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TRANSFER OF ELECTROSTATIC CHARGE PATTERN

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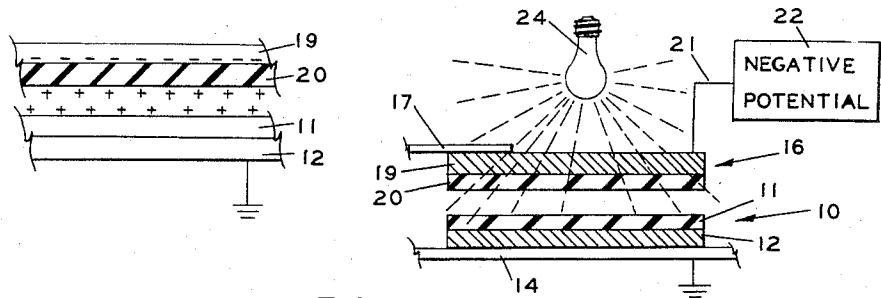


FIG. 1

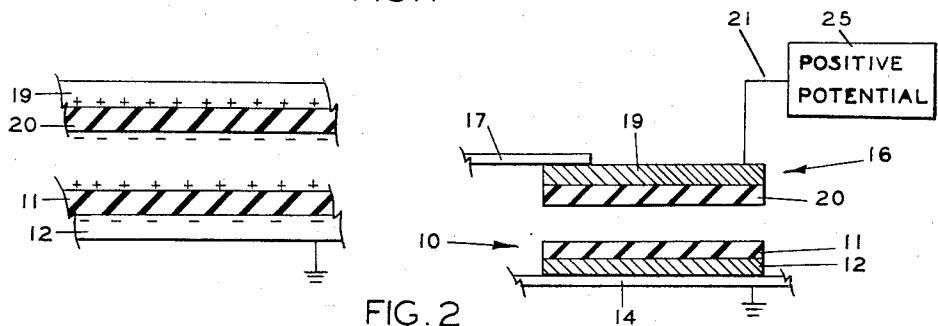


FIG. 2

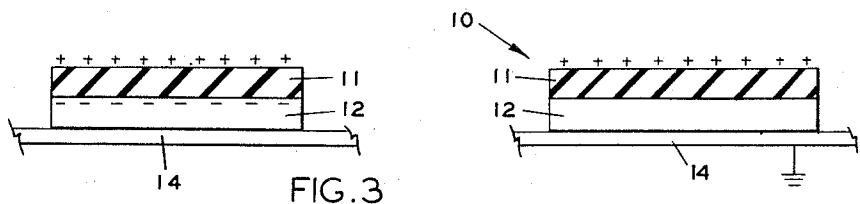


FIG. 3

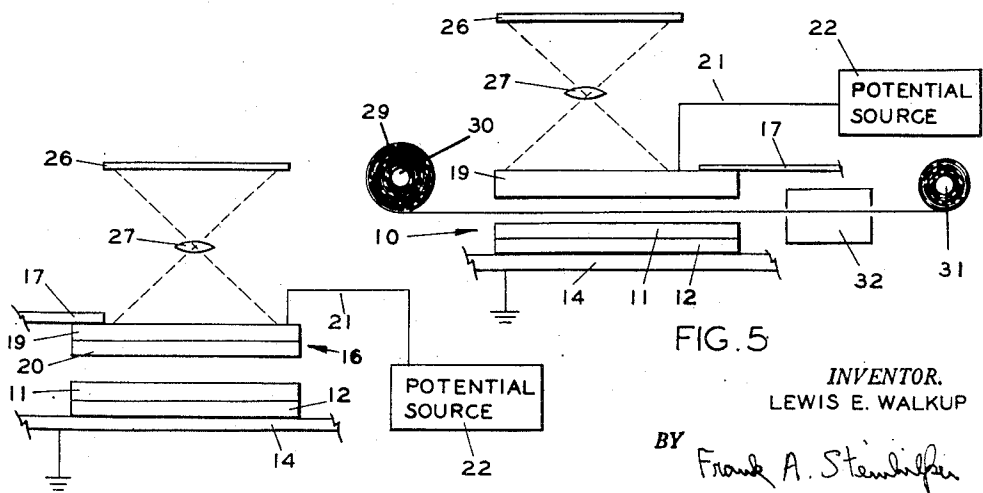


FIG. 4

FIG. 5

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TRANSFER OF ELECTROSTATIC CHARGE PATTERN

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6 Claims. (Cl. 96—1)

