(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 014 061**
A1

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **80300132.0**

(22) Date of filing: **15.01.80**

(51) Int. Cl.³: **G 03 G 5/14**

(30) Priority: **15.01.79 US 3139**

(43) Date of publication of application: **06.08.80 Bulletin 80/16**

(84) Designated Contracting States: **DE FR GB IT**

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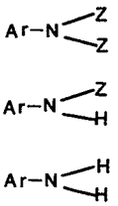
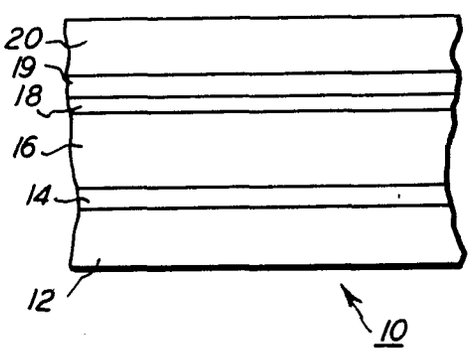
(54) Photosensitive imaging member and method.

(57) A photosensitive imaging member (10) comprises, in order, a support substrate (12); a layer of a charge-injecting material (14); a layer of a charge transporting material (16) into which charges can be injected by the charge-injecting material (14); a layer of a charge-generating material (18) capable of injecting photo-generated charges into, and receiving charges from the charge transporting material (16); a charge-trapping layer (19); and an insulating overlayer (20). The charge-trapping layer preferably contains nitrogen-containing electron-donating molecules, such as aromatic amines having one of the following formulae:



and

wherein Z is Ar or R, Ar being an aromatic radical or a substituted aromatic radical, and R being an aliphatic radical or a substituted aliphatic radical.



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PHOTOSENSITIVE IMAGING MEMBER AND METHOD

This invention relates to a photosensitive imaging member of the kind comprising, in order, a support substrate, a layer of a charge-injecting material, a layer of a charge-transporting material into which charges can be injected by the charge-injecting material, a layer of a charge-generating material capable of injecting photo-generated charges into, and receiving charges from, the charge-transporting material, and an insulating overlayer.

The formation and development of images on the imaging surfaces of photoconductive materials by electrostatic means is well known, one of the most widely used processes being xerography, which is discussed in Carlson U.S. Patent 2,297,691. Numerous types of photoreceptors can be used in the electrophotographic process such photoreceptors including organic materials, inorganic materials and mixtures thereof. Photoreceptors are known wherein the charge carrier generation and charge carrier transport functions are accomplished by discrete contiguous layers. Also known are photoreceptors which include an overcoating layer of an electrically insulating polymeric material and in conjunction with this overcoated type photoreceptor there have been proposed a number of imaging methods. However, the art of electrophotography and more specifically xerography, continues to advance and more stringent demands need to be met by the copying apparatus in order to increase performance standards to obtain higher quality images and to act as protection for the photoreceptor as well as to control the manner and the type of charges that are transported and retained at various levels of the photoreceptor device. In the present invention, there is described in one embodiment an electrophotographic imaging device employing an improved organic electrophotographic imaging member which contains a trapping layer.

A method for utilizing an overcoated photoreceptor device has been recently discovered and is described in UK Patent application No 7906411, published as UK Patent publication No 2015186. In the method described in that application, there is utilized an imaging member comprising a substrate, a layer of a charge carrier injecting electrode

material, a layer of a charge carrier transport material, a layer of a photoconductive charge carrier generating material and an electrically insulating overcoating layer. In one embodiment of operation, the member is charged a first time with electrostatic charges of a first polarity, charged a second time with electrostatic charges of a polarity opposite to the first polarity in order to substantially neutralize the charges residing on the electrically insulating surface of the member and exposed to an imagewise pattern of activating electromagnetic radiation whereby an electrostatic latent image is formed. The electrostatic latent image may then be developed to form a visible image which can be transferred to a receiving member. Subsequently, the imaging member may be reused to form additional reproductions after the erasure and cleaning steps have been accomplished.

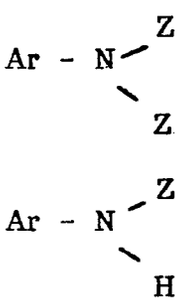
If charges are not substantially retained at the interface between the charge generating layer and the insulating overcoating, the efficiency of the photoreceptor device is adversely affected when such charges are allowed to freely migrate back to the generator layer. If some of the charges are allowed to migrate, they will travel towards the electrode layer (the substrate) and neutralise the opposite charges located between the charge-injecting layer and the charge-transport layer, thus reducing the overall voltage useful for the succeeding imaging process. This would adversely affect the imaging system as well as lower the efficiency of the device and render the cyclic characteristics of such device unstable. Depending on the amount and the frequency with which the charges travel throughout the system, the amount of charges retained at the generator/insulator interface varies, resulting in cyclic instability.

The present invention is intended to overcome this problem, and accordingly provides a photosensitive imaging member which is characterised by a charge-trapping layer between the layer of charge-generating material and the insulating overlayer.

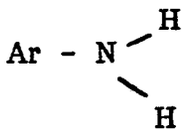
The charge-trapping layer prevents charges from migrating from the interface between the charge-generating layer and the insulating overlayer to the injecting electrode so as to improve image quality and reduce dark decay and improve cyclability of the photoreceptor device.

