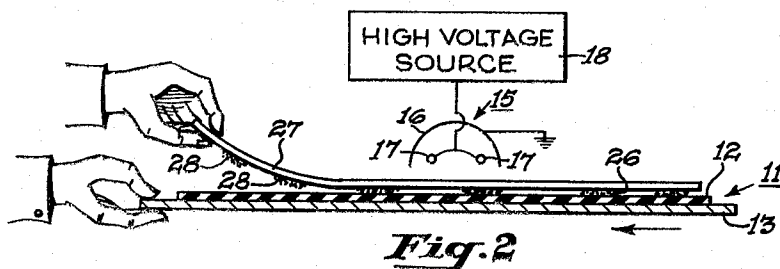
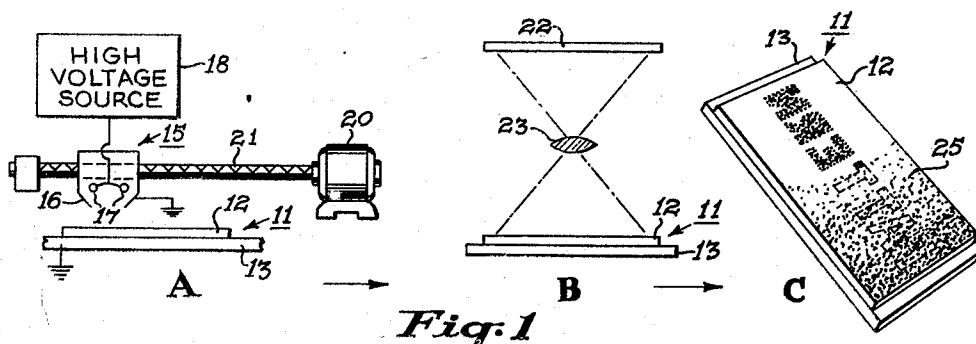
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2,955,052

METHOD OF FORMING A RAISED IMAGE

Filed Jan. 3, 1956

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

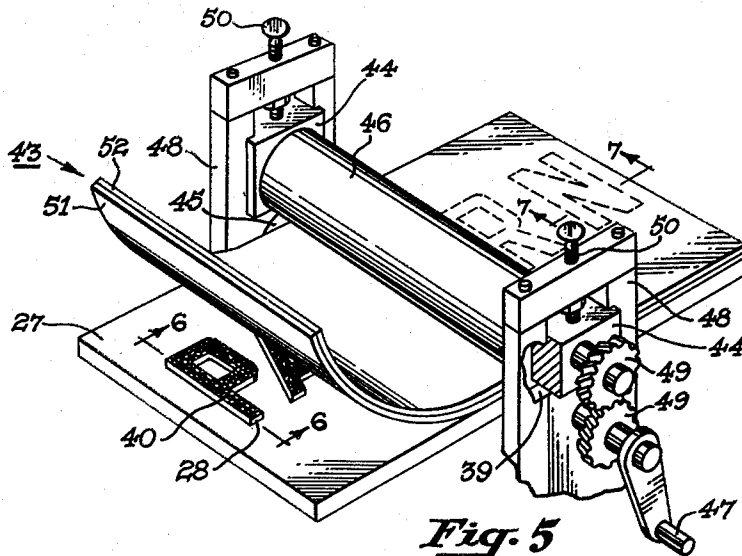


Fig. 5



Fig. 6



Fig. 7

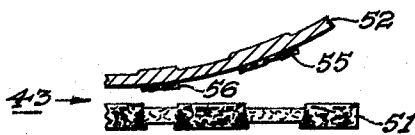


Fig. 8

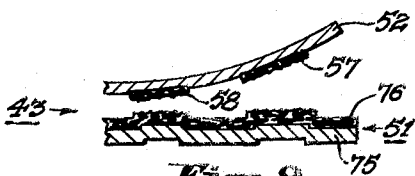


Fig. 9

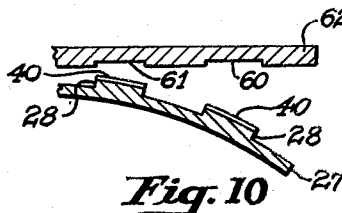


Fig. 10

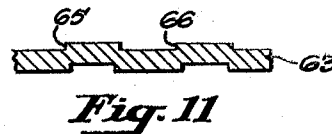


Fig. 11



Fig. 7-A



Fig. 8-A

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2,955,052

METHOD OF FORMING A RAISED IMAGE

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6 Claims. (Cl. 117—17.5)

This invention relates in general to xerography and, in particular, to producing relief images, characters, designs, and the like, impressions therefrom, and other uses thereof.