This invention relates in general to the transfer of electric charge between contiguous insulating surfaces and in particular to the application of an electrostatic charge or potential to a photoconductive insulating member adapted for xerography.

According to the invention of Carlson described in U. S. 2,297,691 there is provided a process for the making of electrophotographic pictures wherein a uniform electrostatic charge is applied to the surface of a photoconductive insulating body and this charge is selectively dissipated by exposure to a pattern of light and shadow. This exposure and its consequent dissipation of electric charge results in an electrostatic latent image which can later be developed or made visible by treatment with an electroscopic material which adheres to the electrostatic charge pattern and which, optionally, may be transferred to a second surface to form an electrophotographic or xerographic print or picture. If desired, other methods of utilization of the electrostatic latent image are available and the basic invention has wide applications in many fields of use.

For the application of the electrostatic charge or charge potential to the photoconductive insulating body of Carlson's invention there have been proposed and tried various means, methods and apparatus. One of these, frictional electrification, is subject to certain difficulties in control and reproducibility. Another method of operation employs, for charging the photoconductive insulating layer, a form of corona discharge wherein an adjacent electrode comprising one or more fine conductive bodies maintained at a high electric potential causes deposition of an electric charge on the adjacent surface of the photoconductive body. This means of charging, however, is subject to the disadvantage, among others of requiring high voltages generally in the order of several thousand volts.

Now in accordance with the present invention there is provided method, means and apparatus for the transfer of electric charge between contiguous surfaces. For example, the invention finds particular application to placing an electric charge or potential on a photoconductive insulating body overlying a conductive backing member whereby there may be imparted to such member an electric charge of voltage in the order of magnitude now employed in xerography and whereby such voltage may be achieved without the need for sources of exceptionally high electric potential.

It is, accordingly, an object of the invention to provide methods, means and apparatus for the transfer of electric charge between contiguous insulating surfaces.

It is another object of the invention to provide apparatus for the charging of a photoconductive insulating body.

It is a further object of the invention to provide apparatus and methods for the application of a substantially uniform electric potential to a photoconductive insulating body overlying a conductive backing member.

It is an additional object of the invention to provide a new process and means for imparting to a photoconductive

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insulating surface an electric potential in the order of magnitude of potentials now required for xerography.

It is a still further object of the invention to provide apparatus, means and method for induction charging of xerographic members.

Additional objects of the invention will in part be obvious and will in part become apparent from the following specification and drawings wherein:

Figure 1 is a diagrammatic view of apparatus for charging a photoconductive insulating body illustrating one stage of the charging operation including a parallel enlarged fragmentary diagrammatic view thereof;

Figure 2 is a similar view of the same apparatus and members in a subsequent stage of the operation;

Figure 3 is a similar view of a charged member according to the previous figures;

Figure 4 is a diagrammatic view of apparatus according to another embodiment of the invention and,

Figure 5 is a diagrammatic view of continuous electrophotographic apparatus according to a further embodiment of the invention.