Preferably, the trapping layer comprises electron-donating molecules, which may be incorporated into a layer comprising adhesive polymers. The trapping layer of the photoresponsive device is of substantial importance as mentioned hereinbefore, its main function being to trap holes, that is, positive charges, thus the material used in this layer must be capable of emitting electrons in order that the positive charges will be trapped, that is, remain in position at the interface between the generating layer and the overcoating insulating layer. The photoresponsive device may remain photosensitive without the trapping layer, however, higher fields will be needed in order to render the device efficient, the disadvantage of using higher fields being that it causes breakdown in the system and more ozone is generated thus posing an environmental problem in some situations. It is preferable to use lower voltages as the system is more efficient and more stable and further with the hole trapping layer, the dark decay of the system, that is leakage of charges, will improve significantly so as to substantially eliminate such dark decay.

The hole trapping material can be any nitrogen containing electron donating molecules which donate sufficient electrons so as to accomplish the above objectives while at the same time not adversely affecting the imaging device and allowing cyclic stability of the photoreceptor device. Generally, most organic electron donor materials can be used, that is, materials that will emit or readily give up electrons. In one embodiment of the present invention, there is employed, as the nitrogen containing electron donating molecules, aromatic amines selected from the group consisting of those within the following formulas:

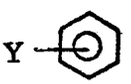


and



wherein Z is Ar or R, R being an aliphatic radical or substituted aliphatic radicals, and Ar is an aromatic radical or a substituted aromatic radical, the substituents including for example alkyl, alkylene, halogen, and the like. Examples of aliphatic materials include saturated as well as unsaturated radicals such as alkyl, of from 1 to about 20 carbon atoms, alkylene of from 2 to about 24 carbon atoms. Illustrative examples of such radicals include methane, ethane, propane, butane, isobutane, pentane, neopentane, heptane, decane, tetradecane, eicosane, ethylene, propylene, butylene, alphabutylene, pentylene, heptylene, decylene, pentadecylene, and the like. The substituted alkyl or alkylene radicals include those mentioned above. Examples of halogen materials include chloride, bromide, iodide and fluoride. Illustrative examples of aromatic radicals include those containing from about 6 to about 20 carbon atoms such as phenyl, napthyl anthryl and the like. Polymeric nitrogen containing electron donating molecules are also useful trapping layers within the scope of the present invention.

In one embodiment the aromatic substituted materials are of the following formula:



wherein Y is an aliphatic radical, or a halogen, as defined herein.

Illustrative examples of specific materials which may be used as the trapping layer of the present invention, it being noted that these examples are not all inclusive, and other similar or equivalent materials can be utilized, include triphenylamine, 2-methyl triphenylamine, 4-methyl triphenylamine, tri-p-tolyamine, diphenylamine, p-bromoaniline, poly(2-vinyl pyridine), polyvinylpyrrolidone, l-dimethylaminonapthylene, 2-amino anthracene, nigrosine, induline, methylene blue, pheno safranine, congo red, indigo blue, capri blue, polyethyleneimine, l-amino-pyrene, 5,6-benzo quinoline, imino dibenzyl, Nphenyl-l-naphthyl amine, and the like.

Although the hole trapping materials described are aromatic type substances, certain aliphatic electron donor molecules particularly aliphatic amines wherein the aromatic nucleus is replaced by an aliphatic radical in the above-mentioned formula can be used in the present invention in certain instances as long as the particular aliphatic amine does not adversely affect

the objects of the invention and performs as an efficient trapping layer so as to improve cyclability.

The hole trapping layer in one embodiment is prepated by coating this layer on the surface of the charge-generating layer followed by application of a laminated material containing an adhesive layer and an insulating overcoat layer such as Mylar. In another embodiment, where the trapping layer is not a discrete layer but is combined with an adhesive material, the trapping molcecules are dispersed in an adhesive polymer and this layer is then applied to the insulating film. In this way the hole trapping layer can be effectively adhered to the generating layer by lamination.

The thickness of the hole trapping layer can range over a wide spectrum and also depends on the manner in which the hole trapping layer is applied. For example, when a lamination process is used, and the hole trapping layer is coated on the generating layer, the thickness of the hole trapping layer ranges from about 0.005 to 1 micron and preferably from about 0.05 to 0.2 microns, while when the hole trapping layer is incorporated into an adhesive material, the trapping layer ranges in thickness from about 1 to 15 microns and preferably from 3 to about 8 microns. The thickness of the adhesive layer when it is employed as a separate layer and is not part of the hole trapping layer ranges from about 1 to about 15 microns and preferably from about 3 to about 8 microns.

In one preferred embodiment of the present invention, the photoresponsive device comprises a hole trapping layer sandwiched in between a generator layer , an adhesive layer and/or an overcoating insulating layer , the remaining portions of the photoreceptor device being comprised of a substrate, a hole injecting electrode layer thereover comprised of carbon black dispersed in a polymer, a charge transport layer comprised of an electrically inactive organic polymer having dispersed therein an electrically active material, the combination of which is substantially nonabsorbing to visible electromagnetic radiation but allows the injection of photogenerated holes from a charge generating layer in contact with the hole transport layer which layer is overcoated with the charge generating material previously described.

A photosensitive imaging member in accordance with the invention, and a method of using it, will now be described with reference to the accompanying drawing, in which:-

Figures 1 and 1A are partially schematic cross-sectional views of two embodiments of the imaging member; and

Figures 2A to 2C illustrate the various method steps employed in using the imaging member.

