

[54] **MULTILAYER ELECTROPHOTOGRAPHIC
ELEMENT CONTAINING HIGH CONTRAST
AND OPAQUE BARRIER LAYERS**

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96/67, 87 R, 84 R

[56] **References Cited**
UNITED STATES PATENTS

2,983,220 5/1961 Dalton et al. 96/1.8 X

3,079,253	2/1963	Greig	96/1.5
3,085,051	4/1963	Hamm et al.	96/1.8 X
3,256,089	6/1966	Clark et al.	96/1.5
3,556,787	1/1971	Letter	96/1.5 X
3,598,591	8/1971	Bishop et al.	96/87 R X
3,629,054	12/1971	De Keyser et al.	96/87 R X
3,649,336	3/1972	Van Paesschen et al.	96/1.5 X
3,674,492	7/1972	Goldrick et al.	96/67 X
3,715,207	2/1973	Ciccarelli	96/1.5

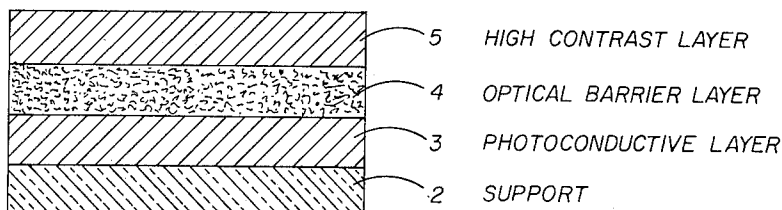
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[57] **ABSTRACT**

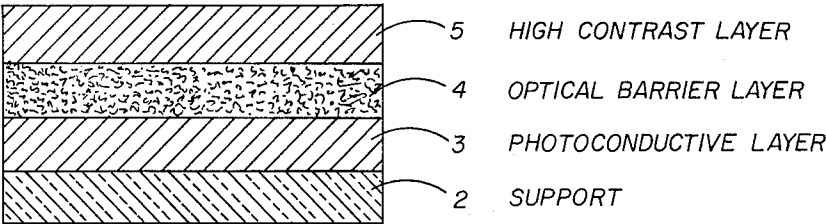
A multilayer electrophotographic element is disclosed containing a photoconductive layer, an opaque optical barrier layer, and a high contrast layer. The element is suitable for use, e.g., in a display screen device, where high contrast, high density images are desired. An electrostatic image carried on the element may be processed under normal room lighting conditions.

17 Claims, 1 Drawing Figure



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MULTILAYER ELECTROPHOTOGRAPHIC ELEMENT CONTAINING HIGH CONTRAST AND OPAQUE BARRIER LAYERS

The present invention relates to electrophographic elements having a novel structure which facilitates use of the element to obtain high contrast images, for example, in a display screen, and which allows electrophographic processing of the element under normal room-lighting conditions.

In conventional electrophotographic imaging processes there is employed an electrophotographic element usually having an electrically-conducting support and overlying the support a photoconductive layer. The photoconductive layer contains a normally insulating material whose electrical resistance varies with the amount of incident electromagnetic radiation it receives during an imagewise exposure. Conventionally these electrophotographic elements are imaged by applying in the dark a uniform electrostatic charge pattern on the surface of the element, exposing the charged element to a pattern of activating radiation which has the effect of differentially reducing the potential of the surface charge in accordance with the relative energy contained in various parts of the radiation pattern, and developing the differential surface charge or electrostatic latent image remaining on the electrophotographic element to form a visible image. Typical developing materials include suitable electrosensitive marking particles (often referred to as toner) which may be contained in an insulating liquid or on a dry carrier vehicle.

In many situations where electrophotographic image-forming processes might be advantageously employed, conventional electrophotographic processes have been found unsatisfactory for the reason that such processes must generally be carried out in the dark. For example, in many situations where temporary prints or copies are desired for immediate viewing with the option of either erasing, adding to, or transferring additional image information to the original image print, it is convenient and desirable to employ an image-forming technique wherein a visible image may be developed under room-lighting conditions. Such image-forming methods substantially reduce cost by minimizing the amount of light-tight image-forming equipment and supporting equipment which must be utilized.

In addition, many situations occur where it is desirable to obtain a visible image exhibiting an exceptionally high image to background differential, i.e., good image contrast, for example, in display screens for x-ray prints or display screens for devices such as teaching machines.

In the past, there has been disclosed lead oxide photoconductive elements having surface coating compositions which apparently enhance image density by reducing background discoloration of the lead oxide photoconductive composition. The surface coating compositions which have been designed for use with lead oxide photoconductive materials are composed of certain pigments such as titanium dioxide (TiO_2), silicone dioxide (SiO_2), and barium sulfate (BaSO_4). These surface coated lead oxide elements are disclosed in German Patent 1,954,634 dated June 11, 1970. A disadvantage associated with the photoconductive element such as described in German Patent 1,954,634 is that

such elements, as is generally conventional in the art, require electrophographic processing in the dark.

Certain attempts have been made in the art to provide photoconductive elements capable of room-light processing. One such element is described in Clark et al. U.S. Pat. No. 3,182,573 issued May 11, 1965. The Clark et al. patent describes, in part, a light desensitizing layer which is alleged to be substantially opaque to actinic light and which contains a suitable dye in a resin binder. However, elements such as those described in U.S. Pat. No. 3,182,573 are generally deficient for various display screen purposes or other purposes where a high contrast image is desired. This is because such elements do not contain a compatible high contrast surface layer incorporated therein. Moreover, it has been found that even when a suitable high contrast layer is incorporated in a photoconductive element having the dye-containing light desensitizing layers described in U.S. Pat. No. 3,182,573, such an element under relatively high ambient light conditions generally does not provide images of acceptable high density and contrast for use in various display screen devices or other elements where a high contrast image is required.

In accord with the present invention there is provided a composite photoconductive element which advantageously is capable of being processed under relatively high ambient room-lighting conditions and, in addition, possesses high contrast image capabilities.

FIG. 1 attached hereto represents a typical cross-section of the multilayer photoconductive element of the present invention comprised of a conductive support 2, a photoconductive insulating layer 3, an opaque optical barrier layer 4, and a high contrast overcoat layer 5. In a preferred embodiment of the present invention elements such as that illustrated in FIG. 1 have a multilayer unitary structure. However, as will be apparent, the various layers comprising the multilayer element of the invention may be removable. For example, the element may comprise three layers, a photoconductive layer, an optical barrier layer, and a high contrast surface layer without a permanent conductive support. When it is desired to utilize the element in an electrophographic process, the three-layer element could then be attached to a reusable conductive support for electrophographic processing. In addition, it will, of course, be apparent that one or more of the layers of the multilayer element of the invention could be removed and the resultant element would still retain its photoconductive properties. For example, the optical barrier layer, could be removed; however, the resultant element would then lose one of its most desirable characteristics, namely its ability to be charged and developed under normal room light conditions. If desired, optional subbing layers not shown in FIG. 1 may be present in the element of the invention to, for example, improve adhesion between adjacent layers. Thus, referring to FIG. 1, a subbing layer or layers may be inserted between layers 2 and 3, 3 and 4, or 4 and 5.

