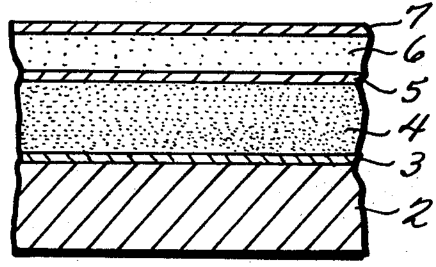
Nov. 28, 1972 KATSUO MAKINO ET AL 3,704,121

ELECTROPHOTOGRAPHIC REPRODUCTION PROCESS USING A DUAL LAYERED PHOTORECEPTOR

Filed Sept. 19, 1969 2 Sheets-Sheet 1

Fig. 1



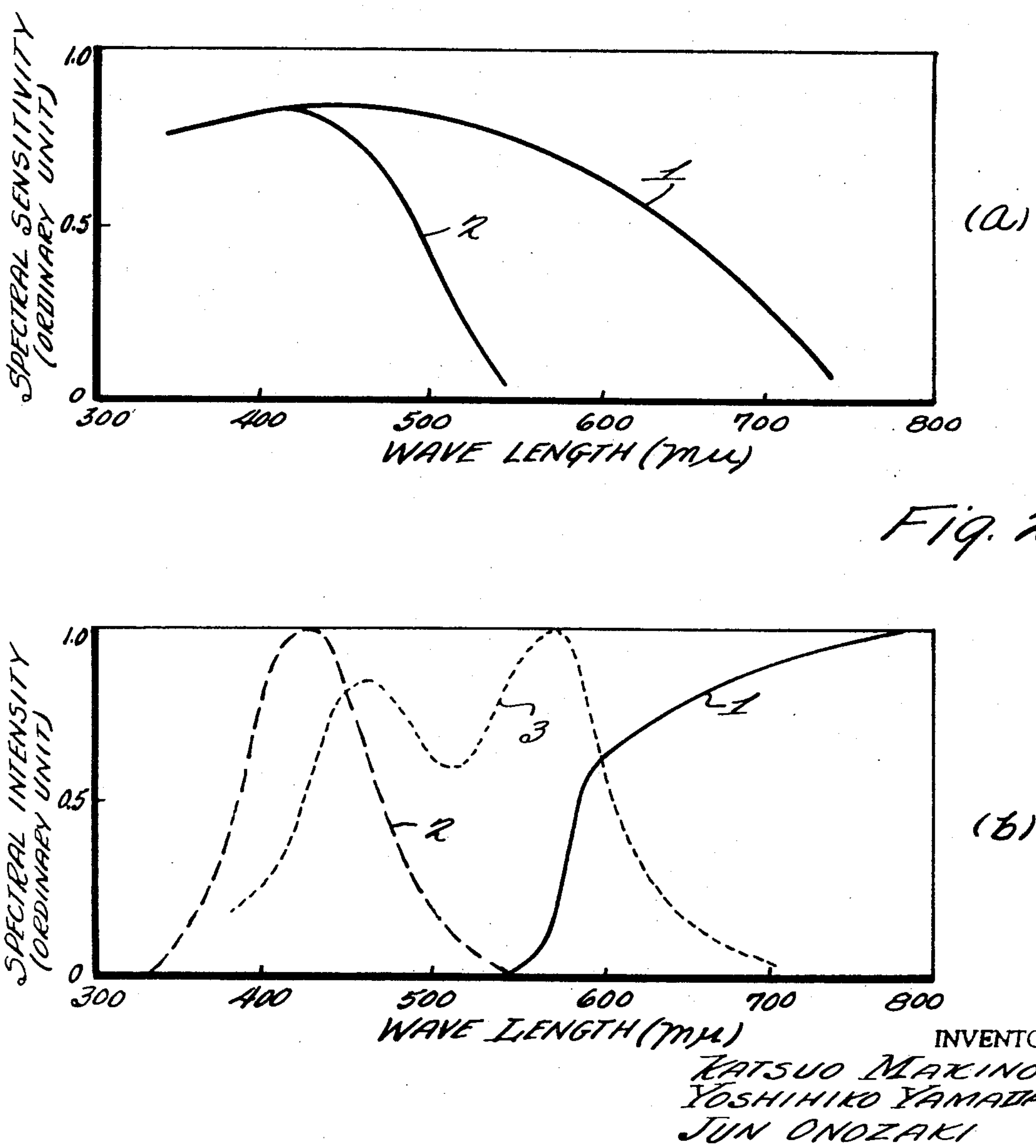
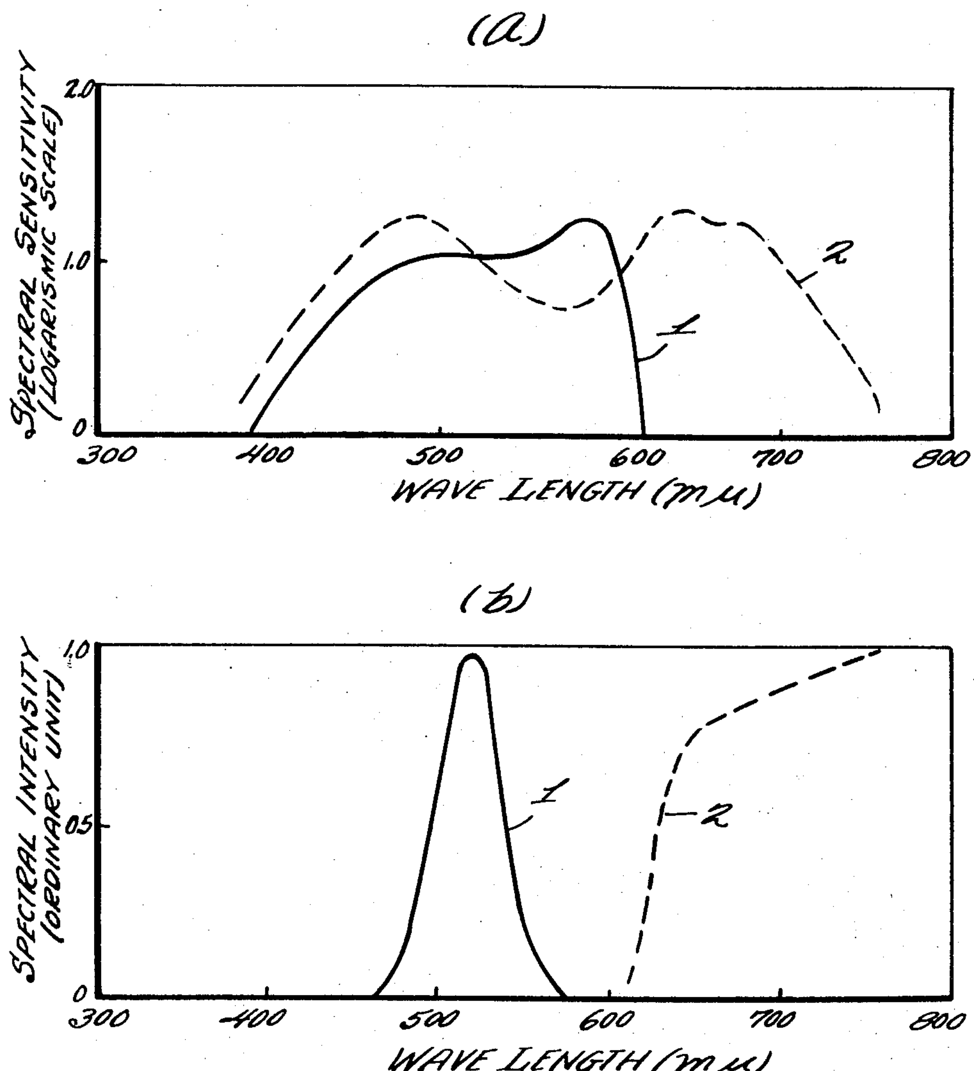


Fig. 2

INVENTORS
KATSUO MAKINO
YOSHIHIKO YAMADA
JUN ONOZAKI

BY
Addams & Ferguson
ATTORNEYS

FIG. 3



INVENTORS
KATSUO MAKINO
YOSHIHIKO YAMADA
JUN ONOZAKI
BY
Addams & Ferguson
ATTORNEYS

United States Patent Office

3,704,121
Patented Nov. 28, 1972

1

3,704,121

ELECTROPHOTOGRAPHIC REPRODUCTION PROCESS USING A DUAL LAYERED PHOTORECEPTOR

Katsuo Makino, Yoshihiko Yamada, and Jun Onozaki, Kanagawa, Japan, assignors to Fuji Photo Film Co., Ltd., Kanagawa, Japan