General apparatus and method for implementing and carrying out the present invention are shown in Figures 1, 2, and 3 which illustrate also the process of the present invention. According to these figures a member to be charged, such as a xerographic plate or the like, generally designated 10, comprising a photoconductive insulating layer or body 11 overlying a conductive backing member 12 is placed on a support 14, and the conductive backing member 12 is electrically connected to ground, either directly or through support member 14. A charging electrode generally designated 16, supported on a support member 17, is positioned contiguous to, or in extremely close proximity to, the photoconductive body 11. This charging electrode 16 comprises generally a transparent conductive electrode member 19 on which is supported a transparent dielectric insulating member 20 which is in contact or virtual contact with the photoconductive insulating body 11. The transparent conductive backing electrode 19 is electrically connected through conductive lead 21 to an electric potential source 22, this source being of polarity opposite to that which is ultimately desired on the photoconductive insulating body. An illumination member 24 such as a lamp or the like is positioned behind the transparent charging electrode and disposed to flood with illumination a selected part or all of the photoconductive insulating body 11.

The next stage of the operation is illustrated in Figure 2, progressing from the stage shown in Figure 1 to the stage shown in Figure 2. The composite body 10 to be charged remains on its support member 14 electrically connected to ground potential. The transparent charging electrode 16 on its support 17 remains in its position closely adjacent to the member being charged. In this stage of the charging operation however, exposure source 24 has been eliminated for example, by closing a shutter, by de-energizing the lamp, or by other suitable method or operation. With the surface of photoconductive insulating body 11 thus maintained in the absence of illumination, the transparent backing member 19 of the charging electrode 16 is then removed from electrical contact with potential source 22 and desirably is connected to a different potential source such as ground potential or another potential source of controlled polarity and potential such as, preferably, a potential source 25 of the same polarity as is ultimately desired on the member being charged.

In the final stage of the operation, as illustrated in Figure 3, the member 10 comprising the photoconductive insulating body 11 overlying the conductive backing member 12 is still positioned on the support member 14 and possesses a high potential electric charge as indicated dia-

grammatically by the plus charge marks on the surface thereof. To reach this stage of the operation the charging electrode 16 on support 17 has been removed from the proximity of member 10 either before or after being disconnected from potential source 25, preferably while still connected thereto. The result of the combined steps of operation is the formation of a charge on the surface of this member which charge is of a potential in the order of those desired for xerography. Thus, for example, potentials of 50 to several hundred volts may be placed on xerographic members with applied potentials not excessively higher than the electric potential achieved.

In diagrammatic illustrations paralleling the structural portion of Figures 1, 2 and 3 is shown the charge distribution now believed to accompany the operating steps of the charging process just described. In the position and arrangement illustrated in Figure 1 illumination from lamp 24 is striking the surface of photoconductive insulating body 11 whereby this body, like backing member 12, becomes conductive. Thus, the upper surface of body 11 becomes in effect one plate of a capacitance series and the lower surface of conductive backing member 19 of the transparent electrode becomes an opposite plate of a capacitance series. Between these two effective capacitance plates are two effective capacitors in series. The lower surface of insulating member 20 thus becomes, in effect, an intermediate capacitance plate which is common to both of these capacitors. Between this surface and the upper surface of member 11 exists a thin air dielectric and between this same surface and the upper member 19 exists the transparent dielectric body 20. This dielectric body 20 is of finite thickness and is comparatively thicker than the infinitesimal air gap, and therefore the predominant potential drop between member 19 and member 11 occurs through the dielectric body 20. Thus, the lower surface of this body 20 becomes charged to a polarity opposite to that on member 19 and the same polarity as that on member 11. It is to be realized that these various members are extremely close together so that a relatively low potential difference between the surface of member 20 and the surface of member 11 results in a potential gradient sufficient for non-sparking discharge between the surfaces, whereby charge can migrate across this air gap.