As suggested above, the multilayer element of the present invention offers numerous advantages. In the first place, to applicant's knowledge, previous photoconductive elements have generally not possessed the dual advantages of room-light electrophographic processing and the production of a high density, high contrast visible images. Moreover, as illustrated in the examples presented hereinafter, the optical barrier layer utilized in the multilayer element of the present invention pro-

vides resultant developed images of high density utilizing normal room-light processing conditions.

A further advantage of the present invention is that electrographic developed images formed using the element of the invention provide extremely high resolution without sacrificing image quality or deleteriously affecting the reusability properties of the photoconductive element. In addition, in a preferred embodiment of the present invention wherein an organic photoconductive material is utilized in the photoconductive insulating layer of a multilayer element, the resultant multilayer element provides high quality electrographic developed images utilizing bi-modal charging, i.e., a developable latent electrostatic charge pattern may be formed on the composite element utilizing either uniform negative charging or uniform positive charging. In contrast, conventional prior art photoconductive elements having a surface layer apparently capable of yielding high contrast developed image, for example the elements described in German Patent 1,954,634, typically contain inorganic photoconductive materials in the photoconductive insulating layer, for example, lead oxide, which yields good electrographic developed images only in a single charging mode.

Furthermore, as described hereinafter in Examples 4 and 5, the multilayer elements of the invention are especially useful in multiple-color electrophotographic processes.

The multilayer photoconductive elements of the present invention, as indicated, typically comprise a photoconductive layer carried on a conductive support. A photoconductive layer comprises a photoconductor and optionally a binder and/or a sensitizer. Typically, the photoconductive layer has a thickness in the range of from about 1 micron to about 500 microns after drying. Useful results can be obtained when a photoconductor is present in an amount ranging from about 1 weight percent to about 99 weight percent of a coating composition. A wide variety of photoconductors can be used in the multilayer photoconductive element of the invention. However, as indicated, it is especially preferred to utilize organic photoconductive materials so that the resultant photoconductive element can be used to obtain high quality developed images in either a positive or negative charging mode. However, inorganic photoconductors can also be used as well as organo-metallic photoconductive compounds. Examples of various photoconductors which may be used include the following:

1. Inorganic photoconductors such as zinc oxide, zinc sulfide, cadmium selenide, zinc silicate, cadmium sulfide, arsenic triselenide, antimony trisulfide, lead oxide, titanium dioxide and others as listed, for example, in Middleton et al. U.S. Pat. No. 3,121,006, issued Feb. 11, 1964;

2. Arylamine photoconductors including substituted and unsubstituted arylamines, diarylamines, nonpolymeric triarylamines and polymeric triarylamines such as those described in Fox U.S. Pat. No. 3,240,597, issued Mar. 15, 1966 and Klupfel et al. U.S. Pat. No. 3,180,730, issued Apr. 27, 1965;

3. Polyaryalkane photoconductors of the types described in Noe et al. U.S. Pat. No. 3,274,000, issued Sept. 20, 1966, Wilson U.S. Pat. No. 3,542,547, issued Nov. 24, 1970 and in Seus et al. U.S. Pat. No. 3,542,544, issued Nov. 24, 1970;

4. 4-Diarylamino-substituted chalcones of the types described in Fox U.S. Pat. No. 3,526,501, issued Sept. 1, 1970;

5. Non-ionic cycloheptenyl compounds of the types described in Looker U.S. Pat. No. 3,533,786, issued Oct. 13, 1970;

6. Compound containing an



nucleus, as described in Fox U.S. Pat. No. 3,542,546, issued Nov. 24, 1970;

7. Organic compounds having a 3,3'-bis-aryl-2-pyrazolone nucleus, as described in Fox et al. U.S. Pat. No. 3,527,602, issued Sept. 8, 1970;

8. Triarylamines in which at least one of the aryl radicals is substituted by either a vinyl radical or a vinylene radical having at least one active hydrogen-containing group, as described in Brantly et al. U.S. Pat. No. 3,567,450, issued Mar. 2, 1971;

9. Triarylamines in which at least one of the aryl radicals is substituted by an active hydrogen-containing group, as described in Brantly et al. Belgian Patent No. 728,563, dated Apr. 30, 1969;

10. Organo-metallic compounds having at least one amino-aryl substituent attached to a Group IVa or Group Va metal atom, as described in Goldman et al. Canadian Patent No. 818,539, dated July 22, 1969;

11. Organo-metallic compounds having at least one amino-aryl substituent attached to a Group IIIa metal atom, as described in Johnson Belgian Patent No. 735,334, dated Aug. 29, 1969;

12. Charge transfer combinations, e.g., those comprising a photoconductor and a Lewis acid, as well as photoconductive compositions involving complexes of non-photoconductive material and a Lewis acid, such as described, for example, in Jones U.S. Defensive Publication T881,002, dated Dec. 1, 1970 and Mammino U.S. Pat. Nos. 3,408,181 through 3,408,190, all dated Oct. 29, 1968 and Inami et al. U.S. Pat. No. 3,418,116, dated Dec. 24, 1968.

The binder materials useful in forming photoconductive compositions include a wide variety of film-forming resinous materials. Typical binders for use in preparing the photoconductive layers are film-forming, hydrophobic polymeric materials having a fairly high dielectric strength and which are good electrically insulating film-forming vehicles. Materials of this type include styrene-butadiene copolymers; silicone resins; styrene-alkyd 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(methyl methacrylate), poly(n-butyl methacrylate), poly(isobutyl methacrylate), etc; polystyrene; nitrated polystyrene; polymethylstyrene; isobutylene polymers; polyesters, such as poly[ethylene-co-alkylenebis(alkyleneoxyaryl)phenylenedicarboxylate]; phenolformaldehyde resins; ketone resins; polyamides; polycarbonates; polythiocarbonates; poly[ethylene-co-isopropylidene-2,2-bis(ethyleneoxyphenylene)terephthalate]; copolymers of vinyl haloarylates and vinyl acetate such as poly-(vinyl-m-bromobenzoate-co-vinyl acetate); etc. Methods of making resins of this type have been de-

scribed in the prior art, for example, styrene-alkyd resins can be prepared according to the method described in Gerhart U.S. Pat. No. 2,361,019, issued Oct. 24, 1944 and Rust U.S. Pat. No. 2,258,423, issued Oct. 7, 1941. Suitable resins of the type contemplated for use in the photoconductive layers of the invention are sold under such trademarks as Vitel PE-101, Cymac, Piccopale 100, Saran F-220, and Lexan 145. Other types of binders which can be used in photoconductive layers include such materials as paraffin, mineral waxes, etc.