Generally in the art of xerography, powder images are formed which correspond to an original being reproduced or an object being examined. These images may be fused and thus made permanent, or they may be viewed, photographed, or the like, and then erased. This invention concerns itself with the deposition of additional particulate material on the xerographic powder image to form improved relief images, characters, designs, and the like. The relief image, once formed, is then utilized according to this invention to impress, transfer, partially or wholly, cut, emboss, of the like, a second surface. Thus, images formed according to this invention have been used to cut stencils, to form masters for the spirit duplicating process, to impress and emboss leather, metal, plastics, wood, linoleum and the like, to transfer material such as carbon and the like, and to form raised and readable Braille characters, and the like.

It is therefore an object of this invention to devise an improved process to xerographically form relief images, characters, designs, or the like.

It is another object of this invention to devise improved xerographically formed relief images, characters, designs, and the like.

It is yet another object of this invention to devise a novel process of impressing, embossing, cutting, transferring, or the like images, designs, characters, or the like using the novel relief xerographic images.

It is still another object of this invention to devise new techniques of master making for duplicating processes.

It is still another object of this invention to devise a novel process of impressing designs into surfaces.

It is still another object of this invention to devise a novel method of carbon printing.

It is still another object of this invention to devise a new technique of forming Braille images.

Additional objects of this invention will in part be obvious and will in part become apparent from the following specification and drawings in which:

Figure 1, A, B, and C, illustrates an embodiment of xerographic steps to form a powdered image corresponding to copy being reproduced;

Figure 2 illustrates an embodiment of transfer of the powder image;

Figure 3 is an isometric partially cut away view of an embodiment of a heat tackifying unit and tackification of the transferred powder image;

Figure 4 is an isometric view of an embodiment of cascade deposition of additional material on the tacky image and an embodiment of cascade mechanism;

Figure 5 is an embodiment of a pressure applying mechanism as an assembly passes through;

Figure 6 is a cross sectional view taken along line 6—6 of Figure 5 of the raised image;

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Figure 7 is a cross sectional view taken along line 7—7 of Figure 5 showing the impression formed in a two-layer impressionable assembly such as a stencil duplicating master set;

Figure 7-A is a cross sectional view taken along line 7—7 of Figure 5 showing the impression formed in a fluid duplicating master set;

Figure 8 illustrates separation of the assembly shown in Figure 7;

Figure 8-A illustrates separation of the assembly shown in Figure 7-A;

Figure 9 illustrates separation of an assembly in which partial transfer takes place such as with a carbon sheet;

Figure 10 illustrates separation of the image on its support base from an impressionable layer such as metal, tile, or the like; and

Figure 11 illustrates the appearance of an embossed and impressed layer following the pressure step.

For a better understanding of this invention, reference is had to Figure 1 wherein there is illustrated an embodiment of xerographic image formation. The steps illustrated in this figure are Figure 1-A, charging of a xerographic plate, Figure 1-B, exposure and electrostatic image formation of a previously sensitized plate, and, Figure 1-C, development of the plate carrying the electrostatic charge pattern or electrostatic image with a fusible or resinous powder.

The plate in this figure is generally designated 11 and comprises a layer of photoconductive insulating material 12 overlying a conductive support base 13. The photoconductive insulating layer may comprise any of a number of photoconductive insulating materials as, for example, sulphur, vitreous or amorphous selenium, selenium-tellurium mixtures, zinc oxide in a binder, or the like. Functionally, the photoconductive insulating material may be described as one able to retain, while unexposed, 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 1-A the charging or sensitizing step is illustrated using a corona discharge electrode generally designated 15 comprising a grounded shield 16 and corona discharge wires 17. Corona discharge wires 17 are connected to a high voltage source 18 which supplies a corona generating potential to the discharge wires. The potential supplied from high voltage source 18 may be in the order of 6,000 to 10,000 volts and the voltage may be direct, positive or negative, or alternating current. Generally, it is desirable to charge the surface of the photoconductive insulating layer 12 to from 100 to 800 volts either positive or negative polarity for image formation in xerography.

The corona discharge electrode 15 is driven by motor 20 along screw 21 connected to both motor 20 and discharge electrode 15. Relative movement between the corona discharge electrode and the surface of the plate being charged is desirable when the electrode covers only a small portion of the plate surface. In this figure, movement of the electrode takes place; whereas, in some instances the plate is moved while the electrode is held stationary. When the electrode substantially encompasses and is able to sensitize substantially the entire image bearing area a stationary electrode may be used with a stationary plate.

