Jan. 1, 1974 W. C. YORK 3,783,021

CONDUCTING LACQUERS FOR ELECTROPHOTOGRAPHIC ELEMENTS

Original Filed March 3, 1969

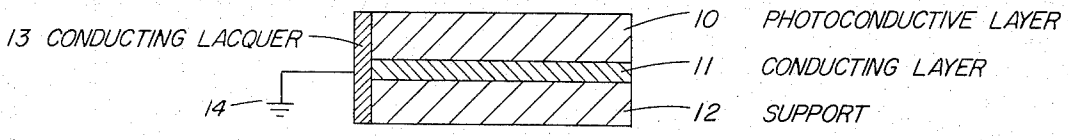


FIG. 1

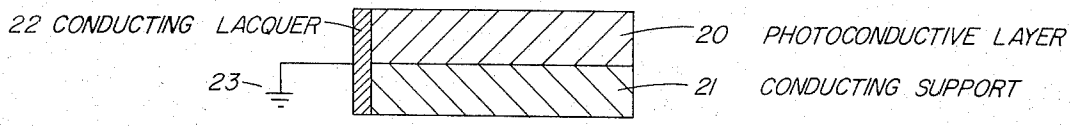


FIG. 2

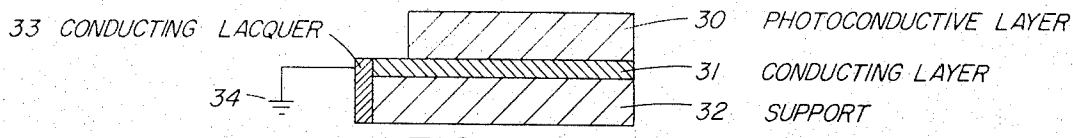


FIG. 3

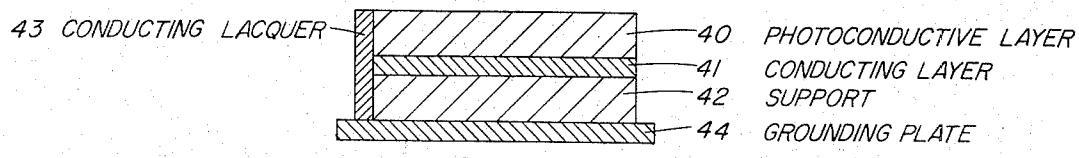


FIG. 4

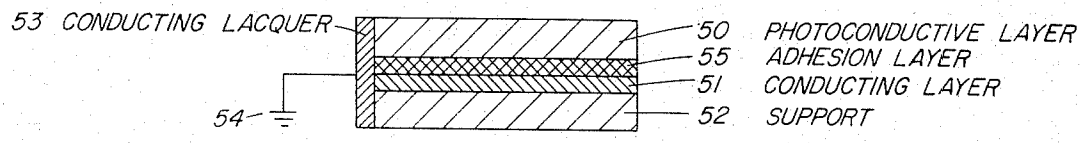
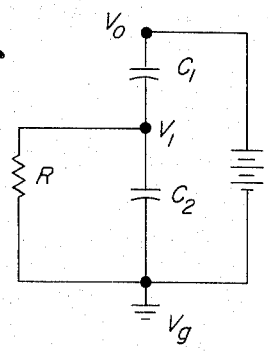


FIG. 5

FIG. 6



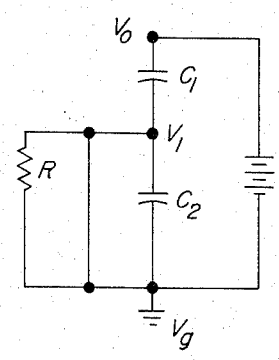


FIG. 7

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3,783,021

CONDUCTING LACQUERS FOR ELECTROPHOTOGRAPHIC ELEMENTS

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Original application Mar. 3, 1969, Ser. No. 803,708, now Patent No. 3,639,121, dated Feb. 1, 1972. Divided and this application Mar. 15, 1971, Ser. No. 124,593
Int. Cl. B44d 1/18
U.S. Cl. 117—212 16 Claims

ABSTRACT OF THE DISCLOSURE

Novel electrically conducting lacquers are coated on the edge of electrophotographic elements to maintain conducting layers at ground potential during charging by providing an electrical path from the conducting layer to a grounding means. Typical conducting lacquers include mixtures of electrically conducting carbon black and graphite in a polymeric resin binder.

This application is a division of U.S. patent application Ser. No. 803,708, Novel Conducting Lacquers for Electrographic Elements, filed Mar. 3, 1969, now U.S. Pat. 3,639,121, issued Feb. 1, 1972.