Filed Sept. 19, 1969, Ser. No. 859,333
Claims priority, application Japan, Sept. 21, 1968, 43/68,510
Int. Cl. G03g *5/00*
U.S. Cl. 96—1 7 Claims

ABSTRACT OF THE DISCLOSURE

Process of electrophotography using a photosensitive member having two photoconductive layers, at least a portion of the range of the spectral sensitivity of the one photoconductive layer being different from at least a portion of the range of the spectral sensitivity of the other photoconductive layer comprising the steps of applying electrostatic charges having opposite polarities in any desired pattern to a surface of one of the two photoconductive layers and to the boundary between the above described two photoconductive layers or a region adjacent thereto, respectively, thereby forming an electrostatic field in the above-mentioned one photoconductive layer, applying mobile electric charges to the above-mentioned one photoconductive layer while it is exposed to a light bearing therein an image to be recorded, the light being of such characteristics that the above-mentioned one photoconductive layer is not rendered substantially photoconductive while the other photoconductive layer is rendered to phoconductive, thereby discharging the electrostatic charges in both faces of the above-mentioned one photoconductive layer according to the photoconductivity of the other photoconductive layer substantially through the other photoconductive layer and the mobile electric charges by virtue of the electrostatic field in the above described one photoconductive layer and an external voltage so as to form an electrostatic latent image in the above described one photoconductive layer, and exposing the above-mentioned one photoconductive layer to a light consisting of spectral components which render the above-described one photoconductive layer to be photoconductive so that the latent image is erased after it has been utilized.

In order to make the latent image more stable, a light having such characteristics that the above described one photoconductive layer is not rendered substantially photoconductive while the other photoconductive layer is rendered photoconductive may be applied uniformly after the discharging step so that the electrostatic latent image is formed in the above described one photoconductive layer.

A photosensitive member for electrophotography comprising two photoconductive layers with or without an intermediate layer of thin thickness therebetween, at least a portion of the range of the spectral sensitivity of one of the two photoconductive layers being different from at least a portion of the range of the spectral sensitivity of the other photoconductive layer, one of the two photoconductive layers being of an electrically insulating photoconductive layer having such an insulating property that it can maintain electrostatic charges at least in a dark place while the other photoconductive layer is of a photoconductive layer having an electric resistance in a dark place which is lower than that of the one photoconductive layer, the boundary between the two photoconductive layers or the intermediate layer located therebetween being of a nature which can substantially prevent carriers of

2

free electric charges in the other photoconductive layer from flowing into the above described one photoconductive layer.

BACKGROUND OF THE INVENTION

The present invention relates to a process of electrophotography and a new photosensitive member, more particularly to a process for forming an electrostatic latent image as well as for erasing the latent image by using a photosenstive member of a novel construction.

The present invention also relates to a photosensitive member for the electrophotography for use in the process according to the present invention.

In the prior art basic process of electrophotography, the surfaces of an electrically conductive support and a photosensitive member are comprised of a photosensitive layer of a photoconductive material which is provided on the support are electrically charged uniformly by corona discharge or the like, and then an optical image corresponding to an image to be recorded is applied to the surface of the photoconductive material by the conventional photographic projection process so as to discharge electrostatic charges on the surface of the photosensitive layer in accordance with the pattern of the distribution of the intensity of the exposure thereby forming an electrostatic latent image on the surface of the photosensitive layer. This electrostatic latent image is made visible by any of various conventional processes, or transferred to another transferring material so as to form thereon an image of electrostatic charges. Therefore, when the above process is carried out, the photosensitive layer must be kept in a dark place so as to maintain sufficiently the electrostatic charges thereof until the electrostatic latent image is developed or transferred after the surface of the photosensitive layer has been electrically charged by the medium of corona discharge or the like. In other words, the photosensitive layer comprised of a photoconductive material is required to be of sufficiently electrically insulating property in a dark place. On the other hand, when the photosensitive layer is exposed, it must exhibit good electrical conductivity in order to obtain high sensitivity. That is, in the prior art of electrophotography, one and the same photosensitive layer of the photoconductive material is required to possess simultaneously two properties inconsistent to each other, i.e., the one being the good electrically insulating property in the dark place while the other is the good electrical conductivity at the time of the exposure of the photosensitive layer. Therefore, in the prior research for the photosensitive layer of electrophotography, effect has been made and importance has been attached to increasing the sensitivity at the sacrifice of the electric resistance in the dark place to the extent practically acceptable. For instance, when a photosensitive layer is made completely panchromatic and the photosensitivity thereof is to be increased, the density of carriers of the free electric charge under the electrically conductive condition by virtue of thermal excitation thereof is necessarily increased so that the electrical resistance in the dark place is lowered. On the other hand, when the average duration of the carriers of free electric charges which are optically excited and/or the mobility in drift thereof are increased so as to increase the sensitivity, the same effect is given to the carriers of free electric charges thermally excited and giving influence on the resistance in the dark place or carriers of free electric charges supplied from the electrode or the surface of the photosensitive layer, so that the resistance in the dark place is lowered. As described above, when the photosensitivity of the electrically insulating but photoconductive material forming the photosensitive layer which has been utilized in the prior electrophotography is to be increased, the electric resistance thereof in the dark place is lowered, i.e., the ability in maintaining the electrostatic charges in the dark place is lowered. On the other hand, there exist a plurality of photoconductive materials which have low electric resistance in a dark place, that is, which have no electrically insulating property in the dark place, while they have extremely high sensitivity.

Should such materials be applicable in the electrophotography, significant increase in sensitivity could be expected in the electrophotography.

The present invention aims at avoiding the above described shortages in the prior art of electrophotography and providing a novel process of electrophotography as well as a novel photosensitive member for use therein.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a novel process of electrophotography which avoids basically the disadvantages of the prior art process.

Another object of the present invention is to provide a novel photosensitive member which avoids basically the disadvantages of the prior art photosensitive member for use in the electrophotography.

Further object of the present invention is to provide a novel process of electrophotography in which a novel photosensitive member having high sensitivity is advantageously and effectively utilized, the photosensitive material having both properties capable of maintaining electric charges in the photosensitive layer and capable of high sensitivity in comparison with the prior art photosensitive materials by virtue of dividing the photosensitive member into two layers one of which has the property capable of maintaining the electric charges therein while the other has the property of high photosensitivity so that the disadvantages in the prior art photoconductive materials are avoided in which, although they have high sensitivity, they cannot be utilized in electrophotography because of their low capability in maintaining electric charges.

Still another object of the present invention is to provide a novel process of electrophotography of the kind described above in which extremely high sensitivity of the photosensitive material is achieved.

Another object of the present invention is to provide a novel process of electrophotography of the kind described above in which the electrostatic latent image formed on the photosensitive layer is effectively erased for the repeated use thereof.

Still another object is to provide a novel process of electrophotography of the kind described above in which an electrostatic latent image capable of being kept stable for a long time can be obtained.

A further object of the present invention is to provide a novel process of electrophotography of the kind described above in which the photosensitive material can be used repeatedly at high efficiency.