Sensitizing compounds useful in electrophotographic elements can be selected from a wide variety of materials, including such materials as pyrylium dye salts including thiapyrylium dye salts and selenapyrylium dye salts disclosed in VanAllen et al. U.S. Pat. No. 3,250,615, issued May 10, 1966; fluorenes, such as 7,11-dioxo-13-dibenzo(a,h)fluorene, 5,10-dioxo-4a,11-diazabenzob-(b)fluorene, 3,13-dioxo-7-oxadibenzo(b,g)fluorene, and the like; co-crystalline complexes of a polycarbonate resin and a pyrylium sensitizer as described in Light U.S. Pat. No. 3,615,414, dated Oct. 26, 1971 and U.S. Pat. No. 3,679,407, issued July 25, 1972; aromatic nitro compounds of the kind described in Minsk et al. U.S. Pat. No. 2,610,120, issued Sept. 9, 1952; anthrones like those disclosed in Zvanut U.S. Pat. No. 2,670,284, issued Feb. 23, 1954; quinones, Minsk et al. U.S. Pat. No. 2,670,286, issued Feb. 23, 1954; benzophenones, Minsk et al. U.S. Pat. No. 2,670,287, issued Feb. 23, 1954; thiazoles, Robertson et al. U.S. Pat. No. 2,732,301, issued Jan. 24, 1956; mineral acids; carboxylic acids, such as maleic acid, di- and trichloroacetic acids, and salicylic acids; sulfonic and phosphoric acids; and other electron acceptor compounds as disclosed by H. Hoegl, J. Phys. Chem., 69, No. 3, 755-766 (March, 1965), and Hoegl et al. U.S. Pat. No. 3,232,755, issued Feb. 1, 1966.

The optical barrier layer utilized in the multilayer element of the present invention typically comprises finely-divided particulate matter dispersed in a resinous binder. The particulate matter, of course, should not possess any significant photoconductive properties when incorporated in the optical barrier layer. In accord with one embodiment of the invention, the optical barrier layer comprises an opaque pigment, typically a black pigment such as carbon black. Preferably black pigments such as carbon black are utilized but any opaque pigment can be used. Pigments, including carbon, which may be used in accord with this embodiment of the invention include Colour Index Pigment Black 5, 6, 7, 8, 9 and 10; Colour Index Pigment Black 13 and 14 (also referred to as cobalt black and manganese black, respectively); copper phthalocyanine; mixtures of the foregoing pigments, etc. Suitable pigments can, for instance, be selected from the various classes of readily dispersible pastes and pigments which usually contain a wetting agent as an adjuvant. In accord with this embodiment of the invention an especially useful pigmenting material is a carbon pigment. Useful such carbon pigments include commercially available carbon black materials typically referred to as "conductive carbon black" or commercially carbon black materials generally considered relatively insulating or semi-conducting carbon black materials. In accord with this embodiment of the invention, if desired, the opacity of the barrier layer may be slightly modified by addition thereto of a small amount of various dyes. The addition

of such dye improves the barrier layer simply by serving as a color-balancing or color-corrective addenda. It should be noted, however, in accord with this embodiment of the invention that the primary opacifying material of the optical barrier layer is the opaque pigment. The addition of small amounts of various dyes or dye typically has a very small effect on the total opacity of the resultant optical barrier layer.

In accord with the above-described embodiment of the optical barrier layer of the present invention, the amounts of opaquing pigment and resinous binder utilized in the layer may vary fairly widely depending upon the particular opaquing pigment selected as well as the resinous binder. Typically, optical barrier layers in accord with this embodiment of the invention generally include from about 10 to about 90 percent of the volume occupied by opaquing pigmenting material and from about 10 to about 90 percent of the resinous binder. (These volume percent figures are based on the composition of the optical barrier layer when dried.) If, as indicated above, as an optional ingredient thereof, a dye or mixture of dyes is also incorporated as a color-balancing or color-corrective addenda, the amount of dye utilized is typically within the range of from about 0.1 to about 10 weight percent based on the total weight of resinous binder.

In accordance with a second embodiment of the optical barrier layer utilized in the present invention, the optical barrier layer may be comprised of a dye resinous binder and light-scattering particulate matter as described in detail hereinafter including, for example, a titanium pigment such as titanium dioxide and various other titanate containing materials which contain therein a material having one of the following formula:



wherein M represents a metallic element selected from Groups I, II, III and IV of the Periodic Table, n represents an integer of from 1 to 4 depending on the valency of M. In this embodiment of the invention the optical barrier layer appears opaque just as in the first embodiment of the invention described hereinabove; however, the opacity of the layer appears to be obtained by a different type of light absorption phenomenon. That is, in accord with this embodiment of the invention, the particulate matter is utilized to scatter light impinging on the optical barrier layer, the light thus scattered being ultimately absorbed by a dyed binder comprising the remainder of the optical barrier layer.

In accord with the second embodiment of the optical barrier layer described hereinabove, the amount of various components contained in the layer may also vary fairly widely depending on the particular components selected. Typically, the amount of light-scattering particles varies within the range of from about 10 to about 90 volume percent and the amount of dyes resinous binder utilized varies within the range of from about 10 to about 90 volume percent. (These volume percent figures are based on the total volume of the barrier layer composition when dry). The amount of dye utilized in accord with this embodiment of the invention is somewhat larger than that which, if desired, may optionally be incorporated in the first embodiment of the optical barrier described hereinabove. Typically, in accord with the second embodiment of the optical barrier layer used in the present invention, the amount of dye comprises from about 20 to about 60 weight percent

based on the total weight of the resinous binder in the optical binder layer composition.

Typical dyes which may be utilized in accord with either the first or second embodiment of the optical barrier layer include the following: Solvent Black 1, 2, 8, 18, 24, 25 or 27; C.I. Solvent Brown 6, 23, 23, 25, 28, 34 or 36. Preferably the dyes are *Colour Index* Solvent Dyes soluble, for example, in alcohol or glycol solvents, to promote compatibility with the resin binder. However, as suggested above, other organic solvent soluble dyes may also be used.

The various resinous binder material which may be utilized as the resinous binder for the optical barrier layers of the present invention may generally be selected from the same class of materials described hereinabove for use as a binder in a photoconductor layer. Especially good results, however, have been obtained in accord with certain preferred embodiments of the invention utilizing a resinous binder material selected from those including poly(vinylacetate) and poly(carbonates).