Illustrated in Figure 1 is a photoreceptor generally designated 10, comprising a substrate 12, a layer of charge injecting electrode material 14, a layer of charge carrier transport material 16, a layer of photoconductive charge carrier generating material 18, a layer of trapping material 21, a layer of adhesive material 22, and a layer of electrically insulating polymeric material 20, it being noted that the layer of adhesive material 22 can be coated on the electrically insulating polymeric material in one embodiment. Figure 1A illustrates a similar type of photoreceptor with the exception that the layer of trapping material is represented by 19, this layer being comprised of a combination of trapping and adhesive materials.

Substrate 12 may be opaque or substantially transparent and may comprise any suitable material having the requisite mechanical properties. The substrate may comprise a layer of non-conducting material such as an inorganic or organic polymeric material; a layer of an organic or inorganic material having a conductive surface layer arranged thereon or a conductive material such as, for example, aluminum, brass or the like. The substrate may be flexible or rigid and may have any of many different configurations such as, for example, a plate, a cylindrical drum, a scroll, an endless flexible belt, and the like. Preferably, the substrate is in the form of an endless flexible belt.

The thickness of this layer can vary but generally is from 75 microns to 2.5 mm and preferably from about 75 to 250 microns although thicknesses of over 2.5 mm and less than 75 microns can be used.

Charge carrier injecting electrode layer 14 must be capable of injecting charge carriers or holes into the transport layer 16 under the influence of an electrical field. The charge carrier injecting electrode layer may be sufficiently laterally conductive to also function as the ground electrode for the photoreceptor and in such a situation a separate additional conductive

layer is not necessary.

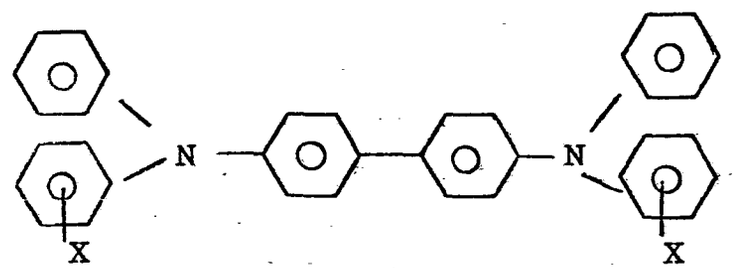
Numerous materials can be used as the charge injecting electrode layer including those materials (such as for example, gold, graphite, carbon black or graphite dispersed in various polymer resins and the like) which effectively inject holes that is positive charges, into the transport layer. These materials are capable of injecting holes under the influence of an electrical field. In a preferred embodiment, carbon black or graphite dispersed in various polymers is used as the injecting electrode, this charge injecting electrode being prepared as described in copending UK Patent application No 7916357, published as UK Patent publication No 2023298 which in one method involves solution casting of a mixture of carbon black or graphite dispersed in an adhesive polymer solution onto a support substrate such as Mylar or aluminized Mylar. The hole injecting electrode which is preferably carbon black or graphite dispersed in a polymer also functions as a permanent adhesive between the substrate and the organic transport layer. Thus, the injecting layer does not have a tendency to peel off, that is to be separated from the transport and support layer so that the quality of the image is not adversely effected after repetitive useage. Gold, silver and other such materials when used as the injecting electrode, perform satisfactorily, however, they do not adhere as well as carbon or graphite dispersed in a polymer. One other advantage of using carbon black and graphite in polymers is that these materials are rather inexpensive when compared to gold, for example, are more readily available and function in some instances more effectively than gold.

Illustrative examples of polymers that can be used as the material within which the carbon black or graphite is dispersed include, for example, polyesters such as PE-100 commercially available from Goodyear Chemical Company. Other polyester materials that are useful include those materials classified as polymeric esterification products of a dicarboxylic acid and a diol comprising a diphenol. Typical diphenols include 2,2-bis(4-beta hydroxy ethoxy phenyl)-propane, 2,2-bis(4-hydroxy isopropoxy phenyl)propane, 2,2-bis(4-beta hydroxy ethoxy phenyl)pentane, 2,2-bis(4-beta hydroxy ethoxy phenyl) butane and the like, while typical dicarboxylic acids include oxalic acid, malonic acid, succinic acid, adipic acid, phthalic acid, terephthalic acid, maleic acid, fumaric acid and the like. Any polyester or other polymeric materials may be used providing they do not adversely affect the system and allow a uniform dispersion of the carbon black or graphite therein.

The hole injecting layer has a thickness in the range of from about 1 to about 20 microns or more with the preferred range being from about 4 microns to about 10 microns. The maximum thickness is generally determined by the mechanical properties desired. The charge carrier injecting materials and charge carrier transport materials require a particular work function relationship in order that hole injection from the former into the latter can be effectively accomplished. Normally the hole injecting materials have a relatively high work function.

The ratio of polymer to carbon black or graphite ranges from about 0.5 to 1 to 2 to 1 with a preferred ratio of about 6 to 5.