In the diagrammatic illustration of Figure 2 it is observed that the illumination has been cut off, whereby photoconductive insulating body 11 now becomes an excellent insulator instead of an electrical conductor. It is observed that in the process operation from the status illustrated in Figure 1 to the status illustrated in Figure 2 the following new conditions have been imposed on the system: first, member 11 has been made electrically insulating whereby the charge on the surface of this member is trapped at this position. Next, member 19 has been brought to a high opposite polarity, in this case a high positive polarity, and member 12 has been maintained at ground potential. This in effect introduces a third capacitance into the series, namely the capacitance between the upper and lower surfaces of photoconductive insulating body 11. Member 19 is maintained at a positive potential and member 12 is maintained at ground and, therefore, the intermediate surfaces between these two members are at intermediate potential. It is remembered however, that the lower surface of member 20 has a high charge that was induced through body 11 and across the air gap while the photoconductor was in its conductive condition by virtue of incident illumination. Subsequently, however, this member was made non-conductive and the electrical polarities so changed as to cause a change in electric potential. Because bodies 20 and 11 are now insulating bodies, migration of electric charge through these bodies is no longer possible and the migration of charge must occur only between the surface of body 11 and the surface of body 20 across the air gap. Here again, it is remembered that this air

gap is extremely narrow so that such migration can occur. Noting again that body 20 is an extremely good dielectric material it is observed that the only way in which the intermediate potentials of these surfaces can be achieved is by migration from the surface of layer 20 to the surface of body 11 of a substantial effective positive charge, whereby the positive charge concentration on the surface of body 11 is substantially increased.

In the next subsequent operation to achieve the status illustrated in Figure 3 the composite electrode 16 is withdrawn from member 10, leaving on the upper surface of body 11 a high potential positive charge and, if necessary, drawing from ground additional negative charge which is induced to the upper surface of the conductive backing member so that member 10 may have an effective net charge of zero. The result is a high and uniform charge on the surface of body 11, the charge being capable of dissipation by the action of light according to the principles of xerography.

Viewing in greater detail the flow of electric charge in the operations between the status of Figure 1 and the status of Figure 2, it is seen that the following effects occur. When the illumination is shut off there resides on the surface of layer 20 a high charge density of positive polarity this charge being induced to this surface by the negative charge or potential on conductive electrode 19. Next, the negative potential on electrode 19 is reduced to an intermediate negative potential, or is reduced to zero by grounding, or is reversed to opposite potential, thus being varied toward the opposite or positive potential. This causes the positive charge on layer 20 to be repelled from electrode 19. As the potential on electrode 19 is varied toward positive polarity, the potential gradient between the contiguous surfaces of layers 20 and 11 exceeds threshold of field emission or of migration across the narrow air gap between the surfaces and causes migration of this positive charge to layer 11 (or, actually, migration of negative charge from layer 11 to layer 20, leaving a net positive charges on layer 11). Thus, in this step, transfer of electric charge is caused between the two insulating surfaces.

As a typical example of actual operation of the present invention, there will now be presented a description of process apparatus and means for charging a selenium xerographic member according to the present invention employing as the charging electrode a metal plate having as its dielectric insulating member a thin layer of polystyrene. According to this specific example, the member being charged consists of a layer of vitreous appearing selenium 50 microns in thickness disposed on the surface of a conductive backing member. This selenium layer has a dielectric constant in the order of about 8. The charging electrode consists of a metal plate having on its surface a polystyrene layer also about 50 microns in thickness which polystyrene layer has a dielectric constant of about three. The two members namely selenium coated plate and the polystyrene coated charging electrode are brought into virtual contact (this being physical contact between the surfaces, although it is realized that the members at most points are separated by an air gap arbitrarily assumed to be about 1 micron). This air gap has a dielectric constant of unity, and a potential of about 100,000 volts per centimeter will cause charge migration across air gaps in this range of thickness.

The selenium coated plate was placed on its support and the charging electrode on a support was brought into virtual contact therewith. A light source was disposed above the charging electrode and the backing member of the charging electrode was connected to a potential source of 1,000 volts negative polarity with respect to the backing plate of the member to be charged, which was connected to ground potential. After exposure to

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light while maintaining the charging electrode at this negative potential for about 5 seconds, the illumination was cut off and the photoconductive member was shielded from light or other radiation, leaving its surface in darkness. After the illumination had been cut off, the backing member of the charging electrode was then connected to a positive polarity potential of 1,000 volts, instead of the negative potential polarity to which it had originally been connected. While thus connected to the positive polarity source, the charging electrode was then removed from the proximity of the selenium surface. The selenium surface was found by electrometer measurement to be charged to a potential of 450 volts, positive polarity. This potential was adequately uniform across the entire charged surface, whereby the member was suitably charged or sensitized for xerography.

