PHOTOELECTROSTATIC COPYING APPARATUS

Robert G. Blancheke, Elk Grove Village, and Loren E. Shiff, Elk Grove Village, III., assignors to Addressograph-Multigraph Corporation, Mount Prospect, Ill., a corporation of Delaware

Filed Feb. 5, 1968, Ser. No. 702,917
Int. Cl. G03g 17/00

U.S. Cl. 355—16

11 Claims

ABSTRACT OF THE DISCLOSURE

A photoelectrostatic duplicating machine which employs a multi-layer belt made up of a first layer of highly insulating material over which is applied a conductive layer followed by the photoconductive material. The conductive layer of the belt, which is aluminum, is exposed along a lateral edge so that a contact rides on the exposed edge connecting the conductive layer to ground potential or alternatively can have a voltage applied to the layer. The rotating belt is thereby continually connected to ground so that the electrostatic charges can leak off along a conductive path upon exposure to electromagnetic radiation. In another embodiment the conductive layer is connected by a metallic plug or strap to a metallic strip on the underside of the insulating layer which makes continual contact with a conductive drive roller which then can be connected to ground or alternatively to a potential source. By means of maintaining such a continuous connection the applicator rod of the developer and the transfer roller at the transfer station operate under conditions in which a potential gradient is applied between the particular roller and the conductive backing of the photoconductive medium.

BACKGROUND OF INVENTION

This invention relates generally to photoelectrostatic copiers and more particularly to the type of copiers employing a photoconductive medium formed into a continuous belt whose construction permits the maintenance of the proper electrical parameters critical to a continuous transfer-type copier. In the known belt-type copiers the photoconductive medium comprises a flexible base support on which is applied a photoconductive layer. The base support to which the photoconductive layer is applied must be suitably conductive in order to provide a path to a reference potential or to ground thereby permitting setting up the proper potential gradient across the photoconductive layer when applying an electrostatic charge, and also to permit a conductive path for the charges to leak off the photoconductive layer after exposure to electromagnetic radiation. When transferring the developed image it is necessary to use an electrode in order to set up a potential gradient which would provide the driving force necessary to move the particles to a suitable receiving sheet. Heretofore known constructions of belt members used thin metal sheets which were flexible or else used a metal drum or cylinder. In both cases the object was to provide a generally circuitous path for the photoconductive layer taking it past a series of processing stations arranged about the periphery of the drum or belt so as to continuously make copies by transferring the powder image to plain paper.

It is desirable to use a base support that is flexible, yet dimensionally stable and is suitably conductive so that it can be utilized in a belt copier.

It is a general object of this invention to provide an improved copying apparatus which utilizes a photoconductive belt construction that is simple, economical, dimensionally stable, and can readily function within the electrical parameters required of photoelectrostatic copiers.

It is another object of this invention to provide an improved copying apparatus employing a photoconductive belt construction in which the base support is a highly insulating polyester film having a thin conductive layer over which is applied the photoconductive layer and connecting members for connecting the conductive layer to a reference potential so that the apparatus may be continuously operated permitting the photoconductive medium to undergo several different processing steps simultaneously.

SUMMARY OF THE INVENTION

The term "reference potential" as used here means a fixed potential including ground but is not necessarily limited to ground potential. While ground potential is often a convenient reference, the reference potential contemplated herein may be a poled potential different from ground or at ground as used in the context of this discussion.

The above and other objects and advantages of the present invention are realized in one embodiment of the invention providing apparatus equipped with a photoconductive medium formed into a continuous belt stretched about a pair of drive rollers and adapted to move in a generally circuitous path past a series of processing stations including charging, exposing, developing and transfer stations where the developed image is transferred to a receiving sheet, usually plain paper. The electrode at the charging station applies an electrostatic charge to the photoconductive layer and the transfer electrode imposes a field across the layer. Optionally, an electrode may be provided at the developer station to impose a field across the photoconductive layer. In all cases the conductive layer must provide a path to a reference potential.

In accordance with the feature of this invention the belt is formed of a tough, dimensionally stable polyester terephthalate film which has been metalized to provide a conductive layer over which is then applied a photoconductive layer. In one embodiment a portion of the metalized layer along the marginal portions of the belt remains uncoated leaving exposed a conductive strip to which is applied a contact member connected to a reference potential. In the present construction it is desirable in certain instances to apply a reference potential other than ground in order to control the amount of charge deposited on the photoconductive layer. Variations in the discharge rate of the photoconductive layer may be controlled by the application of a proper reference potential. Such reference potential is effective to control the developing and transfer steps as well. In the circumstance that the base support is a suitable insulating material, the rest of the apparatus, particularly the drive system, can be made of metal and need not be insulated.