The invention relates to electrophotography, and in particular to electrophotographic elements, processes for making and using these elements and to electrically conducting compositions.

The process of xerography employs an electrophotographic element usually having a support layer, an electrically conducting layer overlying the support layer and a photoconductive layer overlying the electrically conducting layer. The photoconductive layer contains a normally insulating material whose electrical resistance varies with the amount of incident electromagnetic radiation to receives during an imagewise exposure. The support layer can be any one of a wide variety of materials, but illustrative useful supports are paper supports and polymeric supports of film-forming resins such as poly(ethyleneterephthalate) and cellulose acetate. The electrically conducting layer can be a separate layer, a part of the support layer or the support layer. There are many types of conducting layers, the most common being listed below:

(a) metallic laminates such as an aluminum-paper laminate,
(b) metal plates e.g., aluminum, copper, zinc, brass, etc.,
(c) metal foils such as aluminum foil, zinc foil, etc.,
(d) vapor deposited metal layers such as silver, aluminum, nickel, etc.,
(e) semiconductors dispersed in resins such as poly(ethylene terephthalate) as described in U.S. Pat. 3,245,833.
(f) electrically conducting salts such as described in U.S. Pats. 3,007,801 and 3,267,807.

Conducting layers (d), (e) and (f) can be transparent and can be employed where transparent elements are required. such as in processes where the element is to be exposed from the back rather than the front or where the electrophotographic element is to be used as a transparency.

The described electrophotographic element is first given a uniform surface charge, generally in the dark after a suitable period of dark adaptation. It is then exposed to a pattern of activating radiation which has the effect of differentially reducing the potential of this surface charge in accordance with the relative energy contained in various parts of the radiation pattern. The differential surface charge or electrostatic latent image remaining on the electrophotographic element is then made visible by contacting the surface with a suitable electroscopic marking

material. Such marking material or toner, whether contained in an insulating liquid or on a dry carrier, can be deposited on the exposed surface in accordance with either the charge pattern, or in the absence of charge pattern, as desired. Deposited marking material can then be either permanently fixed to the surface of the sensitive element by known means such as heat, pressure, solvent vapor, or the like, or transferred to a second element to which it can similarly be fixed. Likewise, the electrostatic latent image can be transferred to a second element and developed there.

The function of the electrically conducting layer in electrophotographic elements is to create a highly conducting reference plane which ideally is held at or near ground potential. During charging of the photoconductive layer with a corona charger, the potential of the conducting layer has a tendency to build up with respect to ground if it is not grounded. Typically, if the surface of the photoconductive layer is charged to 600 volts, the potential of an ungrounded conducting layer (of type (d), (e) or (f)) is about 450 volts or more. Thus, the differential between the conducting layer and the surface of the photoconductive layer is a maximum of 150 volts. In this situation, when the charging step is completed and the surface of the element is exposed to a pattern of actinic radiation, the photoconductive layer becomes conducting in the light struck regions and the potential of the surface of the photoconductive layer in these areas approaches that of the conducting layer. Because of the small difference in potentials between areas struck by light and those not struck, little or no developable latent image is produced.

Similarly poor results are obtained when the conducting layer is inefficiently grounded. Conventional grounding methods, such as metal strips, rollers, etc. placed in electrical contact with the support, are somewhat ineffective. Direct electrical contact with the conducting layer for grounding purposes is very difficult and inefficient since it is extremely thin, e.g., 0.001 inch or less and creates wear problems if the element is charged while moving. Ideally, during charging of the photoconductive layer, the electrically conducting layer should be held at ground potential to insure that the maximum charge be impressed and stored in the photoconductive layer.

It is therefore, an object of this invention to provide a novel electrically conducting lacquer useful with an electrophotographic element.

It is a further object of this invention to provide novel electrically conducting compositions for edge coating an electrophotographic element.

It is another object of this invention to provide novel electrophotographic elements having electrically conducting layers which are readily grounded.

It is also an object of this invention to provide a process for preparing these novel electrophotographic elements.

It is a further object to provide a process for using the novel electrophotographic elements of this invention.

These and other objects of the invention are accomplished with electrophotographic elements having a support layer, an electrically conducting layer overlying the support layer, a photoconductive layer overlying the electrically conducting layer and a separate conducting lacquer electrically connecting the electrically conducting layer to a grounding means. The separate conducting lacquer is a dispersion of a conducting material in a polymeric binder. The conducting layer is efficiently maintained at ground potential during charging of the photoconductive layer by connecting the conducting laquer to ground. The conducting lacquer functions to provide an electrical path from the conducting layer to ground. It is to be understood that the term "ground" as used herein

is relative and merely represents a relative potential to which other positive or negative potentials are referred. For example, the term +600 volts is to be interpreted as meaning 600 volts above a reference ground potential. For convenience, ground potential as used hereinafter is arbitrarily assigned a value of zero volts.

