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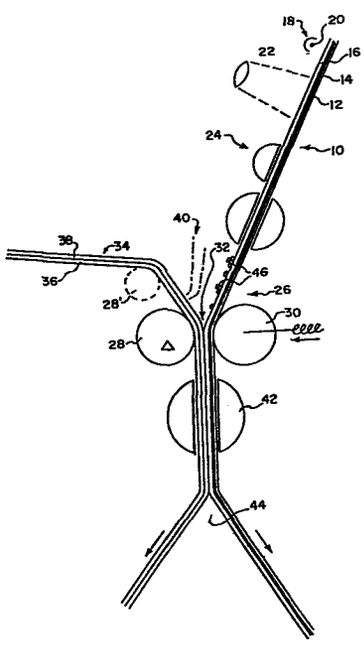
(54) Imaging method and apparatus.

(57) A transparent transfer sheet carrier having a thin coating of compatible resinous material applied thereto, is brought into intimate engagement with an electrophotographic imaging member having a dry toned image developed thereon, laminated together under the influence of heat und pressure to form a laminate and the laminate is separated to provide the transparency consisting of the toned image embedded in the resinous coating below its surface, complete transfer being effected without loss of resolution or optical density.



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This invention relates generally to electrophotographic imaging methods and apparatus for making permanent transparencies for archival or for secondary usage such as for projection or the like. More particularly, the invention concerns the provision of an improved electrophotographic imaging method and means including dry transfer of an electrostatically formed toned image under localized heat and pressure to a transfer medium comprising a resin coated transparent sheet to form a high resolution transparency having the transferred image embedded within and below the surface of the coating carried by said sheet.

Various processes have been proposed for producing an image electrostatically upon a substrate, including photographic processes involving actinic exposure of a photosensitive material carried on a substrate or by exposing o charged electrophotographic member having a photoconductive surface coating or layer to radiation to produce on electrostatic latent image thereupon. This latent image is rendered visible by application of dry toner particles thereto as in cascade type development, or by wet application thereto of a liquid toner suspension wherein the toner particles have electrophoretic properties.

The production of suitable transparencies commonly requires the skill of a trained technician and the substantial expenditure of money and tome. Photographic reproduction processes require controlled exposure, development, washing and fixing of a light sensitive composition present on a support with or without the intermediate production of a negative image.

Xerograhic processes have proven to be an easy and reliable technique for the production of transparencies. Notwithstanding the desirability of these processes, drawbacks have been encountered in that the adherence of the image on the transparent support leaves much to be desired. Additionally, loss of optical density and resolution is experienced when the toned image is transferred to a receiving member.

With the advent of the electrophotographic member disclosed in U.S. Patent 4,025,339, the achievement of heretofore impossible to obtain resolutional capabilities became possible. Toned images were formed electrophotographically by applying a charge potential on the photoconductive coating, expose the charged coating to a radiation image, usually actinic light, toning of the resultant latent image and transferring the toned image onto a carrier by electrically assisted methods. The carriers employed were paper or plastic sheet material.

The toning step was effected generally by electrophoretic methods employing very finely divided particulate toner material suspended in an insulating liquid and attracted to the photoconductive surface by the charge magnitude of the latent image. Electrically assisted methods employing development electrodes and the like have been applied to achieve complete transfer. Normally, the toned image adheres to the photoconductive surface in accordance with the electrical field strength of the latent image until the toner either was fused onto the surface or transferred to the carrier material and fused thereupon. Methods employed for transfer conventionally often resulted in formation of copies which lose a considerable degree of the original optical density and could not be transferred with retention of the high degree of resolution capable of being achieved

with the photoconductive coating of the patented electrophotographic member. Toner particles had difficulty adhering as well as desired and may flake or chip off the surface to which they were transferred. The toner particles adhered to the surface only and were fused onto the surface. Lateral movement of the particles could occur during transfer so that the faithful reproduction of the original image may be difficult, if not impossible.

The particle size of toner particles desirably should be as small as possible in order to gain the most advantage of the novel patented electrophotographic member. Dry particles useful for toning purposes as by cascade toning methods generally have a particle size which is too large. Toner particles of proper size are encountered in liquid suspensions and are not available except in such suspensions. Dry toners normally are applied by way of so-called cascade systems normally bulky and expensive. The task facing the art was to gain the advantages of using a toner to achieve maximum resolution yet have the convenience of a dry transfer system. Adhesives have been employed as coatings for transfer carriers but for many reasons have not been widely accepted, since they normally require curing to eliminate distortion of the transferred image both initially and in subsequent handling and storage. Also, complete transfer is difficult to achieve. Toner material may be left on the master electrophotographic member so that the member cannot be immediately reused.