In another embodiment the underside of the polyester film is applied another continuous narrow band of the metalized coating so that the highly insulating film is sandwiched between conductive portions. With one of the drive rollers being of a conductive material a conductive path to the reference potential is provided by interconnecting the conductive layer directly with the narrow conductive band, either directly through the film thickness or by a connecting strap member between the edge portions of the two metalized layers.

In this manner the belt is continuously connected to a reference potential as it cycles past the various electrodes.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention, together with the above and other objects and advantages thereof, will best be understood
from the following detailed description together with the accompanying drawings in which:

FIG. 1 is a schematic representation of a copying apparatus employing one embodiment of the belt construction of this invention;

FIG. 2 is a perspective of another embodiment of the belt construction and the electrical connections;

FIG. 3a is an enlarged fragmentary view of another embodiment shown in perspective;

FIG. 3b is an enlarged, fragmentary view of another embodiment shown in perspective;

FIG. 4 is a cross-section taken along line 4—4 of FIG. 3b.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, there is shown in FIG. 1 the conductive belt identified generally as 20 stretched about a pair of spaced apart drive rollers 22 and 24 causing the belt to move in a circulatory path past the charging station 26, the exposure station 28, developer 30, and the transfer station 32.

The charging station 26 is provided with a thin wire electrode 34 connected to a high voltage supply 36 forming a corona emission source which is partially enclosed in a grounded conductive shield 38.

The exposure station 28 includes a transparent exposure platen 40 on which is placed the original subject 0 to be copied. The original 0 is illuminated by suitable light sources 42 and a reflected image is projected through a lens system 44 producing a pattern of light and shadow on the belt 20. It will be appreciated that, while a projection-type system is shown for exposing the charged belt 20 to a pattern of light and shadow, other imaging techniques may be employed such as contact printing and cathode ray tube exposure of either the full frame or a line-by-line scanning technique which may be transferred over long-distance transmission lines.

The developing station 30 may be equipped with a variety of devices including cascade developers, powder cloud or brush-type developers including magnetic brush-type developers. The preferred type of developer apparatus is a magnetic brush-type shown illustratively in FIG. 1 which includes a trough 46 charged with a supply of developer powder 48 comprised of magnetically attractable carrier particles and electrostatically attractable toner particles. The toner particles may be heat fusible onto the base support or they may be fixed by a pressure-solvent developer. The general construction and operation of magnetic brush developer devices is well known and will not be described in further detail here. The developer in FIG. 1 is shown connected to a DC source 50 for imposing a potential across the belt 20. The technique of imposing a potential is of particular significance when the photconductive belt employs an organic material as the photodecoupling medium. The optional use of an electrode with the magnetic brush-type device will be discussed hereinafter.

At the transfer station 32 the material image that is applied at the developer station is transferred to the plain paper receiving sheet 5 arranged to pass between the belt and the transfer roller electrode 52 aligned in pressure contact against the drive roller 24 so that the belt 20 passes between the rollers 24 and 52. A direct current supply 54 is connected to the conductive core 56 of the transfer roller to apply a potential gradient between the surface of the electrode 52 and the reference potential in the range of 100 volts to 2000 volts.

The belt 20 may be made of a variety of flexible materials such as paper treated to render it conductive. The preferred base support material which is used in the instant invention is a transparent film material which may be selected from a variety of plastics such as cellulose acetate, cellulose triacetate, cellulose acetate butyrate, polyurethane elastomers, fluorocarbon films such as the copolymer of hexafluoropropylene, and tetrafluoroethylene, cellulose propionate, ethyl cellulose, polyamide, polymethyl methacrylate, polyethylene, ethylene vinyl acetate copolymer, polyvinyl fluoride, polypropylene, polyester teraphthalate, polytetrafluoroethylene, polystyrene, polyvinyl alcohol, polyvinyl chloride, vinylidene chloride, vinyl chloride copolymer, polycarbonate, and rubber hydrochloride.