During charging, support or backing member 13 of plate 11 is generally maintained at ground potential, and when because of the particular photoconductive insulating material a charged plate is sensitive to light, charging is carried out in darkness.

Figure 1-B illustrates exposure of a sensitive plate. In

this figure copy 22 to be reproduced is projected through lens 23 to the surface of charged photoconductive insulating layer 12 overlying backing member 13 of plate 11. Backing member 13 of plate 11 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 activating radiation such as light energy resulting in a charge pattern of electrostatic charges on the surface of the photoconductive insulating layer 12.

Figure 1-C illustrates a possible development technique which may be used to make an electrostatic image pattern visible on the surface of the photoconductive insulating layer 12 overlying backing member 13 of plate 11. The particular type of development illustrated is generally known in the art as "cascade development." In cascade development, which is described in Walkup United States Patent 2,618,551, a mixture of particles 25 is presented to the image bearing surface. The particles are generally fractionally electrostatically charged 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 resulting in image 28.

Various known xerographic developers have been found to work well in this invention in forming image 28. Such developers 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. Desirably the developer material which is used results in low background particle deposition.

It is to be realized that the steps in Figure 1 are included herein for illustrative purposes. To carry out this invention it is desirable to form an image which may be tackified and which when tackified may be fused. Although in Figure 1 specific xerographic techniques are illustrated, it is to be realized that there is no desire to limit this invention to particular process steps shown. For example, although corona charging is illustrated in Figure 1-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 1-B projection exposure to a light image is shown, there is intended to be included herein contact exposure, reflex exposure, X-ray exposure, or the like. Similarly, although cascade development is illustrated in Figure 1-C, other known development techniques such as magnetic brush development, powder cloud development, liquid spray development, or the like are intended to be included herein. 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 2 wherein there is illustrated the transfer of a developed visible image from the surface of a plate to a new support base. The plate 11 comprising photoconductive insulating layer 12 overlying conductive support base 13 has on its surface following development, for example, as illustrated in Figure 1-C, a powder image 26 corresponding to the original copy to which the plate was exposed.

To transfer this powder image to a new support base, such as a sheet or web 27, sheet or web 27 may be positioned against the developed powder image on the surface of plate 11 thereby sandwiching the developed image between sheet 27 and plate 11. The assembly or sandwich is then moved beneath corona discharge electrode 15 comprising corona discharge wires 17 partially surrounded by grounded shield 16. Corona discharge wires 17 are connected to high voltage source 18 which supplies a corona generating potential to the discharge wires. 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 26 and sheet 27. Following passage of the assembly beneath the discharge electrode, sheet or web 27 may be separated from the plate and will carry on its surface the transferred powder image 28.

The technique of transfer illustrated in this figure is generally known in the art as "electrostatic transfer." Electrostatic transfer, which is fully described in Schaffert United States Patent 2,576,047, is accomplished through the deposition of an electrostatic charge on the surface of the transfer sheet removed from the powder image. The polarity of the charge deposited to bring about transfer is opposite to the polarity of charge on the electrostatically charged particles comprising the developed image, and, thus, the transfer charge acts to electrostatically bind the charge particles to sheet or web 27. On separation, the particles which form the image separate with sheet or web 27 and electrostatically adhere to the surface of the transfer sheet.

The technique of electrostatic transfer illustrated in this figure may, of course, be modified, and modifications generally known to those in the art are intended to be encompassed by this invention. Thus, for example, other techniques of electrostatic charge deposition for transfer purposes, such as frictional charging, or the techniques illustrated in Mayo and Lewis United States Patent 2,684,902 or Sabel and Mayo United States Patent 2,684,901, or the like may be used. Also, techniques which involve the use of electrostatic fields to cause transfer as, for example, positioning a field generating electrode above or in contact with the rear surface of the transfer base or the like are intended to be included herein.

Although electrostatic transfer is the preferred technique of transfer in carrying out this invention, there is no intention to limit this invention thereto. Instead, all techniques of transfer generally known to the art which will allow this invention to be carried out are intended to be included herein. Thus, techniques in which the powdered image is transferred using pressure alone, or pressure combined with electrostatics, or using a transfer material which is adhesive only during the transfer step, or the like may be used in carrying out the process 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 2 may be omitted entirely. The purpose of the transfer step is to place the image on a new support surface. When it is desirable to use a plate to form additional xerographic images, transfer of the powder image to a new support base such as paper or the like is desirable to free the plate for additional cycles. However, when the plate itself is considered expendable with one exposure and image development, the transfer step is readily omitted, and the steps of this invention may be carried out with the powdered image remaining on the plate surface.