The charge carrier transport layer 16 can be any number of numerous suitable materials which are capable of transporting holes, this layer generally having a thickness in the range of from about 5 to about 50 microns and preferably from about 20 to about 40 microns. In a preferred embodiment this transport layer comprises molecules of the formula:



dispersed in a highly insulating and transparent organic polymeric material wherein X is selected from the group consisting of (ortho) CH_3, (meta) CH_3, (para) CH_3, (ortho) Cl, (meta) Cl, (para) Cl. This charge transport layer, which is described in detail in copending UK Patent application No 34705/77 is substantially non-absorbing in the spectral region of intended use, i.e., visible light, but is "active" in that it allows injection of photogenerated holes from the charge generator layer and electrically induced holes from the injecting electrode. The highly insulating polymer, which has a resistivity of at least 10^{12} ohm-cm to prevent undue dark decay, is a material which is not necessarily capable of supporting the injection of holes from the injecting or generator layer and is not capable of allowing the transport of these holes through the material. However, the polymer becomes electrically active when it contains from about 10 to 75 weight percent of

the substituted N,N,N',N'-tetraphenyl-[1,1'-biphenyl] 4-4'-diamines corresponding to the foregoing formula. Compounds corresponding to this formula include, for example, N,N'-diphenyl-N,N'-bis(alkyl-phenyl)-[1,1-biphenyl] -4,4-diamine wherein the alkyl is selected from the group consisting of methyl such as 2-methyl, 3-methyl and 4-methyl, ethyl, propyl, butyl, hexyl and the like. In the case of chloro substitution, the compound is named N,N'-diphenyl-N,N'-bis (halo phenyl)-[1,1'-biphenyl] -4,4'-diamine wherein the halogen atom is 2-chloro, 3-chloro or 4-chloro.

Other electrically active small molecules which can be dispersed in the electrically inactive polymer to form a layer which will transport holes include triphenylmethane, bis-(4-diethylamino-2-methylphenyl) phenylmethane; 4',4"-bis(diethylamino)-2,2"-dimethyltriphenyl methane; bis-4(-diethylamino phenyl) phenylmethane; and 4,4'-bis(diethylamino)-2,2'-dimethyltriphenylmethane.

Transport layer 16 may comprise any electrically inactive binder polymeric material such as those described by Middleton et al, in U.S. Patent 3,121,006 . The polymeric binder contains from 10 to 75 weight percent of the active material corresponding to the foregoing formula and preferably from about 35 to about 50 weight percent of this material. Typical organic polymeric materials useful as the binder include polycarbonates, acrylate polymers, vinyl polymers, cellulose polymers, polyesters, polysiloxanes, polyamides, polyurethanes and epoxies as well as block, random or alternating copolymers thereof. Preferred electrically inactive binder materials are polycarbonates having a molecular weight (M_w) of from about 20,000 to about 100,000 with a molecular weight in the range of from about 50,000 to about 100,000 being particularly preferred.

Photoconductive charge carrier generating layer 18 generally may comprise any photoconductive charge carrier generating material known for use in electrophotography provided it is electronically compatible with the charge carrier transport layer and the charge carriers can travel in both directions across the interface between the two layers. Particularly preferred photoconductive charge carrier generating materials include materials such as phthalocyanines like metal free, for example, the X-form of phthalocyanine, or metal phthalocyanines including vanadyl phthalocyanine. These materials can be used alone or as a dispersion in a polymeric binder. Layer 18 is typically from about 0.5 to about 10 microns or more in thickness. Generally,

it is desired to provide this layer in a thickness which is sufficient to absorb at least 90 percent (or more) of the incident radiation which is directed upon it in the imagewise exposure step.

Electrically insulating overcoating layer 20 typically has a bulk resistivity of from about 10^{12} to about 5×10^{14} ohm-cm and typically is from about 5 to about 25 microns in thickness. Generally, this layer provides a protective function in that the charge carrier generating layer is kept from being contacted by toner and ozone which is generated during the imaging cycles. The overcoating layer also must prevent charges from penetrating through it into charge carrier generating layer 18 or from being injected into it by the latter. Preferably, therefore, layer 20 comprises materials having higher bulk resistivities. Generally, the minimum thickness of the layer in any instance is determined by the functions the layer must provide whereas the maximum thickness is determined by mechanical considerations and the resolution capability desired for the photoreceptor. Typical suitable materials include Mylar (a polyethylene terephthalate film commercially available from E. I. duPont de Nemours), polyethylenes, polycarbonates, polystyrenes, polyesters, polyurethanes and the like. The particular material selected in any instance should not be one which will dissolve or react with the materials used in layers 16 and 18.

The formation of the electrically insulating layer 20 over the previous layer may be carried out by lamination or solution coating, where layer 20 constitutes a preformed mechanically tough film, it is typically necessary to provide sufficient adhesive material in order to provide an integral structure which is desirable for use in a repetitive imaging method. The electrical properties of any such adhesive interlayer should be similar to those of the overcoating. Alternatively, they may be similar to the binder material of the charge carrier generating layer 18 where a binder material is present in that layer. Mechanically, the adhesive interlayer should provide an adhesive state that firmly binds the layers together without any air gaps or the like which could disturb image definition.