FIGS. 1–5 illustrate various embodiments of the invention. These drawings show a series of electrophotographic elements having incorporated on an edge thereof the conductive lacquer of the present invention.

FIGS. 6–7 of the drawings are schematic diagrams of equivalent electrical circuits for various electrophotographic elements. FIG. 6 illustrates an equivalent circuit for a conventional prior art electrophotographic element without a conducting lacquer. FIG. 7 illustrates an equivalent circuit for an electrophotographic element of the present invention, i.e. an element such as that of FIG. 1, which includes a conducting lacquer.

FIGS. 1–7 are described hereinafter in greater detail.

The electrically conducting lacquer employed in this invention has adhesion properties such that when it is coated on an insulating layer or a conducting support, a firm bond is formed between it and the material to which it is coated. Additionally, the conducting lacquer is inert to aliphatic solvents. Thus, if it is desirable to clean the element with such solvents, the conducting lacquer will not be adversely effected. Also, aliphatic carrier liquids of the type used in xerographic liquid developers do not effect the lacquer. Another advantage of the conducting lacquer of this invention is that it is resistant to abrasion. In a grounding system such as that described in the following examples, wherein the grounding means is a metal strip or a metal roller, that portion of the conducting lacquer which is exposed on the edge of the element is not worn away by the metal contact produced while the element is in motion. Because of the low per-square surface resistivity of the conducting lacquer, the conducting layer is effectively held at ground potential during charging for both stationary and moving elements.

The term "surface resistivity" conventionally refers to measurement of electrical leakage across an insulating surface. In the present specification, however, the term is used with reference to resistance of conducting film forming the conducting means of this invention that apparently behave as conductors transmitting currents through the body of film. Resistivity is the usually accepted measurement for the conductive property of conducting the semiconducting materials. However, in the case of thin conductive coatings, measurement of the conductive property in terms of surface resistivity provides a value that is useful in practice and involves a direct method of measurement. It should be pointed out that the dimensional units for specific resistance (ohm-cm.) and the unit for surface resisitivity (ohms per square) as used herein are not equivalent and the respective measurements should not be confused. For an electrically conducting material whose electrical behavior is ohmic, the calculated resistance per square of a film of such material would be the specific resistance of the material divided by the film thickness, but this calculated resistance for a given material will not always coincide with measured surface resistivity. Surface resistivity (ohms per square) of the coating is measured by placing a set of 1-cm. long stainless steel electrodes along opposite sides of a 1-cm. square sample cut from the coated surface. Resistance is measured with an RCA Senior Volt Ohmyst. The resistivity of the conducting lacquers of this invention is generally less than 10^4 ohms per square.

The electrically conducting material, which is dispersed in a polymeric binder to form the conducting lacquer, can be any finely divided particulate material having good electrical conducting properties. Typical conducting materials include carbon blacks, graphite, nickel, silver, etc. all of which are particulate and have good electrical conducting properties. The particle size of these conducting materials can vary depending on the particular material used but generally ranges from 0.001μ to 10μ. It is to be understood that the optimum particle size is readily determinable by methods employed by those skilled in the art. The polymeric binder used in the lacquer can be any resinous material which is soluble in ordinary solvents (other than unsubstituted aliphatic solvents) and which is capable of forming films when coated. Materials of this type include styrene-butadiene copolymers; silicone resins; styrene-alkyl resins; silicone-alkyd resins; soya-alkyd resins; poly(vinyl chloride); poly(vinylidene chloride); vinylidene chloride-acrylonitrile copolymers; poly(vinyl acetate); vinyl acetate-vinyl chloride copolymers; poly(vinyl acetals), such as poly(vinyl butyral); polyacrylic and methacrylic esters, such as poly(methylmethacrylate), poly(n-butylmethacrylate), poly(isobutyl methacrylate), etc.; polystyrene; nitrated polystyrene; polymethylstyrene; polyesters, such as poly(ethylene terephthalate); phenolformaldehyde resins; polyamides; polycarbonates; polythiocarbonates; poly(ethyleneglycol-co-bishydroxyethoxyphenyl propane terephthalate); copolymers of vinyl haloarylates and vinyl acetate such as poly(vinyl-m-bromobenzoate-covinyl-acetate); polyolefins such as polyethylene, polypropylene; etc. Methods of making resins of this type have been described in the prior art, for example, styrene-alkyd resins can be prepared according to the method described in U.S. Pats. 2,361,019 and 2,258,423. Suitable resins of the type contemplated for use in the conducting lacquers of the invention are sold under such trade names as Vitel PE–101, Cymac, Saran F–220, Lexan 105 and Lexan 145. A particularly suitable binder from the standpoint of adhesion comprises a copolyester made by reacting dimethyl terephthalate with a 50:50 mole ratio of 2-m-butyl-2-ethylpropane-1,3-diol and ethylene glycol with 2.5 mole percent of the dimethyl terephthalate replaced with pyromellitic dianhydride.