The preferred film material is the polyester teraphthalate film sold under the trademark "Mylar" which offers the greatest dimensional stability. Since the conductivity of the polyester film is 10^-12 mhos per centimeter, it is unsuitable as a base support on which the photconductive material may be directly applied since it is critical that the base support have a conductivity in the range of from 10^-10 mhos per centimeter to the conductivity of metal.

The conductive layer is achieved by applying a thin uniform metallized layer such as aluminum or copper by vapor deposition ranging in thickness from 0.05 mil to 0.50 mil. Other conductive treatments may be applied which involve a metal-containing semi-conductive compound that is dispersed in a film-forming binder and the semi-conductor and binder are then both dissolved to form a coating solution. Since most semi-conductors are not readily soluble in organic solvents they are combined with other compounds to form solubilizing complexes. The semi-conductive materials that are usable are cupric and silver halides, halides of bismuth, gold, indium, iridium, lead, nickel, palladium, rhenium, tin, tellurium, and tungsten. The semiconductor solvents are solubilized by complexing and then being dispersed in a binder such as polyvinyl acetate and the mixture dissolved in cyclohexanone or other suitable ketone. Thickness of the conductive layer may range from 0.05 mil to 0.50 mil on a dry basis.

Referring to FIG. 2 there is shown a base support of Mylar film formed into a continuous belt 66 stretched around a pair of spaced apart drive rollers 68 and 70. The belt has been applied a conductive layer 72 such as aluminum, copper, or a metal halide in a binder. Over the conductive layer is next applied a photocative layer 74 that can be zinc oxide dispersed in a resin binder or an organic photoconductive polymeric film such as polyvinyl carbazole. The photoconductive layer 74 is applied over the support leaving uncoated marginal strips 76a and 76b along either side of the belt and a non-conductive area for the contacting member 78 to make electrical contact with the conductive layer 72.

It will be appreciated that the conductive layer is continuously maintained connected to a source 80 that provides reference potential relative to the various electrodes operating against the photoconductive layer 74 while the belt is being moved in its predetermined path. The source 80 includes a switch 82 that connects to ground 83 or to a DC supply source 84.

Referring to FIGS. 3a and 3b there is shown another embodiment of a belt construction that permits continuously connecting the belt to a reference potential. The polyester film 90 has applied a conductive layer 92 such as a metallized coating over which has been applied a photoconductive layer 94. A conductive strip is applied underneath the film 90 which runs along the marginal edge of the belt and makes continuous electrical contact with one of the conductive drive rollers, such as 22, shown in FIG. 1.

The conductive layer 92 and the conductive strip 96 are interconnected by a conductive strap 98 (FIG. 3a) that bridges the edge of the belt making electrical connection with the respective exposed edge portions of the layer 92 and the strip 96. As the strip 96 rides continuously in surface contact with the conductive roller 23 it is continuously connected to the source of reference potential, shown generally as 80.

FIGS. 3b and 4 represent still another embodiment by which the conductive layer 92 and the conductive strip 96
are placed in electrical contact through the connecting element 100 which extends through the film 90.

In the circumstance that the photoconductive layer is an organic photoconductive material, it has been found advantageous to apply a potential at the developer concurrent with the application of the developer powder to the image-bearing surface. The creation of a potential gradient between the organic photoconductive layer and the developer applicator has particular significance when using organic photoconductors since it tends to give an apparent increase in the photo response of what is otherwise a slow responding photoelectrostatic medium. A detailed description of such a photoelectrostatic copying device appears in the copending application Ser. No. 675,463 of Evan S. Baltazzi et al. filed Oct. 16, 1967 and assigned to the same assignee as the instant invention. It is therefore particularly important in such an application to continuously maintain a conductive layer at a reference potential in order to obtain a continuous and properly developed image.

The various embodiments hereinabove described give rise to a belt-type copier that is unique in its performance since it permits the various processing steps to take place concurrently as the belt moves in its generally circular path past the various processing stations while maintaining the conductive layer of the belt at a reference potential and, hence, functioning as a reference electrode. Referring again to FIGS. 1 and 2, it will be seen that at the charging station 26 the corona electrode 24 operating in conjunction with the belt 20 as a reference electrode with the conductive layer connected to the reference potential source 80 a conductive path is provided through the ionized atmosphere to the belt whereby electrostatic charges are deposited thereon.

