

- [54] **COPYING SYSTEM, METHOD AND COMPONENTS**
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Related U.S. Application Data

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- [52] U.S. Cl. **355/3 DD; 355/16; 117/17.5; 117/37 LE; 96/1 SD; 118/637**
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- [58] Field of Search..... **355/3 R, 3 DD, 16; 117/37, 117/17.5; 96/1 SD; 118/637**

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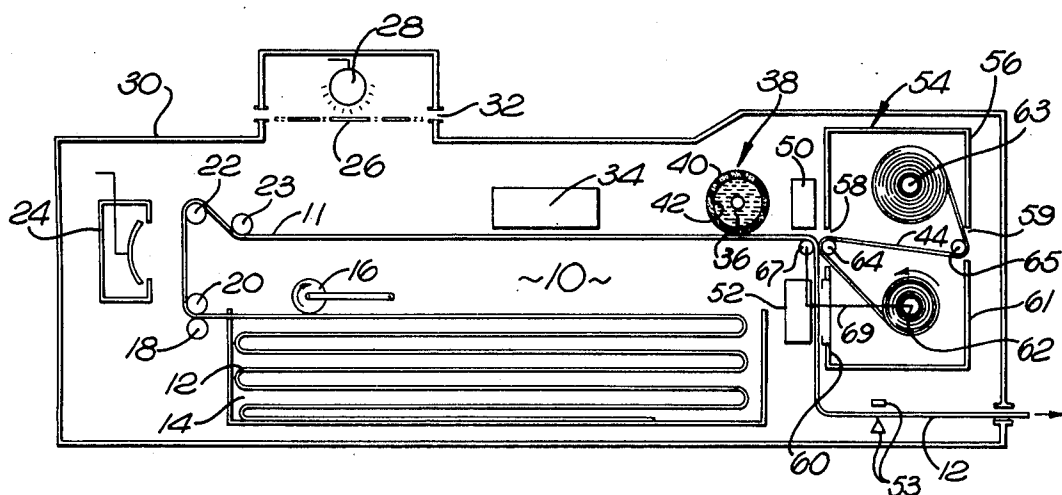
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[57] ABSTRACT

An electrophotographic (or magnographic) copying system is disclosed which employs a doner sheet bearing toner particles adhered by electrostatic charge on one or both surfaces thereof, a photoresponsive member having a copy surface on which a charge image is formed, and electrically insulating liquid for application to the imaged surface whereby toner particles migrate from the doner sheet to the copy surface for fixing thereon.

9 Claims, 3 Drawing Figures



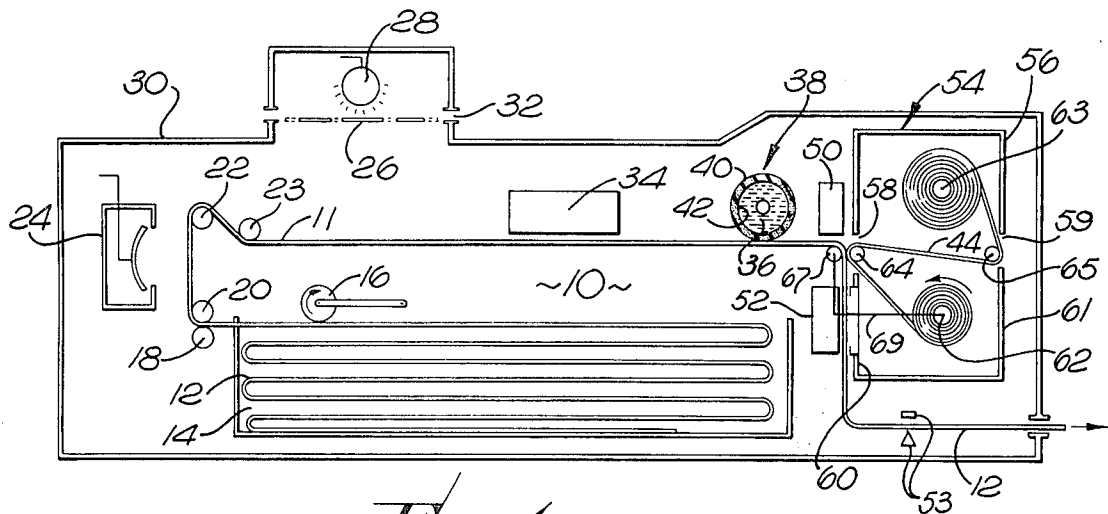


Fig. 1.