In accord with the present invention, the optical barrier layer may generally be characterized as an electrically insulating layer having a resistivity of at least about 10^{10} ohm-cm or greater. The insulating properties of this layer are important to insure compatibility with the underlying photoconductive insulating layer. That is, if the optical barrier layer were, for example, a relatively conductive or semiconductive layer, electrostatic charge leakage could occur across this layer, thereby resulting in a photoconductive element incapable of holding a latent electrostatic charge pattern. The thickness of the optical barrier layers utilized in the present invention may vary. Typically an optical barrier layer may have a dry thickness of about 1 to about 15 microns. So long as the optical barrier layer has the desired opacity and electrical properties, layers having a thickness smaller or greater than the thickness noted hereinabove may be used. Typically the size of the particulate materials utilized in the optical barrier layers of the present invention have an average particle size in the range of from about 0.02 to about 0.5 microns.

As indicated hereinabove the particulate matter selected for use in the optical barrier layer of the present invention are important. For example, it appears that if various dyes, rather than particulate matter, are substituted for the particulate matter utilized in the barrier layers of the present invention, the resultant barrier layer becomes sufficiently transparent to actinic radiation that it is difficult or impossible to achieve high-density, high resolution developed images under normal-room lighting conditions using a multilayer element containing such an optical barrier layer. Moreover, although the amounts of the various components utilized in the optical barrier layers described hereinabove may vary over a fairly considerable range, much larger or much smaller amounts of particulate matter than those specified hereinabove may present difficulties. For example, one may experience difficulty in obtaining a photoconductive element capable of holding an electrostatic charge pattern if much larger amounts of particulate material than those specified hereinabove are utilized. On the other hand, if the amount of particulate material utilized is much smaller than the lower end of the ranges specified hereinabove, the optical barrier tends to lose some of its opacity which may result in charge leakage across the photoconductor

when the element is processed in the presence of normal room-lighting conditions. In addition, very small amounts of particulate matter may increase the resistivity of the optical barrier layer to such a high degree that the reusability feature of the multilayer element of the present invention could be destroyed. That is, the optical barrier layer would become so highly resistive that the charge image formed on the resultant element could not be dissipated across the optical barrier layer.

The term light scattering particles as utilized in the optical barrier layer and high contrast layer of the present invention is defined herein to be any finely-divided, particulate material having a refractive index greater than the refractive index of the resinous binder in which it is dispersed. Conventional resinous binder materials generally have a refractive index on the order of from about 1.3 to about 1.7. A partial listing of various exemplary light-scattering particles includes zinc oxide, titanium pigments such as those described hereinafter, antimony oxide, zirconium-containing materials such as *Colour Index* Pigment White 12, *Colour Index* Pigment White 14, mica, and the like. Advantageously, the light scattering particles utilized in the invention have a refractive index greater than about 1.6, preferably greater than about 2.1, to provide a substantial difference between the refractive index of the resinous binder and the dispersed particulate phase incorporated therein.

The high contrast layer utilized in the multilayer element of the present invention typically includes a light scattering particulate material, as defined above, dispersed in a resinous binder. The phrase high contrast layer is defined herein to be a layer containing particulate matter dispersed therein which has the effect of visually masking the color of the underlying optical barrier layer. Various factors to be considered in preparing useful high contrast layers include particle size of the particulate matter and the thickness of the resulting layer as explained in greater detail hereinafter. Various light scattering particles and resinous binder materials may be used so long as the resultant pigment-containing layer has a relatively high resistivity and relatively high dielectric constant as described hereinafter. Of course, it will be appreciated that the particulate material utilized should not exhibit any significant photoconductive properties when incorporated in the high contrast layer.

For example, in one embodiment a light-scattering material having a dielectric constant within the range of from about 3 to 50 or more may be used, for example, zinc oxide having a dielectric constant of about 7-10, together with a resinous binder having a relatively high dielectric constant greater than about 5, for example, a cellulose nitrate binder having a dielectric constant of about 6, to provide a resultant high contrast layer having a dielectric constant and high resistivity. Other relatively high dielectric constant resins may also be used in place of cellulose nitrate. For example, poly(urethanes), fluorinated resins, poly(amides) such as nylon, and the like may be used.

In accord with a preferred embodiment of the invention, the high contrast layer contains a resinous binder material having a dielectric constant greater than about 2.0 and high dielectric constant light-scattering particles. In accord with this embodiment, the high dielectric constant of the layer is due primarily to the incor-

poration therein of a high dielectric constant particulate material. Especially useful are finely-divided particles having a dielectric constant greater than about 50.

In still another embodiment of the high contrast layer useful in the present invention, both the resinous binder and the light-scattering particles dispersed therein may possess a relatively high dielectric constant. That is, the binder may have a dielectric constant greater than about 5.0 and the light-scattering particles may have a dielectric constant greater than about 50.

A variety of titanium pigment materials having a dielectric constant greater than about 50 have been utilized and found excellent for use as the light-scattering particles in the high contrast layers of the present invention. Such pigments include, for example, titanium dioxide (TiO_2) and titanate materials such as barium titanates, e.g., BaTiO_3 , calcium titanates, e.g., CaTiO_3 , lithium titanates such as lithium meta titanate (Li_2TiO_3), lithium dititanate ($\text{Li}_2\text{Ti}_2\text{O}_5$), lithium orthotitanate (Li_4TiO_4), sodium titanates, potassium titanates, magnesium titanates, aluminum titanates, zinc titanates, mixtures thereof and the like. Typical titanate containing materials which are useful in the high contrast overcoat may generally be selected from materials having the formulas noted hereinbelow as follows:

I. M_nTiO_3 II. M_nTiO_4 and III. $\text{M}_n\text{Ti}_2\text{O}_5$

wherein M represents a metallic element selected from Groups I, II, III, and IV of the Periodic Table and n represents an integer of from 1 to 4 depending upon the valency of M. Typically, M represents a monovalent or divalent metallic ion.

The dielectric constant and the resistivity of the high contrast layer are important. The high contrast layer must be electrically compatible with the properties of the photoconductive layer so the resultant multilayer element is capable of receiving and holding a latent electrostatic charge. Typically, the resistivity of the high contrast layer should be at least about 10^{10} ohm-centimeters and the dielectric constant should be relatively high within the range of from about 5 to about 50. Thus, the high contrast layers utilized in the multilayer element of the present invention may typically be characterized as high resistance, high dielectric constant layers. It has been found, for example, that if an overcoat having a relatively high resistance, i.e., 10^{18} ohm-cm and a relatively low dielectric constant, e.g., 3 or less, is utilized, good resolution may be obtained but the element becomes difficult to re-use because elaborate electrical discharge procedures must be followed to remove the charge pattern so that the element may be reused. On the other hand, if the high contrast layer has a relatively low electrical resistance, for example less than 10^{10} ohm-cm, and a relatively high dielectric constant, the resultant multilayer element is incapable of retaining a good electrostatic charge pattern so that any image developed thereon has very poor resolution. Thus, by utilizing the high contrast layers of the present invention wherein the layers have high resistance and a relatively high dielectric constant, one obtains a resultant element capable of yielding good resolution without diminishing the reusability characteristics of the element.