In preparing the electrically conducting compositions of this invention, the conducting material and binder are admixed with a solvent for the binder. The resultant compositions are readily coatable on the edge of an electrophotographic element so that they contact the conducting layer in the element and subsequently, on drying, can be contacted by a separate grounding means. Solvents of choice for preparing the conducting compositions of the present invention can include a number of organic materials such as aromatic solvents e.g., benzene, xylene, toluene, etc., ketones e.g., acetone, 2-butanone, etc., halogenated aliphatic hydrocarbons e.g., 1,1,1-trichloroethane, methylene chloride, ethylene chloride etc., ethers e.g., tetrahydrofuran, diethylether, etc. or mixtures of these solvents. The amount of conducting material or pigment used in preparing the compositions ranges from about 0.1 to about 100.0 parts by weight for each part by weight of polymeric binder and preferably from 0.5 to 7.5 parts of pigment for each part by weight of binder. The solids (i.e., conducting material and binder) generally from at least 0.1% of the coating composition and preferably at least 1% of the coating composition. An especially useful conducting composition contains a mixture of graphite and a conducting carbon black such as Dixon Graphite No. 635 (a lubricating graphite sold by the Joseph Dixon Crucible Company) and Vulcan XC72 (a conducting oil furnace black sold by the Cabot Corporation) dispersed in a polymeric binder, the ratio of total pigment to binder being the same as those ratios set forth above. The ratio of graphite to conducting carbon black ranges from 0.5 to 2.0 parts by weight of graphite for each part by weight of carbon black.

The conducting compositions, prepared in the manner described, are coated on the edge of the photoconductive element by any suitable method such as with a brush,

spraying, etc. The wet thickness of these coatings can vary widely but generally ranges from about 0.001 inch to about 0.01 inch. After the compositions are coated, they are dried at either room temperature or slightly elevated temperatures (20° C. to about 50° C.). A particular advantage obtained in using the novel conducting compositions of this invention resides in the fact that they penetrate slightly into the element so that exceptionally good electrical contact is established with the conducing layer.

The electrophotographic elements using the novel conducting lacquer of this invention generally contain several layers as described previously. Overlying a support layer, which is usually a transparent insulator, is a conducting layer. This layer may be coated on the support layer, evaporated onto the support, or imbibed into the support layer. However, it is to be understood that the terms "support layer," "conducting support" and "conducting layer overlying a support layer" include those instances where the conducting layer is coated on the support as well as where the conducting layer is imbibed into or evaporated onto the support. The materials useful in the support layer and conducting layer have been described above.

A photoconductive layer containing an organic photoconductor in a polymeric binder overlies the conducting layer. A sensitizer for the photoconductor may optionally be present to change the spectral sensitivity or electrophotosensitivity of the element. Any organic photoconductor is useful in the electrophotographic elements of this invention. Typical ones are described in copending application Ser. No. 772,370, filed Oct. 31, 1968 in the name of Stewart H. Merrill.

Sensitizing compounds useful in the photoconductive layers described herein can be selected from a wide variety of materials, including such materials as pyryliums, including thiapyrylium and selenapyrylium dye salts, disclosed in Van Allan et al. U.S. Pat. 3,250,615; fluorenes, such as 7,12-dioxo-13-dibenzo(a,h) fluorene, 5,10-dioxo-4a,11-diazabenzo(b)fluorene, 3,13 - dioxo-7-oxadibenzo(b,g)fluorene, and the like; aromatic nitro compounds of the kinds described in U.S. Pat. 2,610,120; anthrones like those disclosed in U.S. Pat. 2,670,284; quinones, U.S. Pat. 2,670,286; benzophenones U.S. Pat. 2,670,287; thiazoles U.S. Pat. 2,732,301; mineral acids; carboxylic acids, such as maleic acid, dichloroacetic acid, and salicyclic acid; sulfonic and phosphoric acids; and various dyes, such as cyanine (including carbocyanine), mercocyanine, diarylmethane, thiazine, azine, oxazine, xanthene, phthalein, acridine, azo, anthraquinone dyes and the like and mixtures thereof. The sensitizing dyes preferred for use with this invention are selected from pyrylium, selenapyrylium and thiapyrylium salts, and cyanines, including carbocyanine dyes.