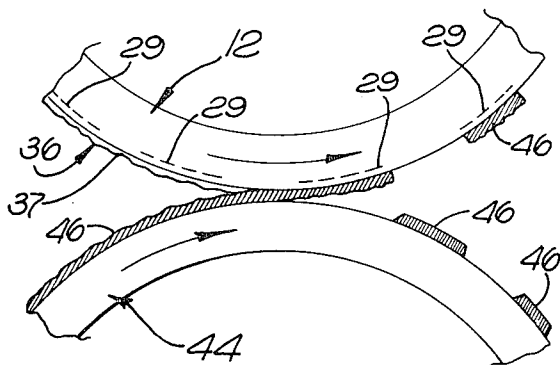


Fig. 2.

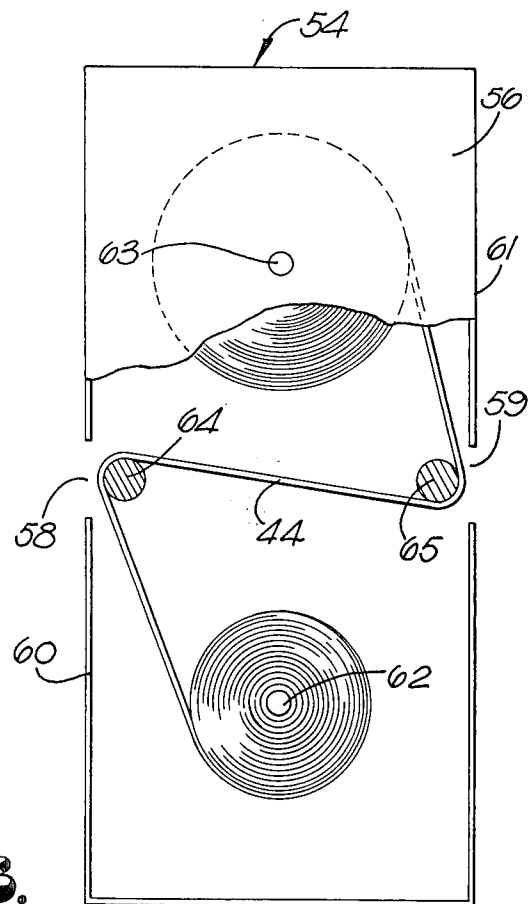


Fig. 3.

COPYING SYSTEM, METHOD AND COMPONENTS

This is a division of application Ser. No. 323,165, filed Jan. 12, 1973.

FIELD OF THE INVENTION

The present invention generally relates to copying and more particularly to an improved method and system for electrophotographic and magnographic copying.

BACKGROUND AND SUMMARY OF THE INVENTION

There are currently several widely used charge copying systems. In electrophotographic systems employing a dry development method, dry toner particles normally are passed into contact with an electrostatically imaged photoconductive surface to form the desired visible image. Problems often arise during continual use of the copying machine. Thus, dry, finely particulate toner particles can spread throughout the body of the machine and may interfere with the production of clean crisp copies. Cleaning of the machine may have to be carried out periodically to reduce such problems. Moreover, untidy replacement of the dry toner also has to be carried out periodically.

Other systems use magnographic principles to form a (magnetically) charged image and utilize magnetically attractable toner particles for providing copies. The foregoing considerations are similarly applicable.

Although liquid development systems avoid the airborne spread of dry toner particles, they are also subject to certain disadvantages including the possibility of spillage and the need for substantial space within which to accommodate a storage tank, agitator, pump, applicator and recovery means for excess liquid toner. They are not sufficiently compact to be used in small spaces and, because of their multitude of components, are usually expensive.