The size of the light-scattering materials utilized in the high contrast layer may vary. However, if materials having a relatively large particle size are utilized, i.e.,

particles having a particle size larger than about 5 microns or more, one obtains a developed image having very poor resolution since thicker layers are needed to yield proper background coloration. Preferably, to obtain high quality, high resolution image, it is preferred to utilize a particulate material wherein the average particle size is less than 0.5 micron in average diameter, typically an average particle size within the range of from about 0.01 micron to less than 0.5 micron.

The high contrast layer may be applied to the multilayer element of the present invention by a variety of techniques including various solvent and dispersion coating techniques and various lamination techniques. Typically, use of a lamination technique is preferred to a solvent coating technique due to the fact that underlying layers of the multilayer element may also be soluble in the coating solvent used to apply the high contrast surface layer.

Typically, the amount of particulate material contained in the high contrast layer varies from about 30 to about 90 volume percent of the total layer when dry and the resinous binder varies from about 10 to about 70 volume percent of the total dry layer. Various resinous binders may be utilized in the high contrast coating so long as the appropriate resistivity and dielectric constant of the resultant coating is obtained as described hereinbefore. These materials may generally be selected from the same binder materials disclosed for use in the photoconductive layer. If a solvent coating technique is used to apply the high contrast layer or the underlying optical barrier layer to the photoconductive layer, it may be desirable to select different resinous binders for the different layers so that the solvent utilized to coat one layer does not have a deleterious effect on underlying layers it may contact during the coating operation.

The thickness of the high contrast layer utilized in the elements of the present invention may vary within rather wide ranges. Typically, one advantage of the present invention is that relatively thick high contrast layers may be utilized without interfering with the electrical properties of the resultant multilayer element. The significance of this advantage provided by the present invention can better be appreciated by considering that prior art elements such as those illustrated in U.S. Pat. No. 3,182,573 typically become inoperable when an opaque dye-containing sensitizing layer having a thickness greater than about 25 microns is used as an overcoat for a 20 micron thick photoconductive layer. However, in the present invention, useful multilayer photoconductive elements have been found to operate quite effectively even with a combined overcoat thickness (i.e. optical barrier layer plus high contrast layer) greater than 25 microns applied to a photoconductive layer having a thickness of about 20μ . This is because of the electrical characteristics of the high contrast layer, i.e., high resistivity and a high dielectric constant. Thus, even a physically relatively thick high contrast layer behaves electrically as a thin dielectric layer. Typically, coating thicknesses on the order from about 1 to about 50 microns may be utilized for the high contrast layer with a preferred coating thickness extending from about 10 to about 25 microns. (The coating thicknesses and percentage composition reported herein with respect to the high contrast layer are based on the layer when dry.)

Typically, the high contrast layer utilized in the multilayer element of the present invention is translucent or opaque and has a whitish appearance which makes the layer useful as a high contrast surface. However, various dyes may be incorporated in the layer (so long as they do not interfere with the optical and electrical properties thereof) to modify color of the layer where, for example, it is desired to have a background having a color other than white.

The conductive supports utilized in the present invention are transparent, electrically-conducting materials such as various film supports, for example, cellulose acetate, cellulose nitrate, polystyrene, poly(ethyleneterephthalate), poly(vinyl acetal), poly(carbonate) and other related films having a conductive substrate thereon. An especially useful conducting support can be prepared by coating a transparent film support material with a layer containing a semi-conductor such as cuprous iodide dispersed in a resin. Suitable conductive coatings also can be prepared from the sodium salt of a carboxy ester lactone of maleic anhydride-vinyl acetate copolymer. Such conducting layers and methods for their optimum preparation and use are disclosed in Minsk U.S. Pat. No. 3,007,901 issued Nov. 7, 1961; Trevoy U.S. Pat. No. 3,245,833 issued Apr. 12, 1966; Serman U.S. Pat. No. 3,262,807 issued July 26, 1966; etc. Additional useful conductive layers include carbon-containing layers such as conductive particles dispersed in a resinous binder. Various transparent vapor deposited metal layers such as silver, nickel, or aluminum on conventional film supports are also useful as are various conductive or conductor coated glasses.

The following examples are included to further illustrate the multilayer element of the present invention, and, in particular, to demonstrate various applications and uses of this element:

EXAMPLE 1

An organic photoconductive composition containing a resinous binder, an organic photoconductor and a crystalline complex of a thiapyrylium sensitizing dye and poly(carbonate) resin as described in Light, U.S. Pat. No. 3,615,414 issued Oct. 26, 1971, is overcoated on an evaporated nickel-coated poly(ethylene terephthalate) support. Next, two additional layers are applied over the photoconductor layer. These two layers are applied by a lamination technique. The two layers applied to the photoconductive layer are prepared as follows:

First, a fine dispersion of carbon black is prepared with the following materials:

- 2.9g Amberol ST-137: Tradename for oil-soluble unmodified phenol-formaldehyde resin sold by the Rohm and Haas Co.
- 5.8 g Beckosol 70: A tradename for soya-modified alkyd resin containing 42 percent phthalic anhydride and 41 percent soya fatty acids sold by the Reichold Chemical Co.
- 3.7 g Carbon Black Regal: Tradename for particulate carbon pigment sold by Cabot Carbon Co.
- 0.6 g Monastral Blue: Tradename of E.I. duPont for copper phthalocyanine; used as portion of opaque pigment material.
- 0.1 g Staybelite Resin: A tradename for hydrogenated wood resin sold by Hercules Powder Co.
- 24.0 g Cyclohexane

This dispersion is ball-milled in a 4 oz. jar, with 60 ml of 1/8 inch steel balls, for 5 days at 40°C and 160 r.p.m. after which it is knife-coated on unsubbed poly(ethylene terephthalate) film support with a 0.003 inch doctor blade. The coating is allowed to dry for 15 minutes at room temperature. The dry thickness of the layer is 8 microns. The resistivity of this layer is 10^{14} ohm-cm and its dielectric constant is 2.2.

A white pigment dispersion is then prepared as follows:

- 50g 20% poly(vinylacetate resin) in toluene
- 15g BaTiO₃ having an average particle size less than 0.2 microns after dispersing
- 10g TiO₂ having an average particle size less than 0.2 microns after dispersing
- 40g Toluene added after dispersing the above with 1/8 inch ceramic balls on a paint shaker for 2 hours.