Where a sensitizing compound is employed with the binder and organic photoconductor to form a sensitized electrophotographic element, it is suitable to mix an amount of the sensitizing compound with the coating composition so that, after thorough mixing, the sensitizing compound is uniformly distributed in the coated element. Other methods of incorporating the sensitizer or the effect of the sensitizer may, however, be employed consistent with the practice of this invention. In preparing the photoconductive layers, no sensitizing compound is required to give photoconductivity in the layers which contain the photoconducting substances, therefore, no sensitizer is required in a particular photoconductive layer. However, since relatively minor amounts of sensitizing compound give substantial improvement in speed in such layers, the sensitizer is preferred. The amount of sensitizer that can be added to a photoconductor-incorporating layer to give effective increases in speed can vary widely. The optimum concentration in any given case will vary with the specific photoconductor and sensitizing compound used. In general, substantial speed gains can be obtained where an appropriate sensitizer is added in a concentration range from about 0.0001 to about 30 percent by weight based on the weight of the film-forming coating composition. Normally, a sensitizer is added to the coating composition in an amount by weight from about 0.005 to about 5.0 percent by weight of the total coating composition.

Solvents useful for preparing the photoconductive coating compositions include a wide variety of organic solvents for the components of the coating composition. For example, benzene; toluene; acetone; 2-butanone; chlorinated hydrocarbons such as methylene chloride; ethylene chloride; and the like; ethers, such as tetrahydrofuran and the like, or mixtures of such solvents can advantageously be employed in the practice of this invention.

In preparing the coating compositions utilizing the materials disclosed herein useful results are obtained where the photoconductive substance is present in an amount equal to at least about 1 weight percent of the coating composition. The upper limit in the amount of photoconductive material present can be widely varied in accordance with usual practice. It is normally required that the photoconductive material be present in an amount ranging from about 1 weight percent of the coating composition to about 99 weight percent of the coating composition. A preferred weight range for the photoconductive material in the coating composition is from about 10 weight percent to about 60 weight percent.

Coating thicknesses of the photoconductive composition on a support can vary widely. Normally, a wet coating thickness in the range of about 0.001 inch to about 0.01 inch is useful in the practice of the invention. A preferred range of coating thickness is from about 0.002 inch to about 0.006 inch before drying although such thicknesses can vary widely depending on the particular application desired for the electrophotographic element.

The electrophotographic elements containing the electrically conducting lacquers of this invention are useful in the xerographic process. In this process, the electrophotographic element, while held in the dark, is given a blanket electrostatic charge by placing it under a corona discharge to give a uniform charge to the surface of the photoconductive layer. During this charging step, the electrically conducting layer is maintained at ground potential by electrically connecting the edge of the photoconductive element containing the conducting lacquer to ground. In the absence of grounding in this manner, the difference in potential between the photoconductive layer and the conducting layer is not large enough to produce a quality developable latent image. The charge is retained on the surface of the photoconductive layer because of the substantial dark insulating property of the layer, i.e., the low conductivity of the layer in the dark. The charging operation can be performed while the element is stationary or in motion. It is in the latter case wherein the benefits of the instant invention are particularly noticeable. When using the conducting lacquer of this invention with an element that is charged while in motion, the potential of the conducting layer is maintained at ground as efficiently as when the element is charged while stationary. In other words, the conducting lacquer permits exceptionally good contact to be made between the conducting layer and the grounding means while the element is in motion. The electrostatic charge formed on the surface of the photoconductive layer is then selectively dissipated from the surface of the layer by imagewise exposure to light by means of a conventional exposure operation such as for example, by a contact-printing technique, or by lens projection of an image, or reflex or bireflex techniques and the like, to thereby form a latent electrostatic image in the photoconductive layer. Exposing the surface in this manner forms a pattern of electrostatic charge by virtue of the fact that light energy striking the photoconductor causes the electrostatic charge in the light struck areas to be conducted away from the surface in proportion to the intensity of the illumination in a particular area.