It will be appreciated that concurrent with the application of a charge the photoconductive layer is exposed to a pattern of light and shadow and in the exposed portions of the photoconductive layer the charge is dissipated through the conductive layer to the reference electrode. Similarly, the transfer electrode 52 operates in conjunction with the belt 20 as the reference electrode to set up a potential gradient across the photoconductive layer 74.

In the circumstance where the layer 74 (FIG. 2) or 94 (FIGS. 3a and 3b) is an organic photoconductor, it may be desirable to utilize an electrode at the developing station 30, and here again, the photoconductive layer 72 (FIG. 2) and 92 (FIGS. 3a and 3b) act as a reference electrode in order to apply a potential gradient across the photoconductive layer so that the exposed areas are at a potential between 0 and within 100 volts of the charged image portions. The belt construction of this invention gives rise to an exceedingly simple photoelectrostatic copier made possible by establishing the belt as a reference electrode.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. In a photoelectrostatic copying apparatus for making copies by transfer to a copy sheet comprising:
   a photoconductive medium comprising a photoconductive layer applied to an insulating base support formed into a web, said layer and base support being separated by a continuous conductive layer and said insulating base support insulating said conductive layer from making direct contact with a drive means,
   a supply of copy sheet material,
   said drive means moves said photoconductive medium in a predetermined path,
   charging electrode means for applying an electrostatic charge to said photoconductive layer,
   developer means for applying electrostatically attractable powder to said photoconductive layer and,
   transfer electrode means for transferring a developed image to said copy sheet material,
   means connecting said conductive layer to a reference potential while said web is moving in said predetermined path to establish a potential gradient between said conductive layer and said transfer electrode and charging electrode whereby said photoconductive layer receives a sensitizing charge and the developed image is provided with the driving force to transfer to the copy sheet.

2. The apparatus as claimed in claim 1 wherein said connecting means further comprises an exposed portion of said conductive layer equipped with a contact member making electrical contact with said exposed portion.

3. The developer means of claim 1 further comprising a developer electrode and establishing a potential gradient between said conductive layer and said developer means.

4. The photoelectrostatic copying apparatus of claim 1, wherein said base support is a polyester terephthalate film.

5. The photoelectrostatic copying apparatus of claim 1, wherein said conductive layer is a metallic coating.

6. The photoelectrostatic copying apparatus of claim 1, wherein said conductive layer is a metal halide.

7. In a photoelectrostatic copying apparatus for making copies by transfer of a developed image to a copy sheet comprising:
   a photoconductive medium comprising a photoconductive layer applied to an insulating base support formed into a web, said layer and base support being separated by a continuous conducting layer,
   a supply of copy sheet material, drive means comprising at least a pair of roller members for moving said photoconductive medium in a predetermined path, one of said rollers being conductive and held at a reference potential, charging electrode means for applying an electrostatic charge to said layer, developer electrode means for applying electrostatically attractable powder to said layer, transfer electrode means for transferring said developed image to said copy sheet material, connecting means for connecting said conductive layer to said conductive roller member while said web is moving in said predetermined path to establish a potential gradient between each of said electrodes and said conductive layer whereby said layer receives a sensitizing charge and is developed with a material image that is transferred to the copy sheet.

8. The apparatus as claimed in claim 7 wherein said connecting means further comprises a conductive band on the side of the support opposite said conductive layer and means interconnecting said band with said conductive layer to provide a conductive path between said conductive layer with said reference potential.

9. The apparatus as claimed in claim 8 wherein said interconnecting means extends through the support to the conductive band.

10. The apparatus as claimed in claim 8 wherein said interconnecting means is a strap member connecting the edge portions of said conducting layer and said conductive band.

11. In a photoelectrostatic copying apparatus for making copies by transfer to a copy sheet comprising:
   a photoconductive medium comprising a photoconductive layer applied to an insulating base support formed into a web, said layer and base supports being separated by a continuous conductive layer and said insulating base support insulating said conductive layer for making direct contact with said drive means,
   a supply of copy sheet material,
   drive means for moving said photoconductive medium in a predetermined path,
charging electrode means for applying an electrostatic charge to said photoconductive layer,
developer means for applying electrostatically attractable powder to said photoconductive layer,
means connecting said conductive layer to a reference potential while said web is moving in said predetermined path to establish a potential gradient between said conductive layer and said developer means, and between said conductive layer and said charging electrode whereby said photoconductive layer receives a sensitizing charge.