Accordingly, it would be desirable to provide an improved charge (electrographic or magnographic) copying system which would be compact and inexpensive and which would avoid airborne contamination problems of dry toner systems as well as the disadvantages of most liquid developing systems. It would also be desirable for such a system to be usable as a home copying system, that is, it should neither require complicated procedures nor training in its use nor the use of elaborate equipment.

The present invention satisfies the foregoing needs and provides an improved charge copying system and method as well as an improved donor cartridge for the same and a novel method of fabricating a donor sheet for use in the system and method. In particular, the improved method and system employ a donor sheet capable of holding an electrostatic charge and bearing toner particles on one or more surfaces thereof, a photoconductive copy surface, means for charging the copy surface and forming a charge image thereon, an electrically insulating liquid for application to the imaged surface and stripping of the toner particles from the donor sheet on contact, means for applying the liquid and means for fixing the toner particles on the copy surface. The donor sheet, copy sheet and liquid can be separately stored, the liquid being applied immediately before the contact with the donor sheet. The donor sheet can be fabricated by electrostatically charging one or both sides of an insulating sheet and then uniformly de-

veloping with charged toner particles which adhere by electrostatic attraction. An external electrical field can be applied to facilitate migration of toner particles from the donor sheet through the insulating liquid to the image copy surface. By appropriate application of the external field, reversal copying can readily be carried out.

The present system is compact, inexpensive and requires no special skilled or complicated techniques. Accordingly, it is ideal for a low cost, efficient home copying unit. It avoids the problems inherent in conventional dry toner systems and in liquid developer systems. The depletable components of the system can be packaged in a cartridge for easy removal and replacement. Moreover, such components can be easily fabricated of conventional, readily available materials. Clear, crisp, accurate copies of original negatives or positives can be provided. Other advantages are set forth in the following detailed description and accompanying drawings.

For purposes of simplicity of presentation the discussion hereinafter will refer to electrophotographic systems, but the considerations, insofar as attraction of toner particles, also apply to magnographic systems, toner compositions for which are well known to the art. When the term "charge" is used, in the claims and specification, it is meant to refer to both electrostatic charge and magnetic charge (or field).

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 schematically depicts one embodiment of the electrophotographic copying system of the present invention;

FIG. 2 schematically depicts in greatly enlarged form the transfer of toner particles from a donor sheet to an electrostatically imaged copy sheet in accordance with the present method and system; and

FIG. 3 schematically depicts in side elevation one embodiment of the donor cartridge of the invention, portions being broken away to illustrate internal features thereof and portions being shown in dotted outline.

DETAILED DESCRIPTION

The present method of electrophotographic copying comprises electrostatically charging a photoconductive copy surface, exposing the charged surface to a light pattern to form a latent electrostatic image thereon, coating the image surface with a layer of an electrically insulating liquid capable of wetting the surface, contacting the layer with a donor surface bearing toner particles, causing the toner particles in the charged state to migrate through the insulating liquid to the imaged surface, after which the resulting visible image is fixed either by drying or by heating to provide a permanent copy.

Referring particularly to FIG. 1, one embodiment of the system of the present invention is schematically depicted. An electrophotographic system 10 is shown which includes a photoconductive surface in the form of or on a sheet 12 of appropriate length disposed in a cartridge compartment 14. The photoconductive sheet 12 is moved from the compartment 14 by suitable means, such as a movable (by mechanism not shown) feed roller 16 and passes through suitable guide means such as guide rollers 18, 20, 22 and 23. It will be understood that the sheet 12 can be relatively short and a

plurality thereof can be stored in stacked relation in the compartment 14. In that event, transparent means such as a moving belt or web (not shown) can be used to pass each sheet 12 through system 10.

The sheet 12 can be fabricated of any conventional electrostatically chargeable photoconductive material, such as zinc oxide disposed in an insulating binder as a coating on a paper sheet or the like. It will be understood that other suitable photoconductors can be used in place of zinc oxide, for example, zinc sulfide, cadmium sulfide, vitreous selenium, zinc silicate, anthracene, triphenylamine, polyvinyl carbazole, and the like. The binder can be any conventional electrically insulating binder, for example, silicone, polyester, vinyl copolymers, phenolic resin, epoxy resin, polyurethanes, phenolic resins, acrylic resins and the like. The supporting sheet, if any, for the photoconductive coating can be paper, plastic, metal foil, or the like, all within the skill of the art.