The charge pattern produced by exposure is then developed or transferred to another surface and developed there, i.e., either the charge or uncharged areas are rendered visible, by treatment with a medium comprising electrostatically responsive particles having optical density. The developing electrostatically responsive particles can be in the form of a dust, or powder and generally comprise a pigment in a resinous carrier called a toner. A preferred method of applying such a toner to a latent electrostatic image for solid area development is by the use of a magnetic brush. Methods of forming and using a magnetic brush toner applicator are described in the following U.S. patents: 2,786,439; 2,786,440; 2,786,441; 2,811,465; 2,874,063; 2,984,163; 3,040,704; 3,117,884; and reissue Re. 25,779. Liquid development of the latent electrostatic image may also be used. In liquid development the developing particles are carried to the image bearing surface in an electrically insulating liquid carrier. Methods of development of this type are widely known and have been described in the patent literature, for example, U.S. Pat. 2,297,691 and in Australian Pat. 212,315. In dry developing processes the most widely used method of obtaining a permanent record is achieved by selecting a developing particle which has as one of its components a low-melting resin. Heating the powder image then causes the resin to melt or fuse into or on the element. The powder is, therefore, caused to adhere permanently to the surface of the photoconductive layer. In other cases, a transfer of the charge image or powder image formed on the photoconductive layer can be made to a second support such as paper which would then become the final print after developing and fusing or fusing respectively. Techniques of the type indicated are well known in the art and have been described in a number of U.S. and foreign patents, such as U.S. Pat. 2,297,691 and 2,551,582 and in "RCA Review," vol. 15. It is frequently necessary during development to maintain the electrically conducting layer at a given potential in order to obtian a clean background. The conducting lacquer of this invention eables one to easily maintain the potential of the electrically conducting layer at a given potential.

FIG. 1 represents an electrophotographic element having support layer **12** and electrically conducting layer **11**. The electrically conducting layer overlies the support layer. Overlying the conducting layer is photoconductive layer **10** which generally contains a photoconductor, a polymeric binder and optionally an optical sensitizer for the photoconductor. Coated on the edge of the element is electrically conducting lacquer **13** comprising a conducting material such as graphite dispersed in a polymeric binder. The electrically conducting lacquer is also in electrical contact with grounding means **14**. The electrically conducting layer **11** is maintained at ground potential during the charging process by electrically conducting lacquer **13** and grounding means **14**. After the charging step is completed, there is a uniform surface charge on the surface of the photoconductive layer and the electrically conducting layer is at ground potential. Thus, there is a potential difference between the photoconductive layer and the electrically conducting layer after charging is completed.

FIG. 2 is similar to FIG. 1 except that the conducting layer and support layer are combined to form electrically conducting support layer **21**. A typical layer of this type is formed by imbibing a conducting salt into the support layer or by using as a support layer a material which is itself conductive. Photoconductive layer **20**, conducting lacquer **22** and grounding means **23** are the same as described in FIG. 1.

FIG. 3 is the same as FIG. 1 except photoconductive layer **30** is set-off so that conducting lacquer **33** does not contact it. Electrically conducting layer **31**, support layer **32** and grounding means **34** are the same as described in FIG. 1. FIG. 4 shows the use of metal plate **44** as the electrically grounding means. Conducting lacqeur **43** is in contact with both electrically conducting layer **41** and grounding plate **44**. The grounding plate can be made of any suitable material, stainless steel being one of the preferred materials. Photoconductive layer **40** and support layer **42** are the same as described in FIG. 1.

Frequently, photoconductive layer **50** does not adhere readily to electrically conducting layer **51**. Adhesion layer **55** is applied between these two surfaces to improve the adhesion. This layer comprises any material which has good adhesive properties yet does not interfere with the electrical properties of either photoconductive layer **50** or conducting layer **51**. An element having this configuration is shown in FIG. 5. Conducting lacquer **53** provides an electrical connection between the electrically conducting layer and grounding means **54**. The support layer is **52**.

FIG. 6 shows an equivalent circuit for a conventional prior art element, i.e., an element similar to FIG. 1 but without conducting lacquer **13**. The photoconductive layer corresponds to capacitor C_1, the support layer corresponds to capacitor C_2 and the conducting layer corresponds to the plate common to both capacitors. The ground is in electrical contact with C_2. The resistance of the support layer is shown as R. Typically, the resistance of the support varies depending on the material used, e.g., a clear insulating support such as poly(etyhleneterephthalate) has a linear resistance in excess of 10^{12} ohms whereas paper has a linear resistance of less than 10^{10} ohms. Likewise, the capacitance of the photoconductive layer (C_1) and support layer (C_2) is depedent upon the thicknesses and dielectric constants of the respective materials. Usually, the thickness of the photoconductive layer is about 10 microns, while that of the insulating support layer is about 5 mils. As a result, C_1 generally has a larger capacitance than C_2. When a voltage is applied across the element between V_0 and V_g, the voltage drop across each of the two capacitors in series is inversely proportional to the respective capacitances. For example, if the applied voltage is 600 volts, typically the drop across C_1 would be 150 volts and the drop across C_2 would be 450 volts. The voltage differential between the photoconductive layer and the conducting layer, being only 150 volts, is insufficient for the formation of a quality latent image upon exposure.