The present invention is characterized by using a photosensitive member comprising at least two photosensitive layers (A and B) at least a portion of the range of spectral sensitivity of one of which is different from at least a portion of the range of spectral sensitivity of the other of the two layers, applying to the surface of one of the photosensitive layers (for example A) and the boundary or the portion adjacent thereto between the two photosensitive layers electrostatic charges of opposite polarities, respectively, thereby permitting the above described one photosensitive layer (A) to maintain an electrostatic field therein, and then applying to the surface of the one photosensitive layer (A) mobile electric charges and, at the same time, exposing it to a light bearing therein an image to be recorded, the light being of such a nature that it will not render the above described one photosensitive layer (A) to be substantially photoconductive while the other photosensitive layer (B) is rendered to be photoconductive by the exposure thereof to the light, thereby discharging or charging the electrostatic charges in both

surfaces of the one photosensitive layer (A) through the other photosensitive layer (B) and the mobile electric charge correspondingly to the pattern of the photoconductivity of the other photosensitive layer (B) so as to form an electrostatic latent image in the one photosensitive layer (A), thereafter exposing uniformly the photosensitive member to a light of such a nature that it will not render the one photosensitive layer (A) to be substantially photoconductive while the other photosensitive layer (B) is rendered to be photoconductive by being exposed thereto after the mobile electric charges have been removed, thereby permitting the electrostatic latent image to be kept more stable, and exposing the photosensitive member to a light having such a nature that it renders at least the one photosensitive layer (A) to be substantially photoconductive after the electrostatic latent image has been used, thereby permitting the used latent image to be erased. According to the feature of the present invention, one (A) of the photoconductive layers forming the photosensitive member for electrophotography with or without an intermediate layer between the two photoconductive layers, one (A) of which possesses a property capable of maintaining electric charges therein while the other (B) possesses a property of high sensitivity, is made of an electrically insulating but photoconductive material and the other layer (B) is made of a photoconductive material which has an electric resistance lower than that of the above described one layer in a dark place. The boundary between the two layers (A and B) or the intermediate thin layer provided therebetween has such a nature that it can substantially completely prevent carriers of free electric charges in the above described other layer (B) from flowing into the one layer (A).

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a fragmentary sectional view showing an example of the photosensitive member for electrophotography constructed in accordance with the present invention; and

FIGS. 2*a*, 2*b*, 3*a*, and 3*b* are graphs respectively showing the spectral sensitivity of the photoconductive layers constituting the photosensitive member shown in the embodiment of the present invention and spectral distribution of the illuminating light used for exposing the photosensitive member of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A photosensitive member shown in FIG. 1 is basically comprised of a support **2**, a photoconductive layer **4** formed on the support **2** and a photoconductive layer **6** formed on the photoconductive layer **4**. A layer **3** is interposed between the support **2** and the photoconductive layer **4** and a layer **5** is interposed between the two photoconductive layers **4** and **6**. A surface layer **7** is located on the surface of the photoconductive layer **6**.

Assume that an electrostatic latent image is to be formed from the side of the surface layer **7**. In this case, the support **2** is located at the opposite side to the surface layer **7** so as to insure the mechanical strength of the photosensitive member. Of course, the provision of the support **2** is not essential and it may be omitted. The support **2** is preferably made of an electrically conductive material, but such a nature is not always necessary. It is advantageous to form the electrostatic latent image in the photoconductive layer adjacent to the surface of the photosensitive member with an electrostatic field kept therein.

Therefore, the photoconductive layer **6** is required to possess an electrically insulating property at least in a dark place (where no active radiation such as a light and the like active to the layer **6** exists) so that electrostatic charges therein, and, therefore, it is not necessarily required to possess a property to be rendered photoconductive in a light place (where an active radiation active to the layer 6 exists). Thus, the layer 6 should not be a mere electrically insulating material.

On the other hand, the photoconductive layer 4 is not required to be capable of maintaining electrostatic charges therein, and, therefore, it is not necessarily required to be of electrically insulating property in a dark place. In a light place, however, the photoconductive layer 4 is required to be sufficiently electroconductive as desired.

Further, the following relationship is required between the two photoconductive layers 4 and 6. In case, for instance, the exposure is given from the side of the surface layer 7, the photoconductive layer 6 must be substantially transparent to at least a portion or the entirety of a radiation such as a light and the like consisting of spectral components within the range of the spectrum which renders the layer 4 photoconductive. In case, for example, the exposure is given from the side of the support 2, the photoconductive layer 4 must be substantially transparent to at least a portion or the entirety of a radiation consisting of spectral components within the range of the spectrum which renders the photoconductive layer 6 photoconductive. Of course, in such a case, the support 2 is also required to possess the same property as that of the photoconductive layer 4. Further, at least a portion or the entirety of the spectral sensitivity of the respective photoconductive layers 4 and 6 must be different from each other.

The boundary layer 3 is not indispensable for the photosensitive member. The boundary layer 3 serves, however, to control the flow of carriers of electric charges from the support 2 into the photoconductive layer 4 and vice versa. It also serves to improve the adhesion of the photoconductive layer 4 with the support 2. The boundary surface or the intermediate layer 5 serves to control the flow of carriers of electric charges therethrough and to improve the adhesion between the two layers. The boundary surface or the intermediate layer 5 must possess in particular a capability preventing the carriers of free electric charges from flowing freely from the photoconductive layer 4 to the photoconductive layer 6.

The surface layer 7 serves to control the passage of carriers of electric charges from the surface to the photoconductive layer 6 and to protect the surface of the photosensitive member. However, the provision of the surface layer 7 is not essential and it may be omitted. The surface layer 7 is required to be of an electrically insulating nature and, further, it is preferably made as thin as possible.

The above described boundary layer 3, the boundary surface or the intermediate layer 5 and the surface layer 7 must be sufficiently transparent to the light applied thereto that the process of the present invention can be carried out without hindrance.

The process of the present invention is carried out by using a photosensitive member having the construction described above in the following procedure. In the first step, the surface of the photosensitive member is uniformly electrically charged, for example, to have negative polarity by means of corona discharge and the like. In this case, the negative charge is given to the surface. On the other hand, the support 2 is induced to have positive polarity. This electric charge is induced in short time (i.e. prior to the second step) into the boundary surface or the intermediate layer 5 or the portion adjacent thereto through the photoconductive layer 4 correspondingly to the negative charge existing on the surface of the photosensitive member. If the electric resistance of the photoconductive layer 4 is sufficiently low, the induction of the positive charge into the boundary surface or the intermediate layer 5 will take place in sufficiently short time and no problem arises. In case the electric resistance is high, however, the time required to induce the positive charge into the boundary surface or the intermediate

layer 5 will become long, thereby obstructing the performance of the process of the present invention.

In order to resolve the above difficulty, a rectifying property, for example, is given to the boundary layer 3 so that the positive charge can easily flow from the support 2 to the photoconductive layer 4 (i.e. by lowering substantially the electric resistance of the photoconductive layer 4). Or, alternatively, the photoconductive layer 4 is exposed uniformly to an active radiation thereby lowering the electric resistance of the photoconductive layer 4 by virtue of the photoconductivity thereof. In this case, it is necessary that the illuminating active radiation will pass through the photoconductive layer 6 but will not render it substantially photoconductive. Thus, the negative and positive electrostatic charges are given to the respective surfaces of the photoconductive layer 6. The electrostatic field produced by the electrostatic charges is maintained by the photoconductive layer 6.

Then, in the second step, electric charges generated by corona discharge, for example, are applied to the surface of the photosensitive member which has been electrically charged as described above, while an optical image to be recorded is projected onto the surface of the photosensitive material. In this case, the projected light will not render the photoconductive layer 6 photoconductive, but it will pass through the photoconductive layer 6 and produce photoelectric current in the photoconductive layer 4. That is, by providing an appropriate external electrical circuit (not shown) connecting the electric charges applied to the surface of the photosensitive member (that is, the charges on layer 7, for example) to the photoconductive support 2, the electrostatic charges held in the respective surfaces of the photoconductive layer 6 are short circuited through the photoconductive layer 4 so that these electric charges are discharged or charged to the counter polarity in accordance with the pattern of the photoconductivity of the photoconductive layer 4—that is, the pattern of the intensity of the illuminating light forming the optical image to be recorded. Thus, the positive electric charge held in the boundary surface or the intermediate layer 5 or the portion adjacent thereto is neutralized with the negative electric charge held in the surface of the photosensitive member through the photoconductive layer 4, the support 2, the external electric circuit and the electric charges applied to the surface of the photosensitive material. Electrical discharge will take place to some extent even through a portion of the photoconductive layer 4 which is not illuminated by the light. However, since the electric resistance of the portion of the photoconductive layer 4 which is not illuminated by the light is greater than that of the portion which is illuminated, the amount of the discharge is small. But, since the photoconductive layer is in general not of an electrically insulating nature, it is necessary to complete this step in short time. In other words, at least the electric charges applied to the surface of the photosensitive member must be removed quickly. Alternatively, it is necessary to open the external electric circuit by opening a switch (not shown), for example, in the electrical connection between the layer 7 and the support 2. Thus, the unnecesary or undesired discharge or the neutralization taking place through the photoconductive layer 4 is prevented. By the above measure, an electrostatic latent image is formed in the respective surface of the photoconductive layer 4 in accordance with the optical image contained in the illuminating light by the medium of the photoconductive layer 6.