It is important in many fields of use such as microfilm or microfiche reproduction to acquire the maximum resolution of the image. The use of the patented film as archival material has been possible and in fact, sought in order to gain advantage of the resolution capabilities of the said material. Of disadvantage is the photoconductive coatings

employed within the scope of the patented electrophotographic material which generally have a characteristic tint. When the photoconductive coating is cadmium sulfide, there is a characteristic yellow color. Of disadvantage also is the relatively high cost of the electrophotoconductive material. Using conventional methods, one could transfer the toned image to transparent plastic sheet material but adherence was not satisfactory. Resolution and optical density retention was reduced during transfer. Adhesive coatings have been suggested but have not been satisfactory to the extent desired dur to "blocking" tendencies, that is, the tendency of coated sheets to adhere to superposed like coated sheets, difficulties encountered in coating the adhesive materials, the lack of satisfactory light transmissive characteristics of the coated material, aging and loss of adhesiveness of the coating, peeling or flaking of the coating from the substrate.

One problem involved in the achievement of transfer on the toned image from the electrophotographic material to a coated transfer medium ist the transport without damage or disturbance of the toner image. Conventional transfer media require that the transferred toner image be fixed or fused to the receiving surface subsequent to receipt thereon. This requires performance on another function upon the transfer medium, requiring more time and expense, as well as complex mechanisms. The transparent transfer media which may be conventionally employed as well as the types of fusible toner available for use distort the transferred image as the same is being transported through the apparatus. Materials may be overcoated upon the transferred image to aid in binding the same to the undersurface. In addition to the presence of still another layer, there would have to be deleterious effect of such material upon the transparency of the finished product, the flexibility thereof, etc.

Accordingly, the invention provides a method of forming a transparency electrostatically including the steps of electrostatically forming a toned image on an electrophotographic member, characterized by the steps of providing a transfer medium consisting of a transparent substrate carrying a thin outer coating of a resinous composition compatible with said substrate and bonded thereto, bringing together said film member and the transfer medium simultaneously with application of sufficient heat locally to soften the resinous coating, applying localized pressure to the engaged film member carrying the toned image and softened coating of the transfer medium to laminate same and thereafter separating said laminated transfer medium and electrophotographic member, the toner image being embedded within said coating and remaining with said transfer medium upon separation, the transfer being effected without loss in resolution or optical density.

Further, the invention also provides apparatus characterized by first and second rollers arranged to define a nip, a feed mechanism for directing an electrostatically formed dry toner image carrier and a transfer member simultaneously to said nip, said transfer member formed of a transparent substrate having a heat softenable resin coating bonded thereto and compatible therewith, the coating side facing the toned image carried by the carrier, a heater capable of locally softening the resin coating, a laminator capable of laminating said transfer member to said image carrier at said nip, a cooler for cooling the laminate and a separator for the laminate, the toned image being transferred in its entirety when the laminate is separated and embedded below the surface of the coating adhered to said transfer.

The preferred embodiments of this invention now will be described, by way of example, with reference to the drawings accompanying this specification in which:

Figure 1 is a diagrammatic representation of the dry transfer process according to the invention, and

Figure 2 is a fragmentary section illustrating the transparency resulting from the method of the invention.

The electrophotographic member preferably employed herein is that described in U.S. Patent 4,025,339 of May 24, 1977. The electrophotographic imaging process includes charging the photoconductive surface of said electrophotographic member, imaging the charged surface by exposure to a radiation pattern of the information to be imaged to form a latent charge image on said surface and developing said latend electrostatic image with toner material. The toner employed comprises fine pigmented particles suspended in an insulating liquid medium. The toned image then is permitted to dry after application. Normally, the toned image would be fused to the surface of a electrophotographic member but in this invention, only drying of the toned image is effected.

Referring to the diagrammatic representation of the method and apparatus of the invention, in Figure 1 there is shown an electrophotographic member 10 formed as a sheet of substrate material 12 on which is applied a thin layer 14 of ohmic material. A thin coating 16 of microcrystalline photoconductive material is r.f. sputter deposited under carefully controlled conditions in accordance with the teachings of U.S. 4,025,339. Generally the coating is from 3000 Angstroms to less than two microns in thickness. The coated substrate is charged at charging station 18 by

corona generator device 20. The charged member is exposed to an actinic radiation pattern of information desired to be reproduced at exposure station 22 and toned at developing station 24 using a suspension of nonfusible toner material in an insulating liquid medium. The toned image is dried at 26.