As the sheet 12 passes between the guide rollers 20 and 22 it is electrostatically charged by a unit 24, which can be any suitable conventional charging unit, for example, a standard corona device well known in the art for such purposes. The sheet 12, now having an electrostatically charged surface 11, is passed to an exposure station wherein the charged surface 11 is exposed to a light pattern formed in any suitable conventional manner such as by interposing a negative or positive original 26 between a light source 28 and sheet 12. The electrostatic charges on the photoconductive surface 11 are discharged in those areas struck by light, while the remaining areas of the surface 11 retain their electrostatic charges. Accordingly, a latent electrostatic image duplicating the original is formed on the surface 11. The latent image 29 is depicted in FIG. 2. Well known techniques for obtaining a positive image from either a positive or negative original can be used.

It will be understood that the sheet 12 is kept in the dark, except for the described exposure, until after it has been developed and fixed. For such purposes, the system 10 may include an outer container 30 with means 32 for inserting and removing the original 26 to be copied. The light source 28 is on only when the exposure is to be made. Either transmissive or reflective optics can be used.

After the described exposure, the sheet 12, now bearing the desired latent electrostatic image 29 on the photoconductive surface thereof, is passed to the developing portion of the system 10 by suitable drive means including the drive roller 67, referred to hereinafter. If desired, the imaged sheet 12 can be provided with a substitute latent electrostatic image which is the reverse of that produced in the manner described above. This can be accomplished by positioning the sheet 12 adjacent to an electrical field generating means 34, such as a constant current corona device of opposite charge with respect to the corona device 24. The device 34 generates an electrical field which neutralizes the electrostatic image pattern 29 on the sheet 12 and imposes an electrostatic charge pattern of opposite polarity on the previously image-free area of the surface 11. Accordingly, if the original document 26 is a negative, a positive copy can be produced by this reversal technique, provided that the photoconductive surface employed is suitable for such purposes and toner is selected so as to cause toner particles to be attracted to the substitute latent electrostatic image. Alternative

methods employing a bias potential during development are also known to the art.

A reversal image can also be provided by eliminating the use of means 34 but reversing the polarity of corona device 24 and utilizing either a conventional bichargeable photoconductive surface such as zinc oxide mixed with zinc sulfide or a photoconductive surface capable of accepting electrostatic charges of the opposite polarity, i.e., those induced by corona device 24 or its reversed polarity mode. In this instance, the toner particles do not deposit out on the latent electrostatic image but are repelled thereby (being of the same polarity) and are deposited on the image-free areas of the photoconductive surface. Accordingly, there would be no need to change the type of toner particles employed in system 10 in order to obtain a positive print.

The imaged photoconductive surface 11 of the sheet 12 is next wetted with a suitable electrically insulating liquid 36 as illustrated in FIG. 2. The liquid 36 is disposed as a layer 37 on the photoconductive surface 11 by applicator means such as a roller 38 having a porous outer surface 40 communicating with an interior liquid storage cavity 42. The liquid 36 need only be applied to the imaged photoconductive surface of sheet 12 immediately before development thereof. Moreover, a layer 37 of the liquid 36 so applied need only be of an extent sufficient to mobilize toner particles, more particularly as described hereafter, and facilitate their migration to imaged photoconductive surface 11. Other suitable storage means for the liquid 36 can be used in addition to or in substitution of the roller cavity 42. The surface 40 can be of any suitable material, such as porous plastic, porous rubber or the like.

The liquid 36 can comprise any suitable electrically insulative liquid, for example, iso-paraffins, such as sold under the trademark Isopar G by Humble Oil and Refining Co., or suitable aromatic hydrocarbons, such as toluene, xylene or the like, substituted or unsubstituted. Certain aliphatic and cycloaliphatic hydrocarbon liquids are suitable, in addition to iso-paraffins, for example, n-pentane, benzene, cyclohexane, and the like. The liquid medium and toner are selected to provide proper attraction of the toner particles to the latent electrostatic image. The liquid 36 should be absorbable by the photoconductive sheet 12 and volatilizable therefrom so that layer 37 thereof is readily eliminated after use.