The electrostatic latent image under such a condition is unstable and it transfers to a stable condition at a speed corresponding to the electric resistance of the photoconductive layer 4 in a dark place or the electric resistance resulting from the after effect in the photoconductivity of the photoconductive layer 4 after the exposure thereof. This is because the electric charges in the surface (either of the same polarity or the opposite polarity) are added by the electric charges which have been applied to the surface of the photosensitive material in the first step and the induced electric charges corresponding to the above additional electric charges are introduced into the electrically conductive support **2**. In other words, a phenomenon similar to that occurring in the first step to some extent takes place in the second step. Therefore, the latent image will transfer to an equilibrium state at a speed coresponding to the electric resistance of the photoconductive layer **4**.

It will be easily understood that such an unstable condition of the latent image is significant in the portion where no illumination is given. It will also be understood that, in the portions where the illumination is given, since the electric resistance thereof is lowered by virtue of the photoconductivity thereof, the equilibrium state, i.e. the stable condition of the latent image will be achieved almost momentarily. If the electric resistance of the photoconductive layer **4** is very high and a stable distribution of electrostatic charges cannot be quickly achieved unless uniform exposure thereof is effected after the electric charging thereof as carried out in the first step, a uniform exposure is given to the photoconductive layer **4** as a third step so as to form a stable electrostatic latent image quickly. The third step is, however, not essential, and this step may be omitted if the electric resistance of the photoconductive layer **4** is substantially low to some extent. The nature of the light to be used in the uniform exposure in the third step is required to be such that, as in the case of the uniform exposure effected in the first step, it passes through the photoconductive layer **6** but it will not render the layer **6** to be substantially photoconductive.

The electrostatic latent image thus obtained is very stable unless an active radiation exists which is active to the photoconductive layer **6**, and it can be used in various applications. The latent image can be made visible by the developing process conventionally utilized in electrophotography, for example. In other words, the latent image is developed by electrically charged colored fine powder by virtue of the electrostatic force. The image formed by the colored powder is recorded and preserved as a visible image which is transferred to another transferring material and fixed thereon. On the other hand, the photosensitive material itself is made ready for the repeated use by removing the remaining colored fine powder thereon. In the case of repeated use of the photosensitive material wherein an electrostatic latent image different from that of the prior use, it is necessary to adapt a fourth step to erase the electrostatic latent image formed in the prior use. This is achieved easily by exposing the photosensitive member uniformly to a light having such a nature that it renders the photoconductive layer **6** to be photoconductive thereby permitting the electrostatic charges forming the latent image to be discharged or to be neutralized through the photoconductive layer **6** so as to erase the latent image.

Now a detailed description of the photosensitive member for carrying out the above described process will be given below.

The support **2** serves as an electrode, however, it may be omitted if no mechanical shortage takes place by omitting it. In such a case, when the above described process is carried out, the photosensitive member may be attached to a separate electrode plate in contact therewith. Alternatively, electric charges may be applied so as to form an electrode. In actual practice, a metallic plate or sheet made of aluminum, brass, nickel or the like is used as an electrode plate. Alternatively, a plastic sheet with the surface thereof processed so as to be electrically conductive by means such as evaporation of metal may be used as the electrode. Further, the electrode may be replaced by a thin film on which metal is vacuum evaporated and located beneath the photoconductive layer **4**.

Since the photoconductive layer **4** is not required to maintain electrostatic charges in a dark place, it is not necessary to be of an electrically insulating property in the dark place. However, it is preferred to be of high sensitivity in photoconductivity. Of course, the photoconductive layer **4** may be of the electrically insulating nature in the dark place, and it is preferred to have an electric resistance as high as possible in the dark place. In a simple model of the present invention, the speed, that is the time constant, at which the electrostatic charges in the respective surfaces of the photoconductive layer **6** are discharged, charged in the counter polarity or neutralized in the second step is expressed by $R_D \cdot C$, where R_D designates the electric resistance (normal to the layer) in a dark place of the photoconductive layer **4** per unit area while C designates the electric capacity per unit area of the photoconductive layer **6**. It is preferable to select the value of $R_D \cdot C$ to be in the order of or greater than the duration of the second step that is the time in which electric charges are applied to the surface of the photosensitive material and the external electric circuit is closed. For example, if the time of the second step (in case the second step is effected by the scanning method, consideration may be given to one point in the photosensitive material) is selected to be 0.01 sec., then the value of $R_D \cdot C$ may be preferably made in the order of 0.01 sec., or greater than this value. Each of the values R_D and C can be varied to some extent depending upon the thickness of the photoconductive layers, but the range of the variation is in the order of 10 at the most. Therefore, the value of R_D is varied in greater degree by the material used, and a photoconductive layer having the specific resistance ρ_D in a dark place in the order of $10^5 \Omega \cdot$cm. or more is used. On the other hand, portions which are subjected to the light are required to have the time constant $R_L \cdot C$ shorter than the duration of the second step. This R_L designates the resistance (normal to the layer) of the photoconductive layer **4** per unit area in a light place. For example, when the time of the second step is 0.01 sec., then the value of $R_L \cdot C$ must be equal to or smaller than 0.01 sec. Assuming that the time of the second step is 0.01 sec. and the value of the lowest limit of ρ_D is 10^5 $\Omega \cdot$cm., then the value of specific resistance ρ_L in a light place must be equal to or less than 10^5 $\Omega \cdot$cm. However, if the duration of the first step is made 1.0 sec., then it is preferred to select the value of the utilizable lowest limit of ρ_D to be 10^7 $\Omega \cdot$cm., while the value of ρ_L is made equal to or less than 10^7 $\Omega \cdot$cm. The above examples are merely exemplary, and, when the thickness of the photoconductive layer is varied, the values are changed. It is necessary to select the value of the sensitivity in photoconductivity ρ_D/ρ_L to be in the order of 10 or higher than 10. Greater the value ρ_D/ρ_L, the superior the results. Thus, the duration of the second step can be made shorter as the value of ρ_L becomes smaller. In other words, the time required for carrying out the second step—this is a value representing the sensitivity of the process of the present invention—cannot be made shorter than the time defined by the value of ρ_L.

On the other hand, the duration of the second step is limited by the value of ρ_D, and the duration of the second step cannot be extended beyond a limit time period as determined by the value of ρ_D.

Therefore, the second step must be carried out within the range defined by two limit time periods as described above.

Thus, it is necessary that the photoconductive layer has a value of ρ_D/ρ_L as great as possible and the value of ρ_D or R_d suited to the speed for carrying out the process of the present invention. The greater value of $\rho_D \rho_L$ makes the range of the time period limited by the two limit time periods greater.

In a high speed process, a photoconductive material having the low value of ρ_d in the order of 10^5 $\Omega \cdot$cm. can be used if the duration of the second step is in the order of 10^{-2} sec. This makes it possible to use photoconductive materials which have not been recognized to be able to be utilized in the prior art electrophotography. For instance, a group of CdS hexagonal system which are of high sensitivity photoconductive material can be used in the present invention. Further, if the duration of the second step can be made short, a photoconductive material having the value of ρ_D less than 10^5 Ω·cm. can be used. As to photoconductive materials which satisfy the above requirements, the following are enumerated: elements of simple substance such as Si, Ge, Su, P, As, Sb, S, Se, Te and the like oxides of elements such as Cu, Ag, Sr, Ba, Zn, Ge, Cd, Si, Hg, Al, In, Ga, Tl, Sn, Mn, Fe, Ni, Pb, Ti, As, Sb, Bi and the like, chalcogenides, halogenides, and compounds consisting of a plurality of kinds of the above substances and a plurality of kinds of negative elements such as, for example, $Cd(x)\cdot Zn(1-x)S$, $CdS(y)\cdot Se(1-y)$, $Cd(x)\cdot Zn(1-x)S(y)\cdot Se(1-y)$ and the like, various intermetallic compounds such as, for example, $CuAlS_2$, $AgInS_2$, $ZnSiAs_2$, $ZnGeP_2$, $CdGeP_2$, InSbI and the like, and solid solutions (including either of crystal form and amorphous form) consisting of a plurality of elements selected from As, Sb, Pb, S, Se, Te, Tl, Br, I or the like, these being of inorganic substances, and various kinds of organic photoconductive materials. Each of these materials itself or a mixture of some of these materials itself is used to provide the photoconductive layer, or dispersed in a binding agent capable of forming a layer so as to form the photoconductive layer. As to the binding agents, inorganic high molecular compounds can be used as the binding agents. These binding agents themselves may be of photoconductive nature to some extent.