Reference is now had to Figure 3 wherein a tackifier and tackification of the developed image is illustrated. In this figure, image 28 is positioned on sheet or web 27 within a tackifier generally designated 30. The tackifier 30 is a heat fusing or tackifying device of the type described in Sabel et al. United States Patent 2,586,484. Tackifier 30 comprises insulated cabinet 31 into which a drawer 32 having a handle 33 is fitted. Positioned within cabinet 31 are heating elements 34.

Drawer 32, which is more clearly illustrated in Figure 4, has four walled sides and two bosses 35 protruding inward into drawer 32 from two opposite walled sides. Positioned against the base or bottom of drawer 32 is a frame 36 attached to drawer 32 by hinges 37. The frame 36 when in its closed position, as illustrated, is held against the base or bottom of drawer 32 by grippers 38, and sheet 27 carrying pattern or image 28 is firmly positioned against the base of drawer 32 by frame 36. Although a particular device is illustrated in Figures 3 and

4, other devices as, for example, heated platens, infrared heating devices, or like devices to accomplish tackification which will generally occur to those skilled in the art are intended to be encompassed within the scope of this invention.

Tackification of a powdered image is accomplished when the 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 particles to cause the viscosities and surface tensions of the image particle materials to decrease thereby allowing the particles to flow together or coalesce as a more liquefied adhesive single image body.

In Figure 4 the cascading of particulate material 40 across the surface of tacky image 28 is illustrated. Drawer 32 has in this figure been removed from the fuser or tackifier and bosses 35 are positioned on brackets 41 affixed to support arms 42. Particulate material 40 is illustrated in this figure as cascading across tacky image 38. The material is made to cascade across the image and across the surface of sheet 27 by movement, controlled by handle 33, about the pivot points defined by bosses 35.

The base or bottom of drawer 32 is formed of a heat retaining material such as Transite, a rocklike compressed asbestos material, or the like. Frame 36 holds sheet 27 against the drawer base and this aids in continuing image 28 in a tacky state. While image 28 remains tacky the cascading particulate material 40 becomes bonded to image areas and a substantially uniform layer of particulate material 40 deposits on image 28. The particles remain in position on image 28 substantially due to the adhesive and tacky quality of the image. Although the image will generally remain tacky when exposed to atmospheric conditions following heat tackification and, using the usual xerographic developer material, for about 30 seconds, contact with the heat retaining base of drawer 32 keeps the image in a tacky state for as long as a number of minutes and thus aids in the production of a substantially uniform deposit of particulate material on the image pattern 28.

Frame 36 accomplishes two purposes; it holds sheet 27 against the heat retaining base of drawer 32 and prevents the particulate material 40 from cascading beneath sheet 27 by making intimate contact at its edges with the base of drawer 32.

Following the cascade step, through the tilting of the drawer backward and forward while supported by brackets 41, sheet 27 is removed from drawer 32 and is allowed to cool and humidify. When cooled, the surface of sheet 27 may be brushed with a light brush such as a camel's hair brush or the like to remove loose particulate material.

The use of a drawer or tray similar to the one illustrated has been found beneficial in forming the raised images of this invention. A noticeable convenience is that particulate material 40 may be allowed to remain in the drawer at all times. When the drawer is tilted to cause particulate material 40 to move to the rear of drawer 32, frame 36 may be opened without disturbing particulate material 40. Also, during the tackification step, if the particulate material remains in the drawer, it is exposed to the heat of tackification, and this results, it is presently believed, in thoroughly dry, free flowing particles. Humidified particles tend to cling together and distort the uniformity of the flow pattern across the surface of sheet 27. Dehumidified particles, on the other hand, tend to be deagglomerated particles and flow uniformly across the surface of sheet 27 as drawer 32 is tilted upward and downward around pivot points or bosses 35.

Particulate material 40 is formed of a material which is stable and infusible at the tackifying temperature of the image, and may preferably comprise glass or metal of rounded shape. The preferred material for the applications of this invention are fine glass beads. A char-

acteristic desired of particulate material 40 is that it holds its shape on contact with the tacky image and during fusing of the image. The applications of this invention also require that the particulate material 40 maintain its shape and rigidity following fusing so that it may cut or emboss or pressure transfer sheet or layer material. Desirably, the particulate material is substantially uniform in shape and size throughout. To date and for all applications involved in this invention the best material used, and thus the preferred particulate material of this invention is extremely small beads of glass having average diameter of 0.0034 inch. These beads will pass through a 170 mesh screen and will be retained on a 200 mesh screen. Glass beads supply the rigidity desired in the images formed according to this invention, and the particular size beads preferred deposit to produce a very effective cutting, impressing, or embossing or pressure transfer relief image according to this invention. Using the preferred glass beads, two passes of the beads over the tacky xerographic developed image appear adequate.