Referring to FIG. 2, development of a latent electrostatic image 29 on the photoconductive surface 11 to a visible image is achieved by passing the sheet 12 into close proximity to a donor sheet 44 bearing a layer 46 of toner particles thereon so that the liquid layer 37 contacts the toner layer 46. Conventional dry toner particles charged with opposite polarity to that of latent image 29 usually are utilized. Such toner particles can be formulated with, for example, carbon black, chrome yellow, cadmium red, red or black iron oxide, Prussian blue, Hansa yellow, crystal violet or other conventional colored toner particles.

The donor sheet 44 comprises a web of electrically insulative material to which the toner particles 48 adhere by a weak electrostatic force so that the electrostatic attraction of toner particles 48 by the latent image 29 on the photoconductive surface 11 substantially exceeds the force binding particles 48 to the surface of sheet 44. The insulating sheet 44 can be of any conventional composition. Thus, one could use dielec-

tric coated paper that is chargeable to the polarity desired. Light sensitivity is not needed as the electrostatic charge will be used only for uniform adherence of the particles. Alternatively, one could use any insulating sheet material capable of carrying an electrostatic charge, such as Mylar, Kapton, polyethylene, polypropylene, polysulfone, or the like. The surface of the donor sheet 44 is then developed by contact with charged toner particles having an opposite polarity. The toner particles can be formulated with a binder, as known, and can be applied, for example, as a liquid slurry. Preferably, the slurry liquid should not be a solvent for the binder. The binder may be thermoplastic, e.g., polyethylene resin, in which case it need not be soluble in the insulating liquid layer 37 and can be subsequently fixed by heating. However, any plastic, thermoplastic or otherwise, which is soluble in the insulating liquid can be used, in which case fixing can be accomplished by single drying and heat fixing would not be required. Alternatively, dry toner particles can be applied to the charged donor sheet surface by spraying. In any case, the toner deposited on the donor sheet 44 will not be fixed but will be transferable, as hereinafter described.

Contact between the liquid layer 37 and the toner layer 46 results, as shown in FIG. 2, in the transfer of charged toner particles to the imaged photoconductive surface 11 in those areas bearing the latent image 29. In the example illustrated in FIG. 2, the electrostatic image 29 bears negative charges, while the toner particles 48 are positively charged. Thus, the electrostatic attraction exerted by the latent image 29 on the toner particles 48 after mobilization of those particles by the liquid layer 37 results in migration of the toner particles from the donor sheet layer 46 to the latent image, adhering thereto and rendering it visible.

Obviously, the influence of the electrostatic attraction by the image 29 after the toner mobilization must be greater than the forces binding the toner particles to the donor surface 46. If such influence is not initially greater, it can be made so through the use of an external electrical charge-generating device 50 positioned adjacent the donor sheet 44, or sheet 12 or both. The charge-generating device 50 can be used to induce as strong an electrostatic charge density in the latent image 29 as is necessary to assure proper migration of toner particles to the vicinity of the latent image 29.

After the toner particles deposit on the latent image 29, the resulting visible image can be made permanent by any suitable fixing procedure. By formulating the toner particles 48 with a thermoplastic binder, heating of the visible image to above the melting point of the thermoplastic binder, as by a heater 52 will fuse the binder to the photoconductive surface 11 and permanently bond the visible image thereto on cooling. For such purposes, binders such as polyethylene, polyvinyls, polystyrene, polypropylene, acrylic resins and the like can be used, provided their melting point is below that of sheet 12 and its photoconductive surface 11 and is reasonably low. A particularly useful material containing toner particles formed with a thermoplastic binder is a developer sold by the Bell & Howell Co. under the trademark Statesman.

The heater 52 also facilitates the evaporation of residual amounts of the liquid 36. After the fixing step, the finished copy is clear and sharp and is passed

through a cutting mechanism 53, as known, and passes from the housing 30.