For instance, a glass-like photoconductive material consisting of As-Sb-Se system is by itself coated or applied to a metallic support by vacuum evaporation or fusing coating process so as to form a photoconductive layer of desired thickness. Fine powder of high sensitivity CdS hexagonal system is sintered together with a fusing agent such as $CdCl_2$ and the like so as to provide a photoconductive layer made by the sintering on a metallic plate. Fine powder of high sensitivity CdS sensitized with coloring matters is dispersed in a synthetic high molecular binding agent and coated on a suitable support so as to form a photoconductive layer. Further, the synthetic high molecular binding agent used herein may be of a photoconductive material (either of inorganic and organic) capable of forming a thin film.

The spectral sensitivity of the photoconductive layer **4** is appropriately selected according to the purpose for which the photosensitive material is used, and it is preferred to make the photosensitive material panchromatic. The range of distribution of the spectral sensitivity of the main component of the photosensitive material can be enlarged by the addition of a little quantity of adding agent or by the sensitization with coloring matters. The minimum requirements for this is to make the photoconductive layer **4** photosensitive to at least a portion of the spectrum of the light passing through the photoconductive layer **6**.

The photoconductive layer **6** is required to possess an electrically insulating property capable of maintaining electrostatic charges in the respective surfaces of the photoconductive layer **6** in a dark place, that is, capable of maintaining an electrostatic field therein. Further, in order to make it possible to effectively erase the electrostatic latent image in the fourth step, the photoconductive layer **6** must possess a certain photoconductivity. This means that an electrically insulating photoconductive material heretofore utilized as a photosensitive material in electrophotography can be used in the present invention.

For instance, a photoconductive layer consisting of powder of high resistance CdS or powder of ZnO dispersed in a binding agent, a photoconductive layer consisting of amorphous selenium, and an organic photoconductive layer of high electrically insulating property can be used. In this case, such a high sensitivity of the photosensitive material for electrophotography heretofore required thereto is not necessary in the present invention, because the intensity of illumination to be given to the surface of the photosensitive material can be easily and sufficiently raised for erasing the latent image therein by uniformly exposing it to the light, and also because the limitation in the duration of the fourth step is not so severe in comparison with that of the second step. Further, a property required in this layer **6** is not to abstract substantially the passage therethrough of a light having the spectrum effectively utilizable in the formation of the electrostatic latent image in the second step, that is, a light having the spectral components which are absorbed in the photoconductive layer **4** after passing through the layer **6** thereby serving to render it to be photoconductive. Which region in the wave length of the light should be transmitted through the photoconductive layer **6** depends upon the circumstances what kind of spectral sensitivity of the photoconductive layer **4** and what kind of the photosensitive material are used.

For instance, when a light having the wave lengths within the visible range is used for recording the optical image, it is preferred to use the photoconductive layer **6** which is transparent to such a light in the visible range of wave length. In case a panchromatic property is required to the photosensitive material, the photoconductivity of the photoconductive layer **4** is required to be panchromatic and the photoconductive layer **6** must be substantially colorless and transparent. For such an electrically insulating photoconductive layer, an organic photoconductive layer is referred to as an example. In this case, the erasure of the electrostatic latent image can be carried out by illuminating the photoconductive layer with the ultraviolet light. In case a copy is to be reproduced from a microfilm or a document of various kinds, a light source such as an incandescent tungsten lamp, an iodine lamp, a zircon lamp and a xenon lamp is generally used. In this case, since the microfilm is of the black and white nature and has nothing to do with the color and the spectrum of the light emanating from the above described lamp contains a great amount of components having long wave lengths, it is preferred to use a photoconductive layer **4** having high sensitivity in the components of the spectrum with the red ranging from 550 mμ to 1.5μ being the center thereamong. Therefore, in this case, the photoconductive layer **6** is allowed to absorb blue light having wave lengths shorter than 550 mμ. Further, an electrically insulating photoconductive material having photoconductivity to the blue light can be used. Such a photoconductive material is, for example, a layer which contains zinc oxide sensitized with coloring matters in the region ranging from about 450 mμ to about 500 mμ by fluoresceine dispersed in a binding agent of an organic resin. At least a portion of the spectral sensitivity each of the photoconductive layers **4** and **6** may be made the same with each other.

The provision of the boundary layer **3** is not essential and it may be omitted. The purpose of the boundary layer **3** is to control the flow of the electric charges from the support **2** to the photoconductive layer **4** or vice versa, but is not to prevent the flow. In case the surface of the photosensitive material is to be charged in negative polarity as previously described, for example, the boundary layer **3** must be such that it allows the positive electric charges to easily flow from the support **2** to the photoconductive layer **4**. Further, in case an electrostatic latent image is formed in the second step, since it is preferred to make the resistance of the photoconductive layer **4** as high as possible in a dark place, it is desirable to prevent the negative electric charges from flowing inadvertently from the support **2**. That is, when the photoconductive layer **4** itself has little carriers of free electric charges under the thermal equilibrium condition and has high electric resistance and the resistance is influenced by the addition of carriers of free electric charges thereto from the outside, it is preferred to make the boundary layer **3** to have rectifying property. The material of this layer is selected depending upon the material used to form the photoconductive layer **4**. Further, the boundary layer **3** may be made to a separate layer, or alternatively, it may be the boundary surface itself of the photoconductive layer **4** or the support **2**.

The boundary surface or the intermediate layer **5** serves to improve the adhesion of the photoconductive layer **4** with the photoconductive layer **6** and also to electrically separate the photoconductive layers **4**, **6** from each other to some extent with respect to the flow of carriers of free electric charges.

The photoconductive layer **6** must be of electrically insulating property throughout the process of the present invention except the fourth step. Of course, there is no generation of carriers of free electric charges in the photoconductive layer **6** in the steps of the process of the present invention which render the photoconductive layer **6** to be photoconductive. However, there is a possibility that carriers of free electric charges produced in the photoconductive layer **4** by the excitation by the light might flow into the photoconductive layer **6**. This is significant if both the photoconductive layers **4**, **6** are made of the same lineage of material. Therefore, when the photosensitive material is illuminated by the light in the steps except the fourth step, the electrically insulating property of the photoconductive layer **6** is lowered. In order to prevent the electrically insulating property of the layer **6** from being lowered, it is necessary to prevent at least the flow of carriers of free electric charges including the carrier produced by the thermal excitation from the layer **4** to the layer **6**. The boundary surface or the intermediate layer **5** serves as means therefore. Further, particular obstruction is not caused even though the carriers of free electric charges excited in the photoconductive layer **6** in the fourth step flow into the photoconductive layer **4**. However, the flow of the carriers of free electric charges in either of the directions tends to be prevented.

If the boundary surface or the intermediate layer **5** satisfies the above described requirements, it may be the boundary surface itself of either of the photoconductive layers **4** and **6**. Otherwise, it is necessary to interpose a thin layer of other material between the two layers **4**, **6** so as to form the intermediate layer **5**. The thickness of the thin layer in this case is made preferably as thin as possible insofar as the above described performance is achieved. In general, the thickness less than 1μ is sufficient for achieving the performance.

The intermediate layer **5** is formed by a thin layer of an electrically insulating material. The examples of the material are as follows: a film formed by vacuum evaporation of inorganic substance such as SiO or SiO_2, ZnS, MgF_2 and the like, a thin layer of synthetic resin such as cellulose nitrate, cellulose acetate, salt vinyl acetate, resins of urethane group, resins of acrylic group, urea resin, silicone resin, epoxide resin and the like. The boundary surface or the intermediate layer **5** may be here the one which has high central density of recombination which extinguishes the carriers of free electric charges.