For mimeograph stencil cutting, beads of diameter between .003 inch and .004 inch are preferred in order to cut through the stencil and still not be large as to reduce resolution of the image unduly. These diameters are preferred for cutting stencil sheets in which the stencil layer (consisting usually of an open mesh long fibre tissue paper filled with a plasticized cellulosic ester or cellulose ether, or other plastic gel or wax) is substantially .002 inch thick. From the experimental work it has been reasoned that beads approximately 0.001 inch greater in diameter than the thickness of the stencil layer or carbon layer of the spirit master set are generally preferred for the usual thin stencil or carbon layers. For certain other purposes, such as embossing of leather, for example, sizes outside this range may sometimes be useful, although this range is generally preferred in substantially all applications to primarily maintain quality resolution.

It has also been found that the uniformity of particle diameter in a charge of beads 40 must be kept within rather narrow limits for successful mimeograph stencil cutting, carbon and spirit duplicating master pressing and the like. Thus, the diameters, from particle to particle or bead to bead, must not vary more than plus or minus 7.5% from the average and, preferably, shall not exceed plus or minus 5% from the average diameter. The importance of this is particularly evident when a rigid roller system is used such as that shown in Figure 5. It is evident that a few larger beads will tend to spread the rollers apart so the remaining smaller beads cannot penetrate adequately through the stencil (or apply adequate transfer pressure in case of carbon sheet, spirit duplicating carbons, and the like). The quantity of beads held in the tray is not critical. It should be sufficient to cover the tacky image area during the cascading operation. The usual charge of beads placed in the drawer for covering a 9" x 12" image has been about 90 grams.

The sheet or web 27 carrying the developed image 28 is removed from the tray 32 following the cascade step illustrated in Figure 4. Generally, by the time removal of sheet 27 is completed or a moment after removal the image pattern 28 will have hardened and there is thus formed a solid image of hardened developer resin adhering to support sheet 27 carrying on its exposed surface areas the beads or particulate material 40.

Reference is now had to Figure 5 wherein there is illustrated an embodiment of a pressure applying device and of a pressure applying step. In this figure, sheet 27, carrying on its surface fused image 28 having on its surface a bound, substantially uniform layer of particulate bead material 40, is rolled against assembly 43, between rollers 45 and 46. In this embodiment manual drive to rotate rollers 45 and 46 is supplied through crank 47 driving helical gears 49. Rollers 45 and 46 are positioned and supported by support walls 48, and space adjusting means 50 are mounted in support walls 48.

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A feature of the pressure applying device is that the pressure rollers 45 and 46 are formed of a rigid material and of adequate diameter to length ratio to resist bending or bowing under the rather high pressures applied across the full width as an assembly passes between.

In this figure, assembly 43 comprises a stencil duplicating set or spirit duplicating carbon set. Thus, assembly 43 comprises, as in the usual and commercially available stencil or spirit duplicating sets, two individual sheets or layers of material designated 51 and 52. If sheet or web 43 is to be used in the spirit duplicating process, 51 represents the carbon member of the spirit duplicating assembly and 52 represents the master sheet. However, when forming a master for spirit duplicating the assembly may pass through the pressure device with the layers interchanged. If 43 represents a stencil assembly to be used in stencil duplicating, 51 represents the wax covered stencil master sheet and 52 represents the stencil backing member. Whether 43 represents the stencil or the spirit duplicating assembly, the pressure supplied by rollers 45 and 46 to raised image 28 and layer 40 on sheet 27 is applied to layer or sheet 51 of the assembly and will cut or impress layer or sheet 51 of the assembly in the proper fashion to form a master for the particular duplicating process for which assembly 43 is applicable. This will appear more clearly below in connection with Figures 6, 7, 7-A, 8, and 8-A.

The rollers of the device of this figure are accurately and rigidly spaced apart by a distance which is in the order of 0.001 inch less than the combined thickness of the materials or layers without the image passing therebetween. Thus, in this embodiment they would be spaced in the order of 0.001 inch less than the combined thickness of the image support layer and the stencil assembly 43 whereby when the assembly is passed through the rollers the beads are forced to enter the stencil and perforate it. Spacing in stencil cutting is usually in the range of from 0.009 to 0.010 inch. Upper roller 46 of the pressure rollers has its bearing in slide blocks 44 which are slideable in vertical guideways formed in support walls 48. Shims are placed under these blocks 44 to set the spacing of the roller 46 in relation to 45. Bearing screws 50 are then tightened to hold the rollers rigidly at the spacing which has been set.