A pair of roller members 28 and 30 are arranged to define a nip 32 to which a sheet of transfer medium 34 is fed simultaneous with toned member 10. Roller 28 is heated to about 170° C. Roller 30 is biased to exert a pressure of 60 pounds per square inch at the nip 32. Roller 28' may be heated so as to function as the heaing roller with roller 30 functioning to back up pressure roller 30 and define the nip 32. Where roller 28 is the sole heating roller, roller 28' functions as an idler roller. In any event the resin coating is softened sufficiently at or prior to the nip 32 to enable the toned image to be compressed thereunto.

The transfer sheet 34 comprises a transparent thin sheet 36 of polyester polymer material manufactured and sold under the trademark MYLAR by the DuPont Company of Wilmington, Delaware. The transfer sheet 34 has an overcoated layer 38 formed of compatible resinous material bonded permanently to one surface thereof. A preferable coating material is a thermoplastic polyester resin composition coated on the sheet of Mylar by conventional coating methods. The preferred coating material has a softening range of about 140° D and can be selected from polyester resins compatible with Mylar such as Nos. 46950, 46983 or 49000 sold by DuPont Company (Wilmington, Delaware) or one of Vitel resins PE 200, PE 207, PE 222, VPE 4583A or VPE 5545A (Goodyear).

As an alternative to heating the roller 28, a hot air vent 40 (broken outline) may be disposed adjacent the nip 32 to

heat the coating proximate to the line of contact between member 10 and the transfer sheet 38 so as to soften the coating 38 without affecting the substrate. The pressure roller 30 may be formed of metal or of hard rubber of about 80 durometer.

The resulting laminate is permitted to cool at 42 and then is peeled apart as at 44. Cooling before delamination is not mandatory. The toned image is transferred completely with no residue being left on the photoconductive coating 16 of member 10. The particles 46 transferred to sheet 34 are embedded in the coating 38 below its outer surface by being drawn therein while the coating was softened locally. The surface of sheet 34 after transfer is very smooth. Some particles of the toner even may migrate further into the interior of the coating 38, with some reaching the interface between the coating and the substrate and others simply floating. Separation can be performed ma-ually or by conventional mechanical separator means. Separation can be performed "hot".

Claims:

1. A method of forming a transparency electrostatically including the steps of electrostatically forming a toned image on an electrophotographic member, characterized by the steps of providing a transfer medium consisting of a transparent substrate carrying a thin outer coating of a resinous composition compatible with siad substrate and bonded thereto, bringing together said film member and the transfer medium simultaneously with application of sufficient heat locally to soften the resinous coating, applying localized pressure to the engaged film member carrying the toned image and softened coating of the transfer medium to laminate same and thereafter separating said laminated transfer medium and electrophotographic member, the toner image being embedded within said coating and remaining with said transfer medium upon separation, the transfer being effected without loss in resolution or optical density.

2. The method according to claim 1 characterized in that transfer member is heated to soften the coating just prior to its engagement with said electrophotographic member.

3. The method according to claim 1 characterized in that the transfer member is heated locally to soften the resin coating simultaneously with application of pressure to laminate same to the electrophotographic member and cooling the laminate prior to separation.

4. The method according to any one of claims 1, 2 or 3 characterized in that transfer of the toner image is complete, the electrophotographic film member being free of toner residue subsequent to transfer.

5. Apparatus for practicing the method of any one of claims 1, 2 or 3 characterized by first and second rollers arranged to define a nip, a feed mechanism for directing an electrostatically formed dry toner image carrier and a transfer member simultaneously to said nip, said transfer member formed of a transparent substrate having a heat sofenable resin coating bonded thereto and compatible therewith, the coating side facing the toned image carried by the carrier, a heater capable of locally softening the resin coating, a laminator capable of laminating said transfer member to said image carrier at said nip, a cooler for cooling the laminate and a separator for the laminate, the toned image being transferred in its entirety when the laminate is separated and embedded below the surface of the coating adhered to said transfer.

6. The apparatus according to claim 5 characterized in that said rollers defining said nip comprise a heated roller and a pressure roller.