The surface layer **7** serves to protect the surface of the photosensitive material and to prevent unwanted carriers of free electric charges from flowing from the surface thereof. The thickness of this thin layer is preferably in the order of 1–2μ, but is not necessarily limited to this thickness, and this surface layer may be omitted. Further, the surface layer must be of an electrically insulating property. As to the material usable in the process of the present invention, a material similar to that used to form the above described intermediate layer **5**.

In the first step, electrostatic charges are charged in the surface of the photosensitive material. The polarity of the electrostatic charges is not necessarily required to be the negative polarity. Either of the positive and negative polarities may be selected depending upon the nature of each of the photoconductive layers **4** and **6**. If the product $\mu \cdot \tau$ of the carriers of free electric charges where μ is

the mobility of the drift thereof while τ is the average life thereof is greater at the electrons than at the holes, then it is preferable to select the positive polarity, and, if the value $\mu \cdot \tau$ is greater at the holes than at the electrons, then it is preferable to select the negative polarity. However, consideration similar to the above should be taken with respect to the photoconductive layer **6**. In other words, for the photoconductive layer **6**, if the value $\mu \cdot \tau$ of the free holes thereof is greater than that of the free electrons, the positive polarity is preferably selected while the negative polarity is selected if the value of $\mu \cdot \tau$ of free electrons is greater than that of the free holes. However, if the above described preferable polarities are inconsistent with each other, consideration should be taken on the basis of the collective characteristics of the photosensitive material in its entirety. However, the selection of the polarity is not essential in the process of the present invention and a photoconductive layer has been found which can be used in either of the polarities to obtain about the same performance. As to the method for electrically charging the photoconductive layer in the present invention, any of the methods heretofore adapted to electrically charging the photoconductive layer may be used. The electric charging is effected in general uniformly over the entire area of the photoconductive layer, but electric charging in any distribution corresponding to the desired pattern may be applied depending upon the purpose of the application. This can be effected by any of the methods heretofore utilized in the electrophotography. For instance, the photoconductive layer **6** may be exposed to a light capable of rendering it to be photoconductive and bearing therein the desired pattern after the layer **6** has been uniformly electrically charged in the first step so as to give the pattern of the electrostatic charges thereon.

The second step may be carried out by applying mobile electric charges to the surface of the photosensitive material while, at the same time, the optical image is projected to the surface. Of course, either of the applications of the mobile electric charges and the projection of the optical image may be carried out prior to the other, or either of them may be continued after the other is stopped. By applying the mobile electric charges, an external electric circuit (not through the interior of the photosensitive material) is formed between the surface of the photosensitive material and the electrically conductive support so that they are short-circuited.

The second step may also be carried out by opening and closing the external electric circuit while the mobile electric charges are being applied. As to the mobile electric charges, they may be an electron current, a group of ions in a gas, a group (current) of electrically charged particles in a gas, a group (current) of ions in a liquid, a group (current) of electrically charged particles in a liquid or the like. For instance, the ion current (group) in a gas may be supplied by corona discharge of an alternate current or a direct current or the like. The projection of the optical image may be carried out from the surface or the rear side of the photosensitive material. As to the manner for carrying out the projection, various methods heretofore utilized may be adapted. For instance, the projection of the optical image may be carried out through a slit located at the rear side of the photosensitive material by displacing the photosensitive material in the direction perpendicular to the exposure slit while a group of ions are applied to the surface of the photo-sensitive material by corona discharge with the pattern of distribution corresponding to the optical image projected to the rear side.

The third step has been described previously.

The fourth step is carried out by exposing the photoconductive layer **6** to an active light active thereto after the electrostatic latent image has been used. The electrostatic latent image may be in general destroyed after it has been devedoped so as to be visible. After the developing, the exposure in the fourth step may be applied prior to the transfer of the image. Alternatively, the exposure in the fourth step may be applied after the transfer of the image and before the remaining substance is removed. It is very effective to neutralize the electric charges in the remaining substance and the surface of the photosensitive material by corona discharge of alternate current or direct current while the photoconductive layer **6** or both the photoconductive layers **4** and **6** are exposed to the active light active thereto or before or after the exposure is effected.

Many developed images can be obtained from one latent image by repeating the development and transferring, using the electrostatic latent image produced in the second or third step.

Now several examples of the present invention will be described below.

Example 1

Arsenic triselenide was vacuum evaporated so as to be coated on a cleaned aluminum plate so that an amorphous layer having a thickness of about 70μ was formed thereon. This layer corresponds to the photoconductive layer **4** shown in FIG. 1. And a layer of magnesium fluoride having a thickness of about 500 mμ was formed on the amorphous layer by vacuum evaporation. Further, selenium of high purity was vacuum evaporated on the magnesium fluoride layer so as to form an amorphous layer of the thickness of about 10μ was formed. This layer corresponds to the photoconductive layer **6** in FIG. 1. The intermediate layer **5** formed by the magnesium fluoride is necessary for preventing carriers of free electric charges generated in the amorphous layer of arsenic selenide from flowing into the amorphous layer of selenium. The thus formed amorphous layer of arsenic triselenide showed the spectral sensitivity as shown by the curve **1** in FIG. 2*a*. This curve shows that the amorphous layer of arsenic triselenide is substantially panchromatic. The abscissa of FIG. 2*a* is graduated by the wave lengths by the unit of mμ. The ordinate of FIG. 2*a* is graduated by the number in which the unit number is divided by the energy required for exhibiting the same response with each other (the unit is arbitrary)). The spectral sensitivity of the amorphous layer of selenium of high purity is shown by the curve **2** in FIG. 2*a*. This curve shows that the amorphous layer of selenium has the spectral sensitivity at the side of the wave lengths shorter than the wave length of about 550 mμ. The amorphous layer of arsenic triselenide had a low capacity of maintaining electrostatic charges therein and about 90% of the electrostatic charges was discharged in about 2 seconds when the electrostatic charges were charged by corona discharge. This means that the amorphous layer of arsenic triselenide can not be readily utilized as a photosensitive material in the prior art electrophotography. On the other hand, the amorphous layer of selenium of high purity could maintain the electrostatic charges in the surface thereof over 3000 seconds.

The aluminum plate bearing thereon the thus formed photosensitive material was earthed and one terminal (negative polarity of high D.C. voltage) of a high voltage electric source for corona discharge with its other terminal being earthed was connected to an electrode for the corona discharge so that negative ions were generated. The thus generated negative ions were applied to the surface of the photosensitive material so that the surface of the photosensitive material was charged in the negative polarity. At this time, the electric charges of positive polarity were introduced adjacent to the intermediate layer through the amorphous layer of arsenic triselenide. It took about 2 seconds to introduce the positive electric charges adjacent to the intermediate layer. This was estimated from the fact that the voltage at the surface (with respect to the earth voltage) was measured immediately after the surface of the photosensitive material was charged in the negative polarity and the measured voltage was about −1800 volts while the voltage decreased to about −300 volts after about 2 seconds to reach substantially the equilibrium state. When the photosensitive material was exposed to a light having the spectrum as shown by curve **1** in FIG. 2*b* at the same time it was electrically charged in the same manner as described above, the voltage at the surface was about −350 volts immediately after the electric charging and this value did not substantially vary as the time elapsed. It can be estimated that the positive electric charges were almost immediately introduced adjacent to the intermediate layer when electrically charged. The abscissa of FIG. 2*b* is graduated by the wave lengths in the unit of mμ while the ordinate is graduated by the relative values of spectral energy of the illumination light used.

When a blue light having the characteristics as shown by curve **2** in FIG. 2*b* was directed to the photosensitive material after the completion of the first step, the voltage at the surface was rapidly reduced to zero. This was due to the discharge in the amorphous layer of selenium.