Reference is now had to Figure 6, which is a sectional view taken along line 6-6 of Figure 5. This figure diagrammatically illustrates the cross sectional view of the improved type of image of this invention. The image area, following the cascade step of Figure 4, comprises the fused xerographic developer material 28 and the bound particulate material 40. Image 28 is fused to and supported on sheet or web 27. The particulate material, to some extent, rests on the surface of the fused image 28, and to some extent, is embedded into fused image 28. The material 40 remains in position due to the adhering and/or holding power of fused xerographic image 28 which adheres and holds to both the particulate material 40 and support sheet 27. Although sheet or web 27 is illustrated in this figure 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 web material are intended to be encompassed by this invention.

Reference is now had to Figure 7 which is a cross sectional view of assembly 43 when a stencil is being formed taken along line 7-7 of Figure 5. Layer 51 comprising a wax carrying fibrous layer of assembly 43 has been pressed or impressed with the contours of the raised image on sheet 27 as, for example, in areas 53 and 54 during passage through rollers 45 and 46. In the impressed areas substantially all wax has been pressed aside and only fibers remain, whereas in the other areas substantially the original composition of this layer is unaltered. Layer 52 will generally be shaped slightly as illustrated in this figure by the pressure applying step.

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However, that surface of layer 52 which is pressed against the solid roller will remain flat as appears in this figure.

In Figure 7-A, a cross sectional view of assembly 43 is taken along the line 7-7 of Figure 5 showing the effect of the pressure step during the cutting of a spirit duplicating master. Layer 52 in this figure represents the master sheet of the master set for the spirit duplicating process, and layer 51 comprises the carbon member of the master set. Layer 51 comprises a support layer generally of paper, designated herein 70, and the carbon layer 71 comprising a mixture of wax and dye or dye intermediate. The raised image impresses layer 70 and compresses layer 71 in areas of contact during passage between rollers 45 and 46.

Reference is now had to Figure 8 wherein separation of the members of assembly 43 representing a stencil master set in this embodiment comprising layer 52, the backing sheet, and layer 51, the wax impregnated fibrous material, is illustrated. When separation takes place, areas 55 and 56 comprising substantially the remaining wax transfer from layer 51 to layer 52. Following separation, layer 51 is a finished master for the stencil duplicating process having the wax or waxlike material removed in image areas and may be used on a stencil duplicating machine or manually to make stencil copies.

When assembly 43 comprises a mimeograph stencil set, layer 51 is a wax filled porous sheet. The wax filling in such an instance appears throughout the porous sheet and on both sides of it. When pressure is applied, for example, as is described in connection with Figure 5, areas of wax move laterally along the surface on which they are disposed and also through the porous sheet. On separation, as is illustrated in Figure 8, areas of wax against which pressure was applied by the raised image to some extent adhere to layer 52 and pull out from layer 51. Following separation, layer 51 comprises a porous sheet coated with wax in all areas other than areas against which the pressure of the raised image was applied. In those areas substantially only the porous sheet remains. When ink is applied to one side of the stencil master, ink travels through the porous sheet in areas of image and deposits on a copy sheet to form the stencil copy.

In Figure 8-A, there is illustrated separation of assembly 43. Assembly 43 comprises a spirit duplicating master set and there is illustrated in this figure separation of the assembly illustrated in Figure 7-A. As in Figure 7-A, layer 52 represents the master sheet. Following separation there is attached to the surface of master sheet 52 dye or dye intermediate 72 and 73 in image areas transferred from the carbon layer 71 on the surface of sheet 51. The backing or support sheet 70 for the carbon dye or dye intermediate layer is deformed or impressed in areas of image. The pressure applied transfers through support sheet 70 to the carbon layer 71 on its surface. Image areas of carbon layer 71 thus press firmly against the surface of the master sheet 52. On separation the dye in image areas adheres to the surface of master sheet 52 thereby forming the master for the spirit duplicating processes which may then be used in the spirit or fluid duplicating processes in which a sheet of paper or the like is moistened with a liquid in which the carbon wax material is soluble resulting in spirit or fluid duplicating copy when the moistened copy sheet is pressed against the master carrying the wax carbon image.