The charge carrier injecting electrode material which comprises layer 14 is a hole injecting material such as graphite, gold, and carbon or graphite dispersed in a polymer and the initial charging step is carried out with negative polarity. More specifically, there is represented in Figure 2A the condition of the photoreceptor after it has been electrically charged nega-

tively a first time in the absence of illumination by any suitable electrostatic charging apparatus such as a corotron. The negative charges reside on the surface of electrically insulating layer 20. As a consequence of the charging, an electrical field is established across the photoreceptor and as a consequence of the electrical field, holes are injected from the charge carrier injecting electrode layer into the charge carrier transport layer. The holes injected into the charge carrier transport layer are transported through the layer, enter into the charge carrier generating layer 18 and travel through the latter until they reach the interface between the charge carrier generating layer 18 and the hole trapping layer where they become trapped. The charges are thus substantially trapped at the interface, and establish an electrical field across the electrically insulating layer 20, therefore, where negative charging is carried out in the first charging step, charge carrier injecting layer 14 and charge carrier transport layer 16 must comprise materials which will allow injection of holes from the former into the latter and charge transport layer 16 comprises materials which will predominantly transport holes. The charge carrier transport layer 16 and the charge carrier generating layer 18 must comprise materials which will allow injection of holes from the former into the latter and allow the holes to travel to the interface between layer 18 and hole trapping layer 19 or 21. Generally, the electrical field established by the first charging is in the range of from 10 volts/micron to about 100 volts/micron.

Subsequently, the member is charged a second time in the absence of illumination with a polarity opposite to that employed in the first charging step for the purpose of substantially neutralizing the charges residing on the surface of the member. The second charging of the member in this embodiment is effected with positive polarity. Subsequent to the second charging step, the surface of the photoreceptor should be substantially free of electrical charges. The substantially neutralized surface is created by selecting a charging voltage based on the dielectric thickness ratio of the overcoating layer 20, plus the hole trapping layer 19, or 21 and 22 to the total of the charge carrier transport and charge carrier generating layers 16 and 18 respectively. By substantially neutralized is meant that the voltage across the photoreceptor member upon illumination of the photoreceptor may be brought to substantially zero.

In Figure 2B, there is illustrated the condition of the photoreceptor after the second charging step, wherein no charges are shown on the

surface of the member. The positive charges residing at the interface of layers 18 and 19 in Fig. 1A or layers 18 and 21 in Fig. 1 as a result of the first charging step remain substantially trapped at that interface at the conclusion of the second charging step. However, there is now a uniform layer of negative charges located at the interface between layers 14 and 16. The net result of the second charging step is to establish a uniform electrical field across the charge carrier transport and charge carrier generating layers. In order to obtain this result, it is important that the negative charges be located at the interface between the charge carrier injecting layer 14 and charge carrier transport layer 16 and prevented from entering into the transport layer. For this reason, it is preferred to utilize a charge carrier transport material which will transport only one species of charge carrier, holes in this situation. Where a charge carrier transport material capable of transporting both species of charge carriers is employed, in layer 16, the charge carrier injecting material would have to be selective so that the latter would be unable to inject electrons into layer 16 thus placing constraints on the selections of materials.

The member is then exposed to an imagewise pattern of electromagnetic radiation (Figure 2C) to which the charge carrier generating material comprising layer 18 is responsive. Exposure of this member is accomplished through the electrically insulating overcoating. As a result of the imagewise exposure an electrostatic latent image is formed in the photoreceptor as the hole electron pairs are generated in the light struck areas of the charge carrier generating layer. The light generated holes are injected into the charge carrier transport layer and travel through it to be neutralized by the negative charges located at the interface between layers 14 and 16 whereas the light generated electrons neutralize the positive charges trapped at the interface between layers 18 and 19 or 21. In the areas of the member which did not receive any illumination, the positive charges remain in their original position, thus there continues to be an electrical field across the charge carrier transport and charge carrier generating layers in the areas which do not receive any illumination whereas the electrical field across the same layers in the areas which did receive illumination is discharged to some low level.

The electrostatic latent image formed in the member may be developed to form a visible image by any of the well known xerographic development techniques, for example, cascade, magnetic brush, liquid devel-

opment and the like. The visible image is typically transferred to a receiver member by any conventional transfer technique and affixed thereto. While it is preferably to develop the electrostatic latent image with marking material the image may be used in a host of other ways such as, for example, "reading" the latent image with an electrostatic scanning system.

When the photoreceptor is to be reused to make additional reproductions as is the case in a recyclible xerographic apparatus any residual charge remaining on the photoreceptor after the visible image has been transferred to a receiver member typically is removed therefrom prior to each repetition of the cycle as is any residual toner material remaining after the transfer step. Generally, the residual charge can be removed from the photoreceptor by ionizing the air above the electrically insulating overcoating of the photoreceptor while the photoconductive carrier generating layer is uniformly illuminated and grounded. For example, charge removal can be effected by A.C. corona discharge in the presence of illumination from a light source or preferably a grounded conductive brush could be brought into contact with the surface of the photoreceptor in the presence of such illumination. This latter mode also will remove any residual toner particles remaining on the surface of the photoreceptor.

Examples of adhesive materials layer 22 or as part of layer 19 include polyesters such as those commercially available from E. I. duPont Co. (re Dupong Polyester 49000), polyurethanes and the like).

The invention will now be described in detail with respect to specific preferred embodiments thereof, it being understood that these Examples are intended to be illlustrative only and the invention is not intended to be limited to the materials, conditions, process parameters, etc., recited herein. All parts and percentages are by weight unless otherwise indicated.