FIG. 7 shows an equivalent circuit for FIG. 1 including the novel conducting lacquer of this invention. The photoconductive layer corresponds to capacitor C_1, the support layer corresponds to capacitor C_2 and the conducting layer corresponds to the plate common to both capacitors. The resistance of the support layer is shown as R. Both R and C_2 are shorted by a line that connects V_1 directly to ground. This line corresponds to the conducting lacquer and functions in the same manner. Comparing FIG. 6 with FIG. 7, it is seen that the only difference is the shorting connection or conducting lacquer. Hence, when a voltage is applied across the element, between V_0 and V_g, the entire voltage drop occurs across C_1 since C_2 and R have been shorted. For example, if the applied potential is 600 volts, the drop across C_1 would be 600 volts. The voltage differential of 600 volts between the photoconductive layer and the conducting layer is sufficient for the formation of a good latent image. In the absence of the conducting lacquer, as explained previously, the differential may be only 150 volts at the most, depending on the capacitance and resistance of the support and conducting layer.

The conducting compositions of the present invention can be used with electrophotographic elements having many structural variations. For example, the photoconductive layer composition can be coated in the form of single layers or multiple layers on a suitable opaque or transparent conducting support. Likewise, the layers can be contiguous or spaced having layers of insulating material or other photoconductive material between layers or overcoated or interposed between the photoconductive

layer or sensitizing layer and the conducting layer. Configurations differing from those contained in the examples and drawings can be useful or even preferred for the same or different application for the electrophotographic element. In all configurations, it is necessary, in order to achieve the advantages of this invention, to establish electrical contact between the grounding means and the conducting layer by using the conducting lacquer described above.

The following examples are included for a further understanding of the invention.

EXAMPLE I

1.4 grams of poly(4,4'-isopropylidenebisphenoxy-ethyl-co-ethylene terephthalate) binder containing 0.5 gram of 4,4'-benzylidene - bis(N,N-diethyl-m-toluidine) photoconductor and .04 gram of 2,4-(4-ethoxyphenyl)-6-(4-n-amyloxystyryl) pyrylium fluoroborate sensitizer are dissolved in 15.6 grams of methylene chloride by stirring the solids in the solvent for one hour at room temperature. The resulting solution is hand coated at a wet coating thickness of 0.004 inch on a conducting layer comprising the sodium salt of a carboxyester lactone, such as described in U.S. 3,120,028, which in turn is coated on a cellulose acetate film base. The coating block is maintained at a temperature of 90° F. After drying, the edge of the electrophotographic element is coated at a wet thickness of about 0.005 inch with a conducting composition containing the following:

	G.
Graphite (Dixon #635)	10
Binder (same as Example IV)	2
Amine C (Geigy Chemical Corp.)	2
Methylene chloride	178

This composition is prepared by ball-milling the above formulation for 16 hours with ⅛-inch stainless steel balls. After the conducting composition is dried for 1 hour at room temperature to form the electrically conducting lacquer, the element is charged under a positive corona source until the surface potential, as measured by an electrometer probe, reaches about 600 volts. Charging is accomplished by passing the corona over the surface of the element while it is held in a stationary position. In the charging process, the conducting lacquer holds the electrically conducting layer at ground potential by providing an electrical path from the electrically conducting layer to the grounding means. In this case, the grounding means is a copper strip which is in electrical contact with the conducting lacquer. The photoconductive layer is then covered with a transparent sheet bearing a pattern of opaque and light transmitting areas and exposed to the radiation from an incandescent lamp with an illumination intensity of about 75 meter-candles for 12 seconds. The resulting electrostatic latent image is developed in the usual manner by cascading over the surface of the layer a mixture of negatively charged thermoplastic toner particles and glass beads. A good reproduction of the pattern results. When the conducting lacquer of this invention is omitted, the reproduction has poor contrast and is generally of inferior quality. This result is due to the ineffective charging which results without the lacquer.

EXAMPLE II

Example I is repeated except that the surface of the element is charged while in motion at 30 feet per minute. In this instance, the corona charger is stationary. A good reproduction of the pattern is again obtained. When the conducting lacquer is omitted, no image is obtainable.

EXAMPLE III

Example I is again repeated except that the surface of the element is charged while in motion at 30 feet per minute and the corona charger is stationary. In this case, the grounding means is a metal roller which is in electrical contact with the conducting lacquer. Again a good reproduction is obtained.

As described previously, a particularly useful conducting lacquer comprises a mixture of graphite and conducting carbon black such as Vulcan XC72R (Cabot Corp.) dispersed in a resinous polymeric binder. The electrical resistivity of the coated material is extremely low. Also, the addition to these compositions of a conducting material such as silver or nickel lowers the electrical resistivity even farther. The following example illustrates this feature.