The photosensitive material to which the first step was applied was subjected to an optical image simultaneously with the corona discharge by alternate current. In other words, the aluminum plate of the photosensitive material was earthed and one terminal of the high voltage electric source for the corona discharge with its other terminal earthed (A.C. high voltage) was connected to the electrode for corona discharge so that positive and negative ions were generated. These ions were applied to the photosensitive material simultaneously with the exposure by the optical image in the slit-form from the rear side of the electrode for corona discharge along the configuration of the electric pale. This procedure was carried out actually by moving the photosensitive material while the exposure by the optical image and the electrode for the corona discharge were kept stationary. The spectrum of the light utilized in the projection of the optical image was the one as shown by curve **1** in FIG. 2*b*. The amorphous selenium is not substantially optically sensitized by such a light. This will be readily understood when compared with curves in FIG. 2*a* at the same time, the amorphous layer of arsenic triselenide exhibits photosensitivity. Therefore, as previously described, the electrostatic charges in the exposed portions were discharged and neutralized through the layer of arsenic triselenide, the external circuit and the ion groups of corona discharge of alternate current. On the other hand, the electrostatic charges in the dark portions (located adjacent to the intermediate layer) were kept as they were. However, the electrostatic charges in the dark portions of the surface were neutralized to some extent by the ion group of corona discharge of alternate current, and they were more or less in unstable condition in consideration of the electric charges corresponding to the positive electric charges locally existing adjacent to the intermediate layer. The voltage at the surface immediately after the completion of the second step and the voltage at the exposed portion of the surface was about −20 volts while the voltage at the dark portion of the surface was about +100 volts. When the variation in surface voltage was successively measured, the voltage at the exposed portion of the surface did not vary substantially but the voltage at the dark portion of the surface was changed to −250 volts in 2 or 3 seconds. Thereafter, the voltage did not substantially change. After the completion of the second step, when the surface was exposed by a light having the spectrum as shown by curve **1** in FIG. 2*b*, the voltage at the surface to which the optical image is projected did not substantially change but the voltage at the dark surface changed rapidly to the equilibrium voltage of −250 volts. Thus, the electrostatic latent image having the electrostatic contrast of about +120 volts immediately after the completion of the second step was made an electrostatic latent image having an electrostatic contrast of about −230 volts after expiration of several seconds after the second step or after the completion of the third step.

These electrostatic latent images were developed by the medium of colored resin powder which were electrically charged so as to render them to be visible. The colored resin powder thus forming the visible image was transferred to ordinary white paper electrostatically and then fused thereon by heating. On the other hand, the remaining colored resin powder on the surface of the photosensitive material was exposed to a light having the spectrum as shown by curve **2** in FIG. 2*b* while the same is applied with ion groups of corona discharge of alternate current, and thereafter, the surface was cleaned by a brush having synthetic fibers. Thereafter, the photosensitive material was exposed to a light having spectrum as shown by curve **2** in FIG. 2*b* so that the electrostatic latent image was completely removed. When a light having the spectrum as shown by curve **3** in FIG. 2*b* was used in place of the light having the spectrum shown by curve **2** in FIG. 2*b*, about the same results were obtained. Each of the lights used in the example was obtained as described below. The light shown by the curve **1** in FIG. 2*b* was obtained by combining the light having the color temperature of about 3200° K. obtained by an iodine lamp with a glass filter having the property intercepting the light having the wave lengths shorter than 580 mμ. The light shown by the curve **2** in FIG. 2*b* is a light obtained by blue fluorescent lamp while the light shown by the curve **3** in FIG. 2*b* is a light obtained by a day light color fluorescent lamp.

Example 2

Arsenic triselenide was vacuum evaporated and coated on a cleaned aluminum plate in like manner as in Example 1 so as to form an amorphous layer of the thickness of about 70μ. Vinyl acetate was applied on the amorphous layer of arsenic triselenide so as to form an intermediate layer having the thickness of about 0.5–1.0μ. Polyvinyl carbazole was further applied on the intermediate layer so as to form a layer having the thickness of about 20μ. This photosensitive material was successfully used by electrically charging the surface thereof in negative polarity in the first step with excellent results. In this case, the photoconductive layer consisting of polyvinyl carbazole is substantially transparent to the visible light and is excited to exhibit a photosensitivity only by a light of the near ultraviolet region. Therefore, almost all the spectral regions of spectral photosensitivity of arsenic triselenide can be utilized, and a photosensitivity higher than that of Example 1 was obtained in this example. The removal of the electrostatic latent image was effected by means of a fluorescent chemical lamp.

Example 3

Selenium containing 15% by weight of tellurium was vacuum evaporated and coated on the surface of a cleaned aluminum pipe so as to form thereon an amorphous layer of the thickness of about 80μ. Polycarbonate was applied on the amorphous layer so as to form a thin layer having the thickness of 0.8μ. An amorphous layer of high purity selenium having the thickness of about 10μ. was formed on the layer of polycarbonate by means of vacuum evaporation of selenium. Further, a thin layer of polycarbonate having the thickness of 0.8μ similar to the above intermediate layer of polycarbonate was formed on the amorphous layer of high purity selenium as the surface layer, thus producing a photosensitive material for electrophotography.

The amorphous layer of selenium containing 15% of weight of tellurium had low capacity in maintaining electrostatic charges therein in the prior art electrophotography and could hardly maintain the electrostatic charges, but the range of spectral photosensitivity was enlarged by about 120 mμ toward the side of longer wave length in comparison with the amorphous layer of high purity selenium. This means that the amorphous layer of selenium containing tellurium is substantially panchromatic. Therefore, excellent results were obtained by using the same light as in Example 1 for the exposure in each step. The photosensitive material in this example is preferably charged at its surface in the negative polarity so as to assure the stability of the characteristics. However, when the surface of the photosensitive material was charged in the positive polarity, substantially the same results were obtained.

Example 4

A solid solution consisting of 25 parts by weight of arsenic, 10 parts of antimony and 49 parts of selenium was vacuum evaporated and coated in a cleaned brass plate so as to form a glass-like layer. The thickness of the layer was about 15μ. Then, a mixture of 45 parts of anthracene dispersed in 55 parts of silicone resin was applied in the glass-like layer. The thickness of the coated mixture was about 15μ. The thus obtained photosensitive material was electrically charged at its surface in the negative polarity in the first step and the exposure was effected in the second step by using a light from a zircon lamp which bears the optical image therein while corona discharge of A.C. was applied simultaneously.

Excellent positive images were obtained by using a cascade developing agent for electrophotography (the colored electrically charged powder was charged in the positive polarity). After the images were transferred to other transferring papers, the photosensitive material was uniformly exposed to a light from a fluorescent chemical lamp so as to remove the remaining image thereon.

Example 5

A glass-like layer like in Example 4 was formed by vacuum evaporating a solution consisting of 15.5 parts of As, 25.3 parts of Sb, 10.0 parts of S and 24.6 parts of Se was used as a high sensitivity photoconductive layer, while a film of polyvinyl carbazole was used as a low sensitivity electrically insulating photoconductive layer. When a light from a zircon lamp was used for the exposure, a sensitivity in the order of ASA 25 was obtained.

Example 6

A high sensitivty CdS powder was produced by adding a very little quantity of copper chloride serving as an activator and about 10% by weight of cadmium chloride serving as a fusing agent to pure cadium powder and by crushing it after sintering the same in an atmosphere at a temperature of 550–600° C. for about 15 minutes. The thus formed powder was dispersed in a thermosetting acryl resin paint and applied to an aluminum sheet so as to form a high sensitivity photoconductive layer. A film of polyvinyl carbazole serving as a low sensitivity and electrically insulating photoconductive layer was formed on the high sensitivity photoconductive layer so that a photosensitive material was produced. This photosensitive material was used in like manner in Example 4 and excellent results were obtained. In this case, however, the polarity of the electric charges applied to the surface of the photosensitive material in the first step was positive.

Example 7

About 18% by weight of cadmium iodide was added to fine powder consisting of $CdS1.5CdCO_3$ the nucleus of each of the particles of which was considered to be $CdCO_3$ and the surface layer of each of the particles of which was considered to be CdS, and the mixture was sintered at a temperature of 200–250° C. The thus formed powder is called A powder hereinafter. A powder in which 0.1% by weight of Malachite Green serving as a sensitizing coloring matter was added to the above A powder is called B powder hereinafter.