In Figure 9 partial transfer on separation following a pressure step is illustrated. The assembly, which is herein again designated 43, may comprise layer 51, a normal carbon sheet comprising a support layer 75 and a carbon layer 76, and layer 52, paper or similar sheet or web material. Assembly 43 of Figure 9 would be shaped through pressure applying means such as the roller illustrated in Figure 5 or the like and then sep-

arated. Portions of carbons 57 and 58 are transferred from layer 76, the carbon layer, to layer 52 thus forming the usual carbon copy as, for example, is obtained when using a typewriter or the like. The formation of carbon copies is similar to the formation of masters for the duplicating process except that only partial transfer usually takes place and also the carbon sheet may be reused to make additional copies.

In Figure 10 impressing of a surface is illustrated, and in Figure 11 embossing of a surface is illustrated. Layer 62 of Figure 10 and layer 63 of Figure 11 have been carried through a pressure step in which sheet 27 carrying fused image 28 and layer 40 of particulate material have been pressed against and into the surface of layer 62 or layer 63. The pressure step may be similar to the one illustrated in Figure 5. To deform only one surface as in Figure 10 the sheet is impressed while backed by a rigid surface or while pressure is applied by rigid and solid rollers. However, to emboss a layer as is illustrated in Figure 11, the rear surface is positioned against a soft layer which acts as a cushion to allow deformation or a relatively soft roller such as soft rubber may be used. Following the pressure step, sheet 27 is separated from layer 62 or layer 63. Layers 62 and 63 may represent a substantially hard but deformable material such as a layer of soft sheet aluminum or hard rubber, wood, linoleum, plastics, or the like, or they may represent a layer of soft material such as paper, cardboard, foil, plastics, or the like. When the surface carrying the image is pressed against material, such as layer 62, backed by a rigid backing only the surface in contact with the image material will become indented; whereas, when pressed against a layer backed by a cushion which is deformable and will allow the impression to affect the entire layer, the entire layer will be impressed and reshaped to conform to the image as illustrated in layer 63 in Figure 11. Thus, in Figure 10, following separation, areas 60 and 61 will appear depressed and will conform with areas of image comprising fused image 28 and layer of particulate material 40. On separation of the layer 63 illustrated in Figure 11, there will appear embossed areas 65 and 66 protruding in areas against which the raised image on sheet 27 was pressed.

The particular layer material which is impressed or embossed as discussed in connection with Figures 10 and 11 will depend on the particular use desired of the impressed or embossed layer. Thus, for example, if it is desirable to form a design in plastics or in tile, plastics or tile would be used as the impressionable surface. If it is desired to form an embossed leather pattern, then an impressionable leather is pressed against the raised image. If it is desirable to form Braille characters on a sheet, then a typical Braille printing sheet such as "Braille Paper" available from the Perkins Institute, Watertown, Massachusetts, which appears to be manila tag stock, is pressed against raised Braille characters formed on the xerographic image support sheet. Similarly, for the various other materials which may be impressed or embossed the particular impressed or embossed end product desired will determine the particular layer material, which is pressed against the raised images of this invention.

Although all forms of transfer material have been used as sheet 27 in carrying out this invention, it has been found that harder sheet material improves cutting, impressing, or pressure transfer in connection with the step illustrated in Figure 5. It is presently believed that improved impressions are formed because the raised image will not push as deeply into a hard layer as it will press into a soft layer and, thus, the raised image penetrates deeper and with greater form into the impressionable surface during the pressure step illustrated in Figure 5. Thus, it is more desirable to use a stiff sheet of paper as compared to a soft sheet of paper or plastic.

When sheet 27 is removed from the fuser or tackifier

tray it is generally dry and thus subjected to electrostatic effects which interfere in the removal of loose beads. It has been found that allowing the sheet to stand in normal room humidity for several minutes usually introduces enough moisture so that the loose beads can be removed with light brushing. A brush treated with an antistatic coating may also be used to remove the particles without the delay, and varying the transfer sheet material also appears helpful.

Impressions have been improved noticeably when the image formed after the cascade step illustrated in Figure 4 is given a protective coating. The bead image may be sprayed with a fixative lacquer or plastic composition such as an aerosol spray of an acrylic resin in a volatile solvent. A commercially available spray which has been found quite effective is sold under the name of "Krylon." The spray not only forms a protective coating but actually penetrates between the beads and reinforces the bond between beads and to the sheet. This may be accomplished by manually passing the spray over the entire image sheet. Desirably, the deposition of spray should be uniform. In fact, the spray places a protective coating over the image carrying sheet and over the image. The improvement noticed in connection with the plastic covered image carrying sheet is twofold. First, the image impressed is improved, and, second, the protective plastic coating prevents the loss of beads during the impression or pressure step thereby further improving the impressed surface and also aids in maintaining the image on the image carrying sheet for subsequent and additional utilization.