The charging electrode 16 generally comprises a transparent conductive electrode member conforming in shape to the surface to be charged or constructed and disposed to be virtually in contact with such surface to be charged. A dielectric member 20 is optionally permanently affixed to such transparent conductive backing member 19 or alternatively is movably positioned between such member and the surface being charged. The transparent conductive backing member 19 suitably may be a conductive glass or conductively-coated glass, a conductive plastic, or other electrically conductive transparent or translucent material such as moist paper, cellophane, or cloth, or transparent or translucent web materials treated with electrically conductive materials, through which light or other activating radiation may be carried. The dielectric body 20 may consist of a plastic film or the like, such as, for example, polystyrene or other polymerized hydrocarbon materials and other suitable resins such as ureaformaldehyde, ureamelamine, and phenolformaldehyde resins, polymerizable vinyl compounds and the like, and, in general, thin film-forming materials characterized by a relatively high dielectric constant and a high dielectric breakdown. This dielectric body, like its backing electrode member, should be either transparent or translucent whereby light can be projected therethrough. If desired, effective transparency can be achieved with a grid of opaque material such as a fine wire grid, or a moving conductor such as a wire brush with wires spaced to pass light, or a conductive fiber pad moved along the surface of the dielectric member. Likewise, exposure of the layer to light may be accomplished by interleaving between an opaque electrode and the photoconductor an illumination-conducting plastic web or sheet.

If desired, the charging electrode may be opaque and the backing member 12 for the photoconductive insulating layer may be transparent. In this instance, the photoconductive insulating layer is exposed to illumination through its own backing electrode during the appropriate portion of the charging operation.

It is apparent that the charge or potential produced on the photoconductive insulating body by the operation of the present invention depends on the relative thicknesses and dielectric strength of the photoconductive insulating body 11 and the dielectric body 20 on the charging electrode, both with relation to the thickness of the air gap assumed to exist between these two members when they are in virtual contact. As illustrated in the specific example included herewith, potentials satisfactorily usable in xerography can be imparted to the photoconductive insulating layer through operating voltages in the order of about one hundred to one or more thousands of volts.

Within the general scope of the invention as specifically illustrated in the foregoing example, it is to be realized that numerous variations and modifications can be made. Thus, for example, it is disclosed that the member being charged comprised a metal plate having a selenium layer thereon. It is to be realized that the method of the

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present invention is adapted to the charging of other photoconductive bodies including, for example, photoconductive insulating selenium, anthracene and the like, and photoconductive bodies containing photoconductors dispersed in binder films and other photoconductive members in general. The backing member for this photoconductive insulating layer is a conductive member such as, for example, a metallic surface, a conductive plastic member, conductive webs or other surfaces able to conduct electricity particularly adapted for xerography, but it is to be understood that other photoconductive insulating bodies overlying conductive backing members may be charged according to the present invention.

In Figure 4 there is shown a further embodiment of the present invention whereby an electrostatic latent image is induced as desired either onto the photoconductive insulating body or onto the dielectric body of the charging electrode. According to this embodiment of the invention the member 16 is to be charged, comprising a photoconductive insulating body 11 on a conductive backing member 12 is placed on support 14, and the conductive backing member 12 is suitably connected to ground potential. Closely adjacent is the charging electrode 16, comprising a transparent conductive backing member 19 and a dielectric body 20 all desirably being supported by support member 17. The conductive backing 19 is again connected through a suitable conductive lead 21 to a potential source 22. Positioned behind the transparent charging electrode 16 is an image source 26, such as a pattern of light and shadows to be recorded, and a lens 27 or light means to direct the pattern of light and shadow through the photoconductive insulating body or layer 11.