EXAMPLE I

A photoreceptor was fabricated using an approximately 125 micron thick Mylar substrate. A charge injecting composition was formed by preparing a 12 percent solution of PE-100 polyester resin available from Goodyear Chemicals in chloroform, adding to it approximately about 10 percent by weight of carbon black and ball milling the mixture for about 24 hours with steel shot. An approximately 4-6 micron thick layer of the composition was deposited on the Mylar substrate and the sample was then dried to remove residual solvents.

An approximately 25 micron thick charge carrier transport layer made up of N,N'-diphenyl-N,N'-bis (3-methylphenyl)-[1,1'-biphenyl] -4-4' diamine in a polycarbonate binder (1:1 ratio) was formed on the carbon black layer by solvent coating from a methylene chloride solution using a draw bar coating technique. The member was then dried in a vacuum oven at a temperature of about 70°C for about 24 hours.

A charge carrier generating layer comprised of a dispersion of 5 percent DuPont 49000 polyester and a 2.3 percent X-metal free phthalocyanine in methylene chloride was applied as an overcoat to the transport layer followed by drying. A 1 percent alcoholic solution of Nigrosine was applied on the surface of the charge carrier generating layer followed by drying to form the hole trapping layer and finally an approximately 12.5 micron thick layer of Mylar film having a polyester adhesive preapplied thereto was laminated to the hole trapping layer.

The photoreceptor was charged at a first time with a potential of -400 volts and then charged a second time with a potential of +800 volts. The photoreceptor was then uniformly illuminated with white light. Electrical measurements show that the field across the photoreceptor was discharged to substantially zero potential. The process was repeated successfully for more than two thousand times thus indicating that the photoreceptor is suitable for use according to the method of the present invention.

When the hole trapping layer was used in the photoreceptor device, excellent cyclic stability was obtained thus allowing the production of continuous images of high quality in a commercial copying machine in excess of five thousand copies. Therefore images of high quality were immediately obtained and there was no waiting period as compared with when no trapping layer is used, the cyclic stability is not maximized and there is a waiting period prior to achieving the cyclic stability desired in order that improved images of high quality can be produced.

EXAMPLE II

A photoreceptor was fabricated by coating an approximately 175 micron thick Mylar substrate with an approximately 8 micron layer of the conductive hole injecting composition as described in Example I by the same technique. An approximately 27 micron thick hole transport layer and 3 micron thick charge carrier generating layer of the same compositions as used in the previous example were deposited successively over the conductive hole in

jecting layer by solvent coating according to the procedures described in Example I.

The hole trapping material was incorporated into the laminating adhesive layer by mixing 0.5 percent by weight of Nigrosine with a solution of DuPont 46923 adhesive polyester. The resulting solution was coated on a 12.5 micron transparent Mylar film to form an approximately 4 micron thick trapping adhesive layer. Finally the Mylar film was laminated over the charge carrier generating layer. This photoreceptor was charged a first time with a potential of -480 volts and then charged a second time with a potential of +1160 volts and subsequently the photoreceptor was then uniformly illuminated with white light. Electrical measurements show that the field across the photoreceptor was discharged to substantially zero potential, thus indicating that the photoreceptor was suitable for use according to the present invention.

When the hole trapping layer was used in the photoreceptor device, excellent cyclic stability was obtained thus allowing the production of continuous images of high quality in a commercial copying machine in excess of five thousand copies. Therefore images of high quality were immediately obtained and there was no waiting period as compared with when no trapping layer is used, the cyclic stability is not maximized, and there is a waiting period prior to achieving the cyclic stability desired in order that improved images of high quality can be produced.

EXAMPLE III

The procedure of Example I was repeated with the exception that Induline 3B • HCl was used in place of the Nigrosine and substantially resolution resulted and improved cyclability was achieved. Also the photoreceptor was charged in accordance with the potentials of Example I with substantially similar results thus indicating that the photoreceptor is suitable for use according to the methods of the present invention.

EXAMPLE IV

The procedure of Example II was repeated with the exception that the trapping material used was methylene blue in place of the Nigrosine and substantially similar results were obtained, that is images of high quality and excellent resolution resulted and improved cyclability was achieved. Also the photoreceptor was charged in accordance with the potentials of Example I with substantially similar results thus indicating that the photoreceptor is suitable for use according to the methods of the present invention.

EXAMPLE V

The procedure of Example II was repeated with the exception that Induline 3B • HCl was used in place of the Nigrosine and substantially similar results were obtained, that is images of high quality and excellent resolution resulted and improved cyclability was achieved. Also the photoreceptor was charged in accordance with the potentials of Example I with substantially similar results thus indicating that the photoreceptor is suitable for use according to the methods of the present invention.

EXAMPLE VI

The procedure of Example II was repeated with the exception that diphenylamine (9.2 weight percent) was used in place of the Nigrosine and substantially similar results were obtained, that is images of high quality and excellent resolution resulted and improved cyclability was achieved. Also the photoreceptor was charged in accordance with the potentials of Example I with substantially similar results thus indicating that the photoreceptor is suitable for use according to the methods of the present invention.

EXAMPLE VII

The procedure of Example II was repeated with the exception that p-bromoaniline (9.2 weight percent) was used in place of the Nigrosine and substantially similar results were obtained, that is images of high quality and excellent resolution resulted and improved cyclability was achieved. Also the photoreceptor was charged in accordance with the potentials of Example I with substantially similar results thus indicating that the photoreceptor is suitable for use according to the methods of the present invention.