100 parts by weight of B powder and 50 parts by weight of thermosetting acryl resin paint (solid component) were mixed and dispersed together with an organic diluent solution and applied to an aluminum sheet and dried. Further, only the same thermosetting acryl resin paint was

applied to the above described coating and dried. Then, 100 parts by weight of A powder was mixed and dispersed in 50 parts by weight of the same thermosetting acryl resin paint (solid component) together with a solvent and the thus formed mixture was applied to the above described coating and dried. Further, the aluminum sheet bearing thereon the above described three coatings was heated at a temperature of 150° C. for about 30 minutes so as to be thermally set thereby producing a photosensitive material. The thickness of each of the layers of the thus formed photosensitive material was as follows after the thermosetting: The lowermost layer in which B powder was used (to be called *b* layer hereinafter) had a thickness of about 60μ, the thickness of the intermediate layer in which only a binding agent was used was about 0.8μ while the thickness of the uppermost layer in which A powder was used (to be called *a* layer hereinafter) was about 20μ. The spectral sensitivity of each of *a* and *b* layers was shown in FIG. 3*a*. The abscissa of FIG. 3*a* is graduated by wave lengths as measured by mμ, while the ordinate was plotted by logarithmic scale of the number in which the unit number is divided by the exposure time required for obtaining a predetermined response to a light having the color temperature of 3200° K. The above layer had a spectral sensitivity at said wave lengths shorter than 610 mμ as shown by curve **1** in FIG. 3*a*. The above *b* layer had a spectral sensitivity up to the wave length near about 750 mμ. Both the *a* and *b* layers were of electrically insulating property in a dark place and had a capacity maintaining electrostatic charges for sufficiently long time. Each of the *a* and *b* layers can be used as a photosensitive material for the prior art electrophotography separately from each other. The surface of the thus formed photosensitive material was electrically charged in the positive polarity in the first step by corona discharge and then was exposed uniformly to a light having the spectrum as shown by curve **2** in FIG. 3*b*. Thus, positive and negative electrostatic charges were charged at the respective surfaces of the *a* layer. Further, in the first step, the corona discharge and the exposure were effected simultaneously, the same results were obtained. Then, ion groups generated by corona discharge of AC, were applied to the surface of the photosensitive material while a light having the spectrum as shown by curve **2** in FIG. 3*b* and bearing therein an optical image was projected to the surface of the photosensitive material thereby forming an electrostatic latent image in the *a* layer. The voltage at the surface after the completion of the first step was +600 volts. The voltage at the surface after the completion of the second step, however, was +10 volts at the exposed portions of the surface while the surface voltage was about −350 volts at the dark portions. That is, under such conditions, the electrostatic contrast was −360 volts. Since the *b* layer was of electrically insulating property at a dark place, the electrostatic contrast was maintained for sufficient time required to permit the image to be developed therefrom. In the third step, an exposure was uniformly applied to the photosensitive material by using the same light as used in the first step. As a result, the voltage at the surface was about +10 volts at the portions exposed in the second step while the dark portions showed the voltage about +350 volts. In other words, an electrostatic contrast of about +340 volts was obtained. Since the electrostatic contrast was formed by maintaining an electrostatic field in the *a* layer, sufficient time was obtained required for the development. These electrostatic latent images were developed by the medium of colored electrically charged powder and transferred to other transferring papers, and thereafter, the remaining powder on the surface of the photosensitive material was removed. Thereafter, the electrostatic latent image was erased by exposing the surface uniformly to a light having the spectrum as shown by the curve **1** in FIG. 3*b* so as to make it ready for the next tests. The abscissa of FIG. 3*b* is graduated by the wave lengths in *m* while the ordinate is graduated by the intensity of the spectrum of the light in any desired unit. The light as shown by curve **1** in FIG. 3*b* is a light from a green fluorescent lamp while the light as shown by curve **2** is a light from a zircon lamp having the color temperature of 3200° K. with a glass filter capable of intercepting the light having the wave lengths shorter than 620 mμ being combined.

The surface of the photosensitive material was electrically charged in the negative polarity in the first step by corona discharge and thereafter processed under the same conditions as described above, and substantially the same results were obtained.

The photosensitive material produced in the Example 7 was subjected to corona discharge in the positive polarity so as to electrically charge the surface thereof in the positive polarity while, at the same time, an exposure was effected uniformly by using a light having the spectrum as shown by curve **2** in FIG. 3*b*. The surface voltage at this time was +600 volts. Subsequently, a light having the spectrum shown by curve **1** in FIG. 3*b* and bearing therein an optical image was projected to the surface so as to form an electrostatic latent image. The surface voltage at the dark portions was about +595 volts while the surface voltage at the exposed portions was about +20 volts, and thus the electrostatic contrast was about +575 volts.

After the surface was electrically charged to +600 volts in the first step, the negative ion groups generated by corona discharge in the negative polarity in the second step were applied to the surface of the photosensitive material while, at the same time, an exposure was effected by using a light having the spectrum as shown by curve **2** in FIG. 3*b* and bearing therein an optical image. The surface voltage at this time was about −1030 volts at the dark portions while the exposed portions showed about −250 volts. In other words, the electrostatic contrast was about −780 volts. Further, a uniform exposure was effected in the third step by using a light as used in the first step. The thus obtained surface voltage was about +180 volts at the dark portions while the exposed portions showed a surface voltage of about −250 volts.

In other words, the electrostatic contrast was about +430 volts. These latent images were developed and transferred by using a colored electrically charged powder, and thereafter, the remaining powder was removed so as to be ready for the next tests. At this time, prior or after the removal of the remaining powder, the photosensitive material was uniformly exposed to a light having the spectrum as shown by curve **1** in FIG. 3*b*.

What is claimed is:

1. A process of electrophotography using a photosensitive member which has two photosensitive layers and which may have an intermediate layer between said two layers, at least a portion of the range of the spectral sensitivity of one of said two photoconductive layers being different from at least a portion of the range of the spectral sensitivity of the other of said two photoconductive layers, said process comprising the steps of

uniformly applying electrostatic charges of a first polarity to the surface of said one photoconductive layer and uniformly inducing electrostatic charges of the polarity opposite to said first polarity on the boundary between said two layers or said intermediate layer or a region adjacent thereto, respectively, thereby forming an electrostatic field in said one photoconductive layer,

applying mobile electric charges opposite in polarity to said first polarity to said one photoconductive layer from either a direct current or an alternating current source,

exposing to a light bearing therein an image to be recorded, the light having such spectral characteristics that said one photoconductive layer is not rendered substantially conductive while said other photoconductive layer is rendered conductive, thereby discharging the electrostatic charges in both faces of said one photoconductive layer for a predetermined duration of time according to the photoconductivity of said other photoconductive layer through said other photoconductive layer so as to form an electrostatic latent image in said one photoconductive layer, thereby permitting said latent image to be utilized to obtain a visible image, and

exposing said one photoconductive layer to a light consisting of spectral components which render said one photoconductive layer conductive thereby permitting said latent image to be erased for the repeated utilization of said photosensitive material.

2. Process according to claim **1**, wherein said latent image is transferred to a transferring material so as to obtain a visible image thereon.

3. Process according to claim **1** further comprising the step of exposing said photosensitive material uniformly to a light having such characteristics that said one photoconductive layer is not rendered conductive but said other photoconductive layer is rendered to be conductive after the discharging step thereby permitting a stable electrostatic latent image to be obtained in said one photoconductive layer.

4. A process as in claim **1** where $R_D \cdot C$ is in the order of or greater than the said duration of time that said charges are discharged where

R_D=the electrical resistance per unit area (normal to the layer) of said other layer in the absence of light; and

C=the electrical capacitance per unit area (normal to the layer) of said one layer.

5. A process as in claim **4** where $R_L \cdot C$ is equal to or less than the said duration of time said charges are discharged where R_L=the resistance per unit area (normal to the layer) of said other layer in the presence of light.

6. A process as in claim **1** where ρ_D/ρ_L is in the order of 10 or greater where

ρ_D=the specific resistance of said other layer in the absence of light; and

ρ_L=the specific resistance of said other layer in the presence of light.

7. A process as in claim **1** where said intermediate layer is electrically insulative and is disposed between said one and said other photoconductive layers to prevent carriers of free electric charges from flowing into said one photoconductive layer.

References Cited

UNITED STATES PATENTS

2,476,800	7/1949	Blackburn	175—366
2,962,374	11/1960	Dessauer	96—1
2,962,375	11/1960	Schaffert	96—1
3,438,706	4/1969	Tanaka et al.	355—11
3,070,900	1/1963	Lot	34—156
3,186,838	6/1965	Graff, Jr., et al.	96—1
3,291,600	12/1966	Nicoll	96—1

CHARLES E. VAN HORN, Primary Examiner

M. B. WITTENBERG, Assistant Examiner

U.S. Cl. X.R.

96—1.5