A desirable characteristic in carrying out this invention is that the assembly of elements and the individual layers subjected to pressure be as thin and rigid as possible to cause the roller pressure to be fully transmitted to the beads or raised image to thereby efficiently press only image areas into the impressionable layer. However, depending on results desired, a film cover sheet may be used to broaden the image and to prevent the beads or particulate material from becoming imbedded in the impressionable sheet or layer. The use of a cushion sheet on the outer area of the assembly is questionable but may have value to overcome specific problems.

The rollers illustrated in Figure 5 are preferably accurately spaced rollers of rigid material. In carrying out this invention, a set of steel wringer type rollers were accurately and rigidly spaced apart a predetermined distance dependent on the thickness of the assembly to be passed through. The spacing is chosen to be about 0.001 inch less than the combined thickness of the entire assembly including the image support sheet without the image. Spacing is critical. Too great a spacing results in incomplete impressions and cutting; whereas, too small a spacing will distort the impression, make cranking difficult, put undue strain on the rollers, and, if the impressionable material is a tearable material, tears will often appear. A test which has been found workable with stencil duplicating and spirit duplicating masters, for example, involves the passing of an assembly of the various layers of materials through the rollers, excluding the image, and adjusting the spacing of the rollers to a point of minimum spacing which will not transfer stencil or spirit duplicating carbon or wax. Thus, when using a spirit duplicating master assembly, an image sheet similar to the image sheet carrying the image is placed in contact with the master assembly and is rolled between the pressure applying rollers. The rollers are then adjusted to the minimum possible spacing at which carbon does not transfer to the master sheet. This spacing, it has been found, is about 0.001 inch less than the thickness of the assembly passed between the rollers.

Rollers which have given good results comprise two 9-inch long solid steel rollers 2 inches in diameter. It has been found that rollers 1½ inches in diameter having a similar length tend to bend or bow under load and thus were unsatisfactory.

Pressure has also been applied to create the desired impression on the impressionable surface by passing the assembly while between steel plates between rollers similar to those illustrated in Figure 5. Pressure may also be applied by placing the assembly between platens and applying the pressure between platens, or the like.

Generally, the developed xerographic image will be in the order of 0.00025 inch to 0.00050 inch. The deposition of the beads or other particulate material results in an image substantially equal to the thickness of the fused image plus the thickness of the layer of the bead or particulate material. Using this invention with the preferred bead material the thickness of the image will range from .00365 inch to .00039 inch.

Using normal and available xerographic developer materials it is usual to maintain the fuser or tackifier illustrated in Figure 3 in the temperature range of 200° F. to 400° F. although controls exist to increase or decrease fuser temperature depending on the developer being used. This temperature range generally will not affect the image support material. The image on its support base when using the usual tackifier heated to from 200° F. to 400° F. should be kept in the tackifier from 5 to 45 seconds, depending on such factors as the particular xerographic image material, the particular temperature of the tackifier, and the like.

It has been found that movement of the assembly through the pressure unit illustrated in Figure 5 is generally not critical. Attempts, however, should be made to move the assembly through the unit at a uniform rate of speed to thereby apply a uniform amount of pressure to the raised image. Uniform pressure will uniformly impress the raised character into the impressionable surface.

While the present invention as to its objects and advantages as have 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. The method of forming a raised image comprising xerographically forming a powder image of tackifiable xerographic developer material on a support layer, tackifying the powder image, cascading across the tackified

image thoroughly dried free-flowing solid particulate material to adhere a layer of said particulate material only on said tackified image, said particulate material being stable and unfusible at the tackifying temperature of the tackified image and being substantially uniform in size and shape and having a diameter of no more than about 0.004 inch, and then hardening the tackified image thereby bonding thereto the particulate material.

2. The method of claim 1 in which the particulate material comprises beads and in which the size of the beads is such that they will pass through a 170 mesh screen and be retained by a 200 mesh screen.

3. The method of claim 1 in which the particulate material comprises beads and in which the diameter of the beads is in the size range of between 0.003 and 0.004 inch.

4. The method of claim 3 in which the particulate material comprises glass beads.

5. The method of claim 3 in which the particulate material comprises metal beads.

6. The method of claim 3 in which the diameter of the particulate material deviates from the average diameter of the material by no more than $\pm 7.5\%$.

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