EXAMPLE VIII

The procedure of Example II was repeated with the exception that polyvinylpyrrolidone (9.2 weight percent) was used in place of the Nigrosine and substantially similar results were obtained, that is images of high quality and excellent resolution resulted and improved cyclability was achieved. Also the photoreceptor was charged in accordance with the potentials of Example I with substantially similar results thus indicating that the photoreceptor is suitable for use according to the methods of the present invention.

EXAMPLE IX

The procedure of Example II was repeated with the exception that phenazine was used in place of the Nigrosine and substantially similar results were obtained, that is images of high quality and excellent resolution

resulted and improved cyclability was achieved. Also the photoreceptor was charged in accordance with the potentials of Example I with substantially similar results thus indicating that the photoreceptor is suitable for use according to the methods of the present invention.

EXAMPLE X

The procedure of Example II was repeated with the exception that triphenylamine (9 weight percent) was used in place of the Nigrosine and substantially similar results were obtained, that is images of high quality and excellent resolution resulted and improved cyclability was achieved. Also the photoreceptor was charged in accordance with the potentials of Example I with substantially similar results thus indicating that the photoreceptor is suitable for use according to the methods of the present invention.

EXAMPLE XI

The procedure of Example II was repeated with the exception that in place of the Induline 3B • HCl there was used a polyethyleneamine (9 weight percent) in place of the Nigrosine and substantially similar results were obtained, that is images of high quality and excellent resolution resulted and improved cyclability was achieved. Also the photoreceptor was charged in accordance with the potentials of Example I with substantially similar results thus indicating that the photoreceptor is suitable for use according to the methods of the present invention.

EXAMPLE XII

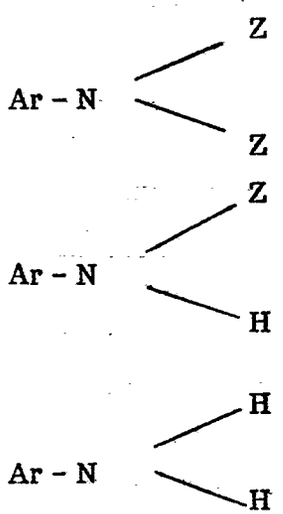
The procedure of Example II was repeated with the exception that 5,6-benzo quinoline, a tertiary amine was used in place of the Induline 3B • HCl and substantially similar results were obtained, that is images of high quality and excellent resolution resulted and improved cyclability was achieved. Also the photoreceptor was charged in accordance with the potentials of Example I with substantially similar results thus indicating that the photoreceptor is suitable for use according to the methods of the present invention.

CLAIMS:

1. A photosensitive imaging member comprising, in order, a support substrate (12), a layer of a charge-injecting material (14), a layer of a charge-transporting material (16) into which charges can be injected by the charge-injecting material (14), a layer of a charge-generating material (18) capable of injecting photo-generated charges into, and receiving charges from, the charge-transporting material (16), and an insulating overlayer, (20) characterised by a charge-trapping layer (21 or 19) between the layer of charge-generating material (18) and the insulating overlayer (20).

2. An imaging member according to Claim 1 wherein the trapping layer comprises nitrogen-containing electron-donating molecules.

3. An imaging member according to Claim 2 wherein the nitrogen-containing electron-donating molecules are of one of the following formulae:



wherein Z is Ar or R, Ar being an aromatic radical or a substituted aromatic radical, and R being an aliphatic radical or a substituted aliphatic radical.

4. An imaging member according to Claim 3 wherein Z is R, and R is an alkyl radical of from 1 to about 20 carbon atoms or an alkylene radical of from 2 to about 24 carbon atoms, and Ar is phenyl.

5. An imaging member according to Claim 3, wherein aliphatic R radicals, and the aromatic radicals, Ar, contain substituents selected from aliphatic radicals, and halogen.

6. An imaging member according to Claim 1, wherein the material is Nigrosine, methylene blue, 5,6-benzoquinoline, triphenyl amine, Induline 3B• HC1, diphenylamine, or p-bromoaniline.

7. An imaging member according to any one of Claims 1 to 6, wherein said trapping layer contains as an additional ingredient an adhesive material as part of the same layer.

8. An electrophotographic imaging method utilizing the imaging member of any one of Claims 2 to 7 characterized by charging the imaging member with negative electrostatic charges, charging the imaging member with positive electrostatic charges in order to substantially neutralise the negative charge residing on the surface of the imaging member, and exposing the imaging member to an imagewise pattern of electromagnetic radiation to which the charge generating material is responsive, whereby there is formed an electrostatic latent image within the imaging member.