It will be understood that the photoconductive sheet 12 can be, if desired, a plurality of separate sheets disposed in a suitable storage area and sequentially retrievable therefrom by any conventional transport and handling means. The donor sheet 44 also can be a plurality of sheets sequentially retrievable from a separate storage area, also by conventional transport and handling means. However, it is preferred to provide a single long donor sheet in the form illustrated more particularly in FIG. 3, or a long donor sheet 44 in the form of a continuous roll (not shown). FIG. 3 schematically depicts the donor sheet 44 disposed in and as part of a donor cartridge 52. The cartridge 54 includes a housing 56 defining apertures 58 and 59 in opposite, respective side walls 60 and 61. The donor sheet 44 is wound on opposed feed and take-up spindles 62 and 63. Guide rollers 64 and 65 are disposed within the housing 56 so that opposite surfaces of the donor sheet 44 are exposed through the respective apertures 58 and 59. In operation, one of the guide rollers (64 as shown) is closely spaced adjacent a drive roller 67 within the container 40 (FIG. 1) to press the donor sheet 44 into contact with the processed sheet 12. A gearing mechanism (not shown, but indicated at 69 in FIG. 1) can connect the drive roller 67 to the take-up spindle (62 in this case) so that the donor sheet 44 is advanced in synchronization with the photoconductor sheet 12.

In the embodiment depicted in FIG. 3, and also in FIG. 1, when one side of the donor sheet 44 has been exhausted, i.e., toner particles have been stripped from the entire length thereof, the cartridge 54 can be removed from housing 30 and reversed so as to abut the other aperture 59 against the photoconductive sheet 12 and expose the second of the two toner-bearing sides of the donor sheet 44. The donor sheet 44 can then be progressively rewound as subsequent copies are developed until the second side is depleted of toner and replacement of the cartridge 54 is required.

It will be understood that the cartridge 54 can be provided with a continuous donor sheet disposed around spindles 62 and 63 and rollers 64, 65 and bearing toner particles on only one side thereof, if desired. In such event, the cartridge 54 need only contain one aperture 58.

Various modifications, changes, alterations and additions can be made in the present electrophotographic copying method, its steps and parameters, in the method of fabricating the donor sheet, in the present electrophotographic system, its components and in the novel donor cartridge and its components. All such modifications, changes, alterations and additions as are within the scope of the appended claims form part of the present invention.

I claim:

1. An improved copying system comprising, in combination:

- an elongate donor sheet of insulating material having a donor surface bearing toner particles uniformly adhered to said surface by electrostatic charge;
- a copy member having a copy surface;
- means for charging said copy surface;
- means for selectively dissipating said charge to form a charge image on said copy surface;
- storage means containing an electrically insulating liquid capable of stripping said toner particles from

said donor surface for migration to said charged-imaged surface;

applicator means for applying said liquid as a layer to said copy surface when said copy surface bears said charge image;

means for bringing said donor surface and said liquid layer on said copy surface into contact; and means for fixing said toner particles as a permanent visible image on said copy surface.

2. The system of claim 1 wherein said toner particles are held on said donor surface by forces weaker than the charge attraction afforded by said imaged copy surface.

3. The system of claim 2 wherein said copy member comprises at least one elongate, flexible sheet.

4. The system of claim 3 wherein said copy member, said donor sheet and said insulating liquid are in separate compartments and wherein said applicator means is positioned to apply said liquid to said imaged copy sheet immediately before contact with said donor

sheet.

5. The system of claim 3 wherein both sides of said donor sheet bear said toner particles adherent thereto and wherein said donor sheet is disposed in a cartridge providing access to both sides of said donor sheet.

6. The system of claim 3 wherein said toner particles include thermoplastic binder transferable therewith.

7. The system of claim 3 wherein said toner particles include plastic binder soluble in said layer of electrically insulating liquid.

8. The system of claim 2 wherein said system includes means for providing an external electrical field adjacent said donor surface during said migration to facilitate the same.

9. The system of claim 2 wherein said charge image is an electrostatic charge image and said system includes means for providing an external electrical field adjacent said copy surface for reversal of said charge image on said copy surface.

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