According to this embodiment of the invention, an electrostatic charge pattern corresponding to image member 26 is placed on the photoconductive insulating body 11 by operation of the same steps as are employed in the embodiments of the invention described in Figures 1 to 3. Where the light portions of the image pattern fall on the photoconductive insulating body it will be seen that an electrostatic charge will be formed on the photoconductive insulating body. On the other hand, where the shadow portions of said pattern fall on the photoconductive insulator it will be apparent that substantially no charge or pattern will be imparted to that body. The result, therefore, is an electrostatic charge pattern or electrostatic latent image corresponding to the light image which is cast on the photoconductive insulator.

According to another form of a similar embodiment of the invention, an electrostatic latent image can be imposed on the dielectric body or layer 20 of the charging electrode 16. According to this form of the invention, the image of member 26 is cast upon the photoconductive insulating body 11 while the charging electrode 16 is suitably connected to a potential source 22. As is seen by reference to Figure 1 an electrostatic charge is thus imposed on the lower surface of dielectric member 20 and this dielectric charge corresponds to the luminated portions of the photoconductive insulating body. When the source of illumination is then cut off, the photoconductive body is shielded from light and therefore remains an insulator. Thus, when the charging member 16 is removed from the vicinity of the photoconductive insulating body, this charge pattern remains on the surface of member 20, forming an electrostatic latent image corresponding to the image formed according to the previous embodiment of the invention.

In Figure 5 there is shown a further embodiment of the invention whereby an electrostatic latent image is formed on a web, film or the like which is adapted to be moved between adjacent members. In this embodiment of the invention the photosensitive member, comprising a photoconductive insulating body 11 overlying the surface of a conductive backing member 12, is placed on a support member 14 within a light-tight compartment, chamber, box or the like, and suitably connected to ground poten-

tial. Closely adjacent to the photoconductive insulating surface is disposed a transparent conductive electrode 19 on a suitable support 17, which electrode is connected to a potential source 22 through a suitable conductive lead 21. A lens 27 projects a light image 26 through the transparent electrode onto the surface of the photoconductive insulating body 11. A dielectric web material 29 leads from a support 30 or the like between electrode 19 and body 11 to take-up roll 31 or other suitable take-up source.

According to this embodiment of the invention, as illustrated in Figure 5, the suitable dielectric member 29 is placed between transparent electrode 19 and the photoconductive insulating body 11. Desirably these two bodies are then brought together in such a manner that air gaps between the members are kept to a minimum. The exposure is made while electrode 19 is connected to the potential source 22 as in the case of the previous embodiments of the invention. The dielectric film 29 then is moved from its position between the electrode members, optionally through a development zone 32 in which electroscopic material is deposited thereon, and may be picked up on take-up roll 31 or otherwise processed, for example, by permanently fixing the deposited material on the film or by other treatment as desired.

It will be recognized also that modifications may be made in the apparatus for implementing the process described herein. Thus, for example, the process and apparatus are particularly suited to continuous operation through the employment of either or both members 10 and 16 in the form of rotating drums, whereby continuous charging may be accomplished. For example, the apparatus indicated in the figures may comprise one station of a continuous xerographic machine designed to produce xerographic pictures. It will be recognized that these and other modifications of the invention are within the spirit and scope of the new improvement in the art.