EXAMPLE IV

10 grams of graphite (Dixon No. 635), 10 grams of carbon black (Vulcan XC72R), 12 grams of polyester prepared by reacting dimethyl terephthalate with a 1 to 1 mole ratio of 2-m-butyl-2-ethylpropane-1,2-diol and ethylene glycol with 2.5 mole percent of the dimethyl terephthalate replaced with pyromellitic dianhydride, 2 grams Amine C (surfactant sold by Geigy Chemical) and 178 grams of methylene chloride are ball-milled for 16 hours using ⅛-inch diameter spheres. The composition is coated on a 3-mil poly(ethylene terephthalate) support and dried. The surface resistivity of the dried lacquer is measured and found to be 80 ohms per square.

EXAMPLE V

Example IV is repeated except that the carbon black is omitted and only 2 grams of the polyester are used as a binder for the graphite. The surface resistivity is found to be 100 ohms/square.

EXAMPLE VI

Example IV is again repeated omitting the graphite and using only 10 grams of the polyester as a binder for the carbon black. The surface resistivity of the lacquer is found to be 200 ohms per square.

EXAMPLE VII

Example IV is repeated omitting both the graphite and the carbon black. The surface resistivity is found to be unmeasurably high (i.e., in excess of 10^{10} ohms).

The invention has been described in detail with particular reference to preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention.

I claim:

1. A process for preparing an electrophotographic element comprising the steps of
   (a) providing a support layer,
   (b) applying an electrically conducting layer over said support layer,
   (c) applying a photoconductive layer containing an organic photoconductor and a polymeric binder over said conducting layer, and
   (d) applying an electrically conductive edge coating of lacquer covering at least the side edge of said electrically conducting layer by which said electrically conducting layer can be maintained at ground potential while charging the element, said lacquer comprising a liquid dispersion of a conducting material comprising a mixture of graphite and a conducting carbon black in an organic solvent solution of a polymeric binder.

2. A process for preparing an electrophotographic element comprising the steps of
   (a) providing a support layer,
   (b) applying an electrically conducting layer over said support layer,
   (c) applying a photoconductive layer over said conducting layer, and
   (d) applying an electrically conductive edge coating of lacquer covering at least the side edge of said electrically conducting layer by which said electrically conducting layer can be maintained at ground potential while charging the element, said lacquer

comprising a liquid dispersion of a conducting material comprising about 1 part by weight of graphite and about 1 part by weight of a conducting carbon black in an organic solvent solution of a copolyester polymeric binder prepared from dimethyl terephthalate, 2-m-butyl-2-ethyl propane-1,3 diol, ethylene glycol, and pyromellitic dianhydride.

3. A process for preparing an electrophotographic element comprising the steps of

(a) providing a support layer,

(b) applying an electrically conducting layer over said support layer,

(c) applying a photoconductive layer over said conducting layer, and

(d) applying an electrically conductive edge coating of lacquer covering at least the side edge of said electrically conducting layer by which said electrically conducting layer can be maintained at ground potential while charging the element, said lacquer comprising a liquid dispersion of a conducting material in an organic solvent solution of a polymeric binder.

4. The process as defined in claim 3 wherein said support layer is a poly(ethyleneterephthalate).

5. The process as defined in claim 3 wherein said conducting lacquer covers to the edge of the electrophotographic element.

6. The process as defined in claim 3 wherein the resistance of the conducting lacquer is less than about 10^4 ohms per square.

7. The process as defined in claim 3 wherein the conducting material in said lacquer is graphite.

8. The process as defined in claim 3 wherein the conducting material in said lacquer is a conducting carbon black.

9 The process as defined in claim 3 wherein the conducting material in said lacquer is nickel.

10. The process as defined in claim 3 wherein the binder is selected from the group consisting of polyesters and polyolefins.

11. The process as defined in claim 3 wherein the ratio of conducting material to binder in said lacquer ranges from about 0.1 to about 100.0 parts of conducting material by weight for each part of binder.

12. The process as defined in claim 3 wherein the electrically conducting layer comprises a conducting metal salt.

13. The process as defined in claim 3 wherein said electrically conducting layer is applied by vapor depositing a metal.

14. The process as defined in claim 3 including the step of interposing an adhesion layer between said electrically conducting layer and said photoconductive layer.

15. The process as defined in claim 3 wherein the conducing material in said lacquer is a mixture of graphite and a conducting carbon black.

16. The process as defined in claim 15 wherein the ratio of graphite to conducting carbon black ranges from about 0.5 to about 2.0 parts by weight of graphite for each part by weight of carbon black.

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