This white pigment dispersion is knife-coated on an unsubbed poly(ethylene terephthalate) film support with a 0.006 inch doctor blade. The coating is allowed to dry for 15 minutes at room temperature. The dry thickness is 12 microns. The dielectric constant of this coating is 25, and its resistivity is 10^{14} ohm-cm.

The two coated layers are brought into face-to-face contact and laminated together with the aid of a pair of 3 inch diameter rubber coated rollers one of which is heated to a surface temperature 300°F. The force exerted on the rollers for the 10 inch nip length is 25 pounds. The thickness of the rubber coat is 1/8 inch. The metal core of the rollers is made of aluminum. The coated elements pass through the rollers at 1 in/sec. After cooling, the unsubbed film base is removed from the carbon black-containing layer. The two layers, now together on unsubbed film base are laminated to the 20-micron organic photoconductor layer coated on nickelized film support described hereinabove. The lamination conditions are identical to those listed above. The unsubbed film support is finally stripped from the white overcoat leaving the structure shown in FIG. 1.

To test the effectiveness of the optical barrier layer (transmission optical density >5.5) to ambient light conditions, the element is corona charged to 1,200 volts and the surface potential monitored while light-exposed with 100 fc of tungsten light from the white overcoat side. The data indicates that the surface potential is reduced by only 60 volts more than the normal dark decay after one minute for positive charging. The normal dark decay is about 50 volts per minute. The reduction for negative charging is about 100 volts. Normal electrical H and D data reveal no significant differences in curve shape or speed for the overcoated photoconductor relative to a similar non-overcoated photoconductor for either negative or positive charging and with rear exposure. Recycling the overcoated element through a conventional electrophotographic process including the steps of charging, exposing, read-out, light flooding, recharging, etc. at 3 second intervals shows no change in curve shape or speed for 100 cycles.

This element is used in a normal electrophotographic manner to produce liquid-developed prints of good quality with 15 lp/mm resolution while the white layer side of the element is constantly being exposed to room light. The resultant images could be erased readily by wiping with a cleaning pad and new ones formed or they could be transferred to another support by a tacky

transfer method or by other known means. In addition, part of the image could be erased and a new one put in its place by recharging the erased area. A typical exposure for this element when fitted into a Crown Graphic (trademark of Graflex Inc.) camera back is 1 sec. at $f/4.7$. The light intensity incident on the subject being photographed was 15 fc.

EXAMPLE 2

The element in this example was the same as in Example 1 except that the semi-transparent conductive support is reduced in optical density and is composed of a different material, also, the formulation for the two overcoats is changed to make the fabrication thereof easier.

The semitransparent support is changed from evaporated nickel to a Cermet, tradename of Cerex Co. The particular Cermet used is a sublimable mixture of 50 percent chromium and 50 percent silicon monoxide. The optical density of the Cermet is 0.1 compared to 0.4 for the nickel, thus gaining a factor of two in speed when exposing through it.

The cyclohexane in the carbon black optical barrier layer formulation is replaced with Isopar G, a trademark of Humble Oil and Refining Co., used to designate an isoparaffinic hydrocarbon liquid having a boiling point in the range of 145°C to 185°C., so that the dispersion could be coated directly on the photoconductor without degrading it. The toluene in the white layer formulation is changed to methanol so that this dispersion could be coated directly over the black layer.

This multilayer element had electrical and print-making characteristics similar to the one in Example 1.

EXAMPLE 3

A double overcoated layer similar to the one in Example 1 is made utilizing tetragonal PbO in a binder as the photoconductor. The photoconductor containing layer is 60 microns thick.

In addition to making good quality electrophotographic prints, this element is used to make xeroradiographic prints. Liquid development is used for both forms of radiation. The processing steps, reusability, and room light handleability are substantially the same as in Example 1 both for light exposure and x-ray exposures. The resolution of the prints as developed on the multilayer for both x-ray and light exposure is 5 lp/mm.

The x-ray exposures are made with a Faxitron (trademark of Field Emission Corp.) unit. The voltage and current is 110 KV and 3 ma. The source to exposure plane is 18 inches. The filters are $\frac{1}{2}$ mm. of Al and $\frac{1}{4}$ mm. of Cu. The exposure time is of the order of 10 seconds. The xeroradiographs are made by exposures from either side of the element.

The light exposures are made with a Xenon source and a Kodalith (trademark of Eastman Kodak Co.) original in contact with the support side of the element. The light intensity at the exposure plane is 300 fc and the time of exposure is 0.5 sec.

Example 4

Another element similar to the one in Example 2 is used to make a negative-to-positive multicolor print composed of superimposed color separation images of an original image.

The steps for producing a color electrographic image are to sequentially (1) charge the overcoated photoconductor element, (2) expose it to blue, green, or red image separations, (3) develop the separation image on the translucent white overcoat with the appropriate yellow, magenta, or cyan developer, (4) rinse the developed image, (5) repeat steps (1) to (4) for each color separation image.

A continuous xenon light is used as the exposing source. The original used is a 35-mm color negative or positive enlarged to 3X at the photoconductor surface. The white light intensity of the xenon source is 20 foot-candles at the exposure plane. The filters used for the red, green, and blue exposures are, respectively, Wratten 70 filter (for negative-to-positive exposure) or Wratten 29 filter in combination with a 674 nm interference cut-off filter for positive-to-positive exposure); a Wratten 58 filter and a 674 nm interference cut-off filter; and a Wratten 47B filter.

Liquid developers of similar formulation are used for all three colors. The developers are prepared by blending a small amount of developer concentrate with Isopar G (a trademark of the Humble Oil Co. used to designate a volatile isoparaffinic hydrocarbon solvent), the ratio being about 1 to 100. The developer, therefore, is a suspension of the concentrate in the Isopar G. The concentrate comprises the desired dye or pigment in Solvesso 100¹ with Beckosol 70,² Amberol ST-137,³ a small amount of Uversol Cobalt Liquid,⁴ and a small amount of aluminum stearate as additional ingredients. The colorants for the yellow and cyan developers are Permanent Yellow HR⁵ and Monastral Blue,⁶ respectively. The magenta colorant consists of a precipitate formed from Astraphloxine FF (Shultz No. 930) phosphotungstic acid, and phosphomolybdic acid. All the developers intrinsically carry a positive charge. The rinses are pure Isopar G, unless otherwise specified.

The overcoated photoconductor element is corona charged positively and rear-exposed. The order of exposure is blue, green, and red. After development, a negative-to-positive color image is reproduced. A table of the pertinent voltages, all with respect to the nickel conducting layer, is included below:

Order of exposure	Blue	Green	Red
Charge (volts)	+1300	+1300	+1050
Exposure (seconds)	62	25	32
Development (volts)	+1100	+1200	+980
Rinse (volts)	+100	+200	-20

The long blue exposure is attributed to the high density of the yellow coupler of the color negative.