7. The apparatus according to claim 5 characterized in that the heater is arranged to heat the transfer member whereby to soften the resin overcoat just prior to its entry into the nip.

8. The apparatus according to any of claims 5 or 7 characterized in that said heater is a hot air blower positioned to direct heat on said resin coating just prior to its arrival at the nip.

9. The apparatus according to any of claims 5 to 9 characterized in that said pressure roller is formed of metal or of hard rubber of about 80 durometer hardness.

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FIG. 1

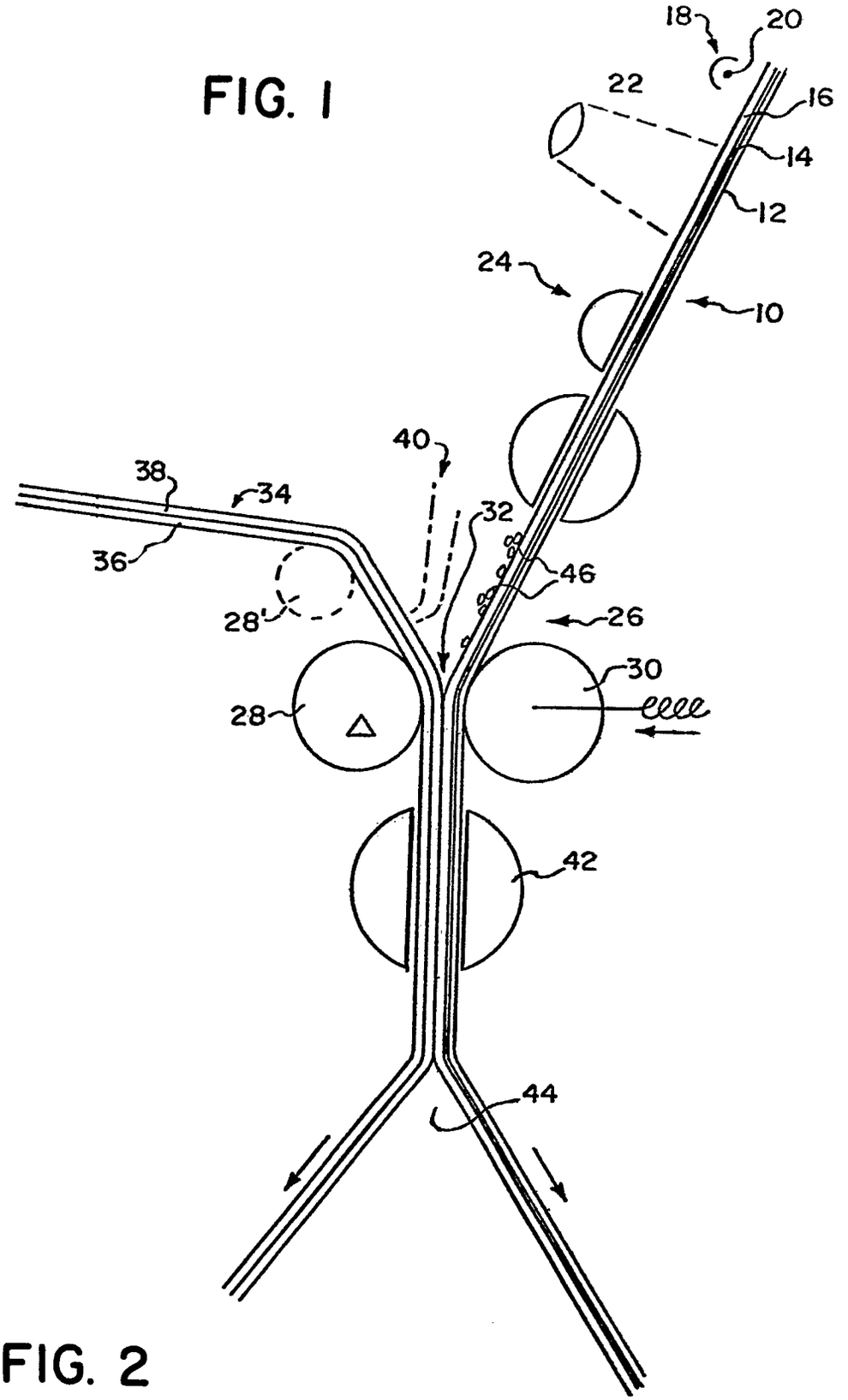

FIG. 2