As one example of the scope of the invention, reference is made to its application to the recording of X-ray patterns. In the case of X-rays it will be recognized that metal layers are substantially transparent to such activating radiation, and thus the transparent member may be a metal sheet or the like. Thus, specifically, it may be desired to form an electrical image from X-ray activation, in which case both backing member 12 and electrode 16, or either of them, may be metal, and exposure to the X-ray pattern may be accomplished at the desired stage in the operations by exposure through such metal layer. In this manner, X-ray activation is effective either for placing a charge on the radiation-sensitive layer, or for forming a charge pattern on either that layer or the adjacent insulating layer. It is to be understood, furthermore, that operation of the invention with X-rays or other penetrating radiation can be improved with a heavy metal such as lead or the like as a simulated intensifying screen either as the non-transparent conductive electrode or backing member or as a thin layer on the surface of the transparent member through which the radiation sensitive layer is activated. Likewise, in view of the suitability of the invention for X-rays or penetrating radiation the term "photoconductive" should be interpreted in its broader sense to denote a layer that is an insulator in the absence of activating radiation and is rendered conductive by the action of such radiation.

What is claimed is:

1. A method of forming an electrostatic latent image on a xerographic plate comprising a photoconductive insulating layer overlying a conductive backing member and in electrically conductive contact therewith, said method comprising positioning closely spaced over the photoconductive insulating layer a conductive electrode separated from said photoconductive insulating layer by a layer structure comprising a solid insulating film, the surface of the insulating film facing the photoconductive insulating

layer being in virtual contact therewith, applying to said electrode a first potential, with respect to the backing member, of a magnitude of at least about 100 volts while simultaneously exposing the photoconductive insulating layer to a light image pattern to selectively increase its conductivity selectively allowing current flow to the surface of the photoconductive insulating layer in virtual contact with said insulating layer in accordance with the light image pattern, said first applied potential being of a sufficient magnitude to cause charge transfer in areas exposed to light between the surfaces in virtual contact, cutting off said light image pattern from said photoconductive insulating layer, and subsequently applying to said electrode a second potential, with respect to the backing member, of a polarity opposite to the polarity of said first potential and of a magnitude of at least about 100 volts and of a sufficient magnitude to cause transfer between the surfaces in virtual contact at least in the areas previously exposed to light thereby forming an electrostatic latent image on the photoconductive insulating layer usable in xerography.

2. The method of claim 1 in which said first potential is of negative polarity and in which the electrostatic latent image is formed with positive electrostatic charges.

3. The method of claim 1 in which said first potential is of positive polarity and in which the electrostatic latent image is formed with negative electrostatic charges.

4. The method of claim 1 in which said electrode and said insulating film are substantially transparent and in which exposure of the photoconductive insulating layer to the light image pattern takes place by directing said pattern first through said electrode and then through said insulating film to said photoconductive insulating layer.

5. The method of claim 1 in which said conductive backing member is substantially transparent and in which exposure of the photoconductive insulating layer to the light image pattern takes place by directing said pattern first through said conductive backing member and to said photoconductive insulating layer.

6. A method of forming an electrostatic latent image on a xerographic plate comprising a photoconductive insulating layer overlying a conductive backing member and in electrically conductive contact therewith, said method comprising positioning closely spaced over the photoconductive insulating layer a conductive electrode separated from said photoconductive insulating layer by a layer structure comprising a solid insulating film, the surface of the insulating film facing the photoconductive insulating layer being in virtual contact therewith, applying to said electrode a first potential, with respect to the backing member of a magnitude of at least about 100 volts while simultaneously exposing the photoconductive insulating layer to a light image pattern to selectively increase current flow to the surface of the photoconductive insulating layer in virtual contact with said insulating layer in accordance with the light image pattern, said first applied potential being of a sufficient magnitude to cause charge transfer in the areas exposed to light between the surfaces in virtual contact, cutting off said light image pattern from said photoconductive insulating layer, applying to said electrode a second potential, with respect to the backing member, opposite in polarity to the polarity of said first potential and of a magnitude of at least about 100 volts, and while said second potential remains applied removing said insulating film and said electrode from said photoconductive insulating layer, said second potential being of a sufficient magnitude to cause charge transfer between the facing surfaces of said insulating film and said photoconductive insulating layer at least in areas previously exposed to light thereby forming an electrostatic latent image on the photoconductive insulating layer usable in xerography.

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