The overcoated surface is moist throughout the whole operation. Room lights are turned on to examine the image quality and color of each separation before making the next color separation image. The final multicolor image is ferrotyped by placing a sheet of polyester film over it and passing the assembly through a pair of heated rubber-coated rollers. The surface tempera-

ture of one roller is maintained at 300°F. A high gloss, good quality print resulted. The image is imbedded in the overcoat and is stable.

REFERENCES

1. A trademark of the Humble Oil Co. used to designate a hydrocarbon solvent, b.p. 160-174°C.
2. A tradename of Reichhold Chemical Co. used to designate a soya-modified alkyd resin.
3. A Rohm and Haas Co. trade name for an oil-soluble unmodified phenolformaldehyde resin.
4. A Harshaw Chemical Co. trade name for a solution of cobalt naphthenate containing 6 percent by weight cobalt.
5. An American Hoechst trade name for Colour Index Pigment Yellow 83.
6. A duPont trade name for copper phthalocyanine pigment.

EXAMPLE 5

A stable positive-to-positive, high quality multicolor print is made on an element as disclosed in Example 1 by a procedure similar to Example 4, except for certain differences in the magnitude and polarities of voltages used. The exposures are changed, also. A table below delineates the changes.

Order of exposure	Blue	Green	Red
Charge (volts)	-850	-850	-850
Exposure (seconds)	6.5	11 (+0.65 ND)	7
Development (volts)	-75	-75	-75
Rinse (volts)	-1075	-1075	-1075

EXAMPLE 6

Another element similar to the one in Example 2 is used in an electrophotographic system involving the simultaneous application of a voltage and exposure followed by a development step.

A receiver paper coated with an electrically insulating layer (7 microns thick) is brought into contact with a photoconductive element identical to the one of Example 2. A portion of the photoconductive element covered by the receiver does not contain any overcoats, i.e., no carbon-containing optical barrier layer or titanate-containing high contrast layer.

The electrostatic charge image is produced on the receiver by first applying 1,700 volts across the sandwich with a white flooding light. This operation charges the insulator covered paper uniformly negative. The polarity of the applied voltage is reversed and its magnitude is changed to 1,500 volts simultaneously with a projection exposure of 2 seconds duration. The light intensity is 3 footcandles. The projected image is that of a line copy document. The receiver is separated from the photosensitive element and developed in a liquid developer. A high quality positive-to-positive reproduction of document results. No difference could be detected between the overcoated and non-overcoated areas, thereby indicating that the optical barrier layer and high contrast surface layer do not interfere with the photoconductive imaging capabilities of the photoconductive element.

EXAMPLE 7

The overcoated element of Example 2 is used in conjunction with a binderless polyyne coated receiver of the type generally described in U.S. Pat. No. 3,501,302, issued Mar. 17, 1970, to obtain a dry processed, direct-printout copy.

The polyyne coated receiver is prepared by applying to a paper support a half percent solution of the monomethyl ester of 10, 12-docosadiyne dioic acid in a 50/50 percent by weight mixture of ethyl alcohol and acetone. After drying, the polyyne-coated receiver paper is contacted to an element as described in Example 2. In normal roomlight, a potential of 1,800 volts is applied across the sandwich simultaneously with an image projected from a microfilm reader for an exposure of 2 seconds at 40 foot-candles. Upon separation a blue negative-to-positive image is visible on the polyyne receiver paper. The neutral density of the blue image is 0.3 and the background is 0.1. The system is found to be independent of voltage polarity and may be used under ambient light conditions.

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. In an electrographic element comprising a transparent conductive support bearing a photoconductive insulating layer, the improvement which comprises an optical barrier layer overlying said photoconductive layer and a high contrast layer overlying said barrier layer, said optical barrier layer opaque to visible light, possessing a specific resistivity greater than about 10^{10} ohm-cm, and comprising finely-divided opaque particulate matter dispersed in a film forming resinous binder or light scattering particulate matter having a particle size of less than 5 microns dispersed in a dyed film forming resinous binder, wherein the optical barrier layer comprises from about 10 to about 90 volume percent of the particulate matter, said optical barrier having no significant photoconductive properties and said finely-divided light scattering particulate matter having a refractive index greater than the refractive index of said film-forming resinous binder, said high contrast layer having a thickness of 1 to 50 microns and having a specific resistivity greater than about 10^{10} ohm-cm and a dielectric constant from about 5 to about 50 and comprising finely-divided particles of a titanium pigment dispersed in a film-forming resinous binder, wherein the high contrast layer comprises from about 30 to about 90 volume percent of the pigment, said particles of titanium pigment having a refractive index greater than the refractive index of said film forming binder.

2. The invention as described in claim 1 wherein said optical barrier layer comprises from about 10 to about 90 volume percent of opaque pigment particles and wherein said high contrast layer comprises from about 30 to about 90 volume percent of a titanium pigment having an average particle size less than about 0.5 microns and selected from the group consisting of TiO_2 and compounds having the formulas:

I. M_nTiO_3 II. M_nTiO_4 III. $M_nTi_2O_5$ wherein M represents a metallic element selected from Groups I, II, III, and IV of the Periodic Table and n represents an integer within the range of 1 to 4 depending on the valency of M.

3. The invention as described in claim 1 wherein said optical barrier layer comprises carbon black particles.

4. The invention of claim 1 wherein said optical barrier layer comprises a light scattering titanium pigment,

a resinous binder, and a dye present in an amount equal to about 20 to about 60 percent by weight based on the amount of resinous binder, said titanium pigment selected from the group consisting of titanium dioxide and titanium compounds having the formulas:

I. M_nTiO_3 II. M_nTiO_4 III. $M_nTi_2O_5$

wherein M is a metallic element selected from Groups I, II, III, and IV of the Periodic Table and n is an integer within the range of 1-4 depending on the valency of M.

5. A multilayer electrographic element comprising a transparent conductive support bearing (a) a photoconductive insulating layer, (b) an opaque optical barrier layer adjacent to said photoconductive insulating layer, and (c) a high contrast layer having a thickness of 1 to 50 microns adjacent to said optical barrier layer, said opaque optical barrier layer having a specific resistivity greater than about 10^{10} ohm-cm and comprising from about 10 to about 90 volume percent of finely-divided opaque pigment particles dispersed in a film-forming resinous binder, said optical barrier layer having no significant photoconductive properties and said high contrast layer having a specific resistivity greater than about 10^{10} ohm-cm and a dielectric constant from about 5 to about 50 and comprising a titanium pigment dispersed in a film-forming resinous binder wherein the high contrast layer comprises from about 30 to about 90 volume percent of the pigment, said particles of titanium pigment having a particle size of less than 5 microns and having a refractive index greater than the refractive index of said film-forming binder, said pigment selected from the group consisting of titanium dioxide and compounds having the formulas:

I. M_nTiO_3 II. M_nTiO_4 III. $M_nTi_2O_5$

wherein M represents a metallic element selected from Groups I, II, III and IV of the Periodic Table and n represents an integer within the range of from 1 to 4 depending on the valency of M, said titanium pigment having an average particle size less than about 0.5 microns.