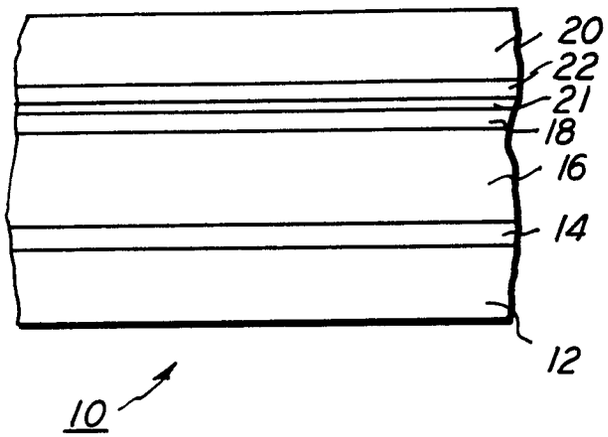


FIG. 1

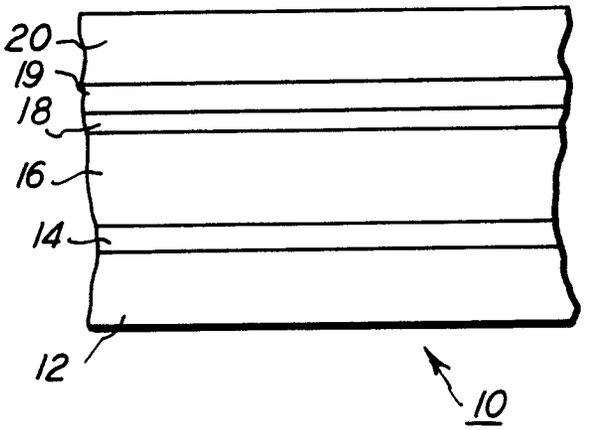


FIG. 1A

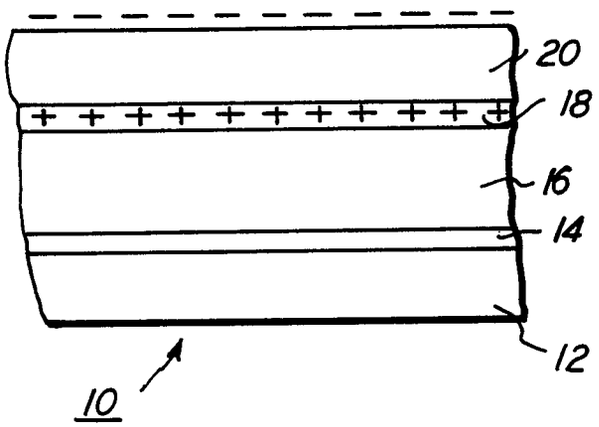


FIG. 2A

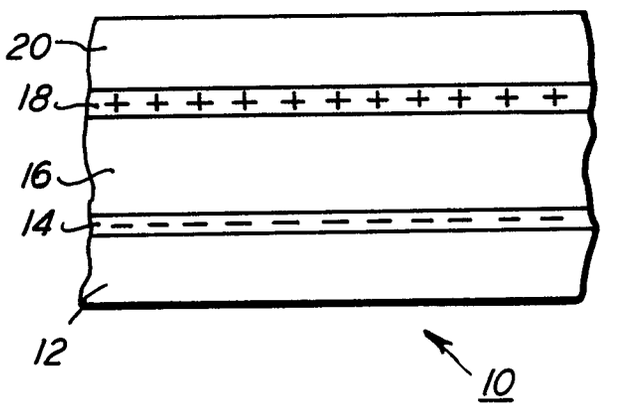


FIG. 2B

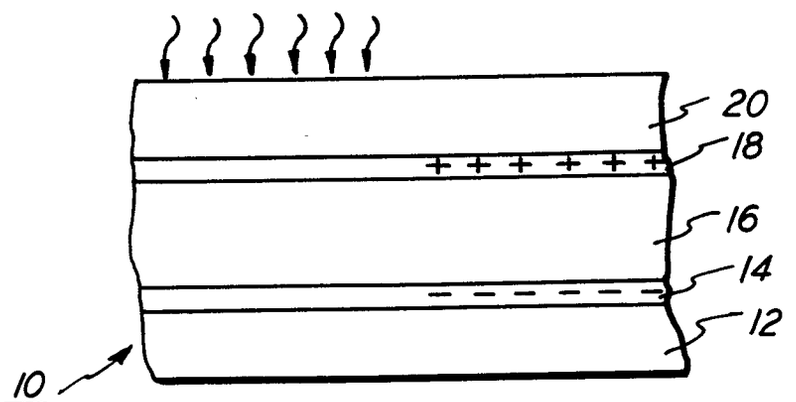


FIG. 2C

European Patent Office

EUROPEAN SEARCH REPORT

0014061

Application number

EP 80 30 0132

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	GB - A - 1 507 493 (XEROX) * Claims; figures; page 2, line 64 - page 3, line 35 *	1
	GB - A - 1 137 766 (XEROX) * Claims; figures; page 2, line 55 - page 3, line 12 *	1-6
	GB - A - 1 335 699 (CANON) * Claims; figure 8; page 5, lines 4-130 *	1
	FR - A - 2 254 050 (XEROX) * Claims *	1
	DE - A - 2 337 295 (HOECHST) * Claims; figure 3; page 4, paragraph 3 - page 10, paragraph 1 *	1,7
	US - A - 3 989 520 (J. ROCHLITZ) * Claims; abstract; figure 2; column 3, line 52 - column 4, line 9 *	1
	DERWENT JAPANESE PATENTS REPORT, vol. R, no. 33, 6th October 1970 London, G.B. part G, page 3, column 2, last paragraph, abstract no. 58676R	8

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CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)

G 03 G 5/14

TECHNICAL FIELDS SEARCHED (Int.Cl. ³)

G 03 G 5/14
5/06

CATEGORY OF CITED DOCUMENTS

X. particularly relevant
A. technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	29-04-1980	VANHECKE

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DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
	& JP - B - 70 24916 (CANON) * Entire abstract * ----		TECHNICAL FIELDS SEARCHED (Int. Cl. 3)