6. The invention as described in claim 5 wherein said optical barrier layer contains a color balancing dye in an amount equal to about 0.1 to about 10 weight percent based on the amount of resin binder and wherein said titanium pigment is selected from the group consisting of titanium dioxide, barium titanates, calcium titanates, lithium titanates, lead titanates, zinc titanates, and mixtures thereof.

7. The invention as described in claim 5 wherein said organic photoconductive insulating layer comprises an organic photoconductive material dispersed in a resinous film-forming binder and a co-crystalline complex of a polycarbonate resin and a pyrylium sensitizing dye.

8. The invention as described in claim 5 wherein said organic photoconductive insulating layer comprises an inorganic photoconductor.

9. A multilayer electrographic element comprising a transparent support bearing (a) a photoconductive insulating layer, (b) an opaque optical barrier layer adjacent to said photoconductive insulating layer, and (c) a high contrast layer having a thickness of less than 50 microns adjacent to said optical barrier layer, said optical barrier layer having a specific resistivity greater than about 10^{10} ohm-cm and comprising from about 10 to about 90 volume percent of finely-divided titanium pigment particles, 90 to about 10 volume percent of a film-forming resinous binder and 20 to 60 weight per-

cent of a dye based on the amount of film-forming resinous binder, said optical barrier layer having no significant photoconductive properties and said finely-divided titanium pigment particles having a refractive index greater than the refractive index of said film-forming resinous binder, said high contrast layer having a specific resistivity greater than about 10^{10} ohm-cm and a dielectric constant from about 5 to about 50 and comprising titanium pigment particles dispersed in a film-forming resinous binder, wherein the high contrast layer comprises from about 30 to about 90 volume percent of the pigment, said particles of titanium pigment having a particle size of less than 5 microns and having a refractive index greater than the refractive index of said film-forming binder, said titanium pigment particles having an average particle size less than 0.5 microns and selected from the group consisting of titanium dioxide and compounds having one of the following formulas:

I. M_nTiO_3 II. M_nTiO_4 and III. $M_nTi_2O_5$

wherein M is a metallic element selected from Groups I, II, III and IV of the Periodic Table and n is an integer within the range of from 1 to 4 depending on the valency of M.

10. The invention as described in claim 9 wherein said organic photoconductive insulating layer comprises an organic photoconductive material dispersed in a resinous film-forming binder and a co-crystalline complex of a polycarbonate resin and a pyrylium sensitizing dye.

11. The invention as described in claim 9 wherein said photoconductive insulating layer comprises an inorganic photoconductor.

12. The invention as described in claim 9 wherein the titanium pigment is selected from the group consisting of titanium dioxide, barium titanates, lithium titanates, calcium titanates, lead titanates, zinc titanates, and mixtures thereof.

13. In an electrographic element comprising a transparent conductive support bearing a photoconductive insulating layer, the improvement which comprises an optical barrier layer overlying said photoconductive layer and a high contrast layer having a thickness of 1 to 50 microns overlying said barrier layer, said optical barrier layer opaque to visible light, possessing a specific resistivity greater than about 10^{10} ohm-cm, and comprising finely-divided opaque particulate material dispersed in a film-forming resinous binder or light scattering particulate matter dispersed in a dyed film-forming resinous binder wherein the optical barrier layer comprises from about 10 to about 90 volume percent of the particulate matter; said optical barrier layer having no significant photoconductive properties and said finely-divided light scattering particulate matter having a refractive index greater than the refractive index of said film-forming resinous binder; said high contrast layer having a specific resistivity greater than about 10^{10} ohm-cm, a dielectric constant from about 5 to about 50, and comprising a finely-divided light-scattering particulate material dispersed in a film-forming resinous binder wherein the high contrast layer comprises from about 30 to about 90 volume percent of the particulate material, said finely-divided light-scattering particulate material having a particle size of less than 5 microns and having a refractive index greater than the refractive index of said resinous binder.

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14. The invention as described in claim 13 wherein said high contrast layer comprises a resinous binder having a dielectric constant greater than about 5.0.

15. The invention as described in claim 13 wherein said high contrast layer comprises a finely-divided light-scattering particulate material having a dielectric constant greater than about 50.

16. The invention as described in claim 13 wherein said high contrast layer has a dry thickness within the range of from about 1 micron to about 50 microns and comprises a finely-divided light-scattering particulate material having a dielectric constant greater than about 50 and a particle size less than about 0.5 micron.

17. In an electrographic process wherein a visible image corresponding to an original image pattern of electromagnetic radiation is formed utilizing a photoconductive element comprising a transparent conductive support bearing a photoconductive insulating layer and an overcoat therefor, the electrographic element being exposed to said image pattern of electromagnetic radiation while the overcoat for said element is subjected to ambient light conditions, the improvement wherein said overcoat comprises an optical barrier layer overlying said photoconductive layer and a high contrast layer having a thickness of 1 to 50 microns

overlying said barrier layer, said optical barrier layer opaque to visible light, possessing a specific resistivity greater than about 10^{10} ohm-cm, and comprising finely-divided opaque particulate material dispersed in a film-forming resinous binder or light-scattering particulate matter dispersed in a dyed resinous binder wherein the optical barrier layer comprises from about 10 to about 90 volume percent of the particulate material; said optical barrier layer having no significant photoconductive properties and said finely-divided light-scattering particulate material having a refractive index greater than the refractive index of said film-forming resinous binder; said high contrast layer having a specific resistivity greater than about 10^{10} ohm-cm, a dielectric constant from about 5 to about 50, and comprising a finely-divided light-scattering particulate material dispersed in a film-forming resinous binder wherein the high contrast layer comprises from about 30 to about 90 volume percent of the particulate material, said light-scattering particulate material having a particle size of less than 5 microns and having a refractive index greater than the refractive index of said film-forming resinous binder.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,816,117 Dated June 11, 1974

Inventor(s) Joseph Y. Kaukeinen

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 5, line 51, "Block" should read --Black--;

Column 6, line 29, "dye" should read --dyed--;

Column 6, line 57, "dyes" should read --dyed--;

Column 7, line 6, that part of the line reading
"6,23, 23, 25, 28," should read --6,23, 24, 25, 28,--;

Column 12, line 66, the second "be" should read --by--;

Column 13, line 42, "douuble" should read --double--.

Signed and sealed this 8th day of October 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents