

Feb. 22, 1966

L. E. WALKUP ET AL
IMAGE METHOD FOR ELECTROSTATIC RETENTION
IN PHOTOCONDUCTIVE LAYERS

3,237,197

Original Filed Oct. 29, 1958

2 Sheets-Sheet 1

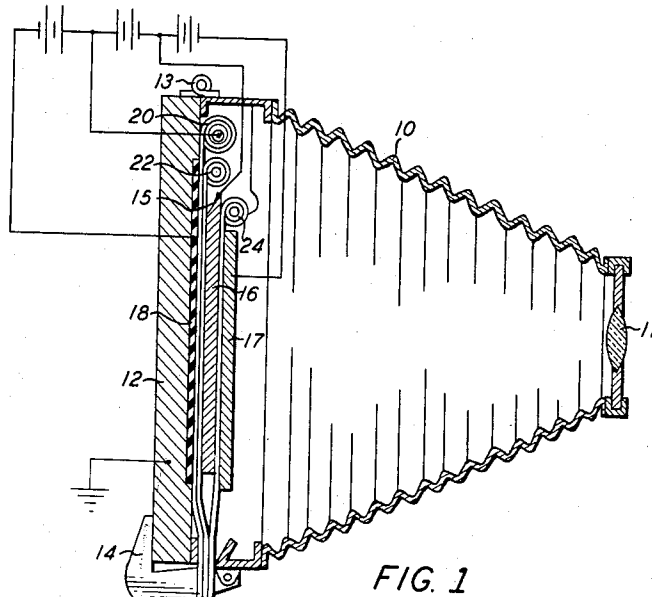


FIG. 1

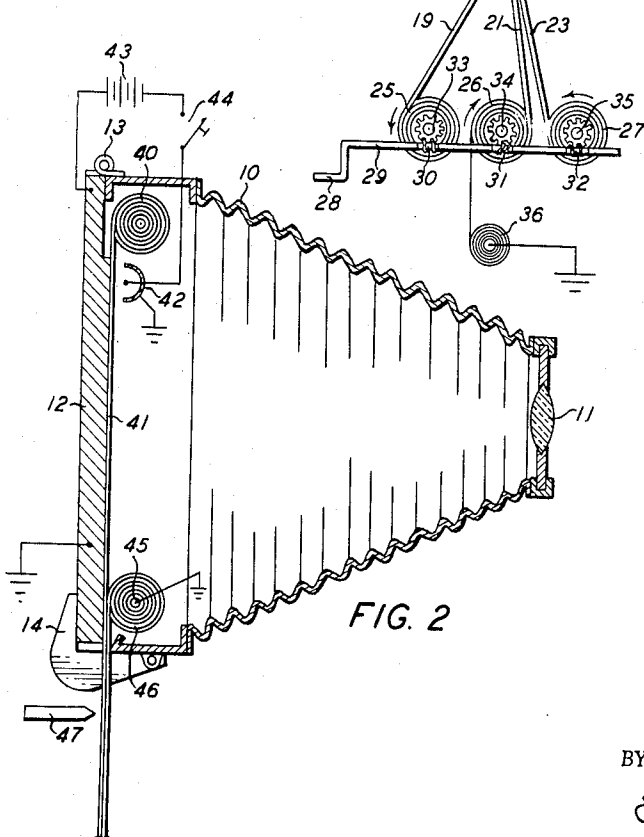


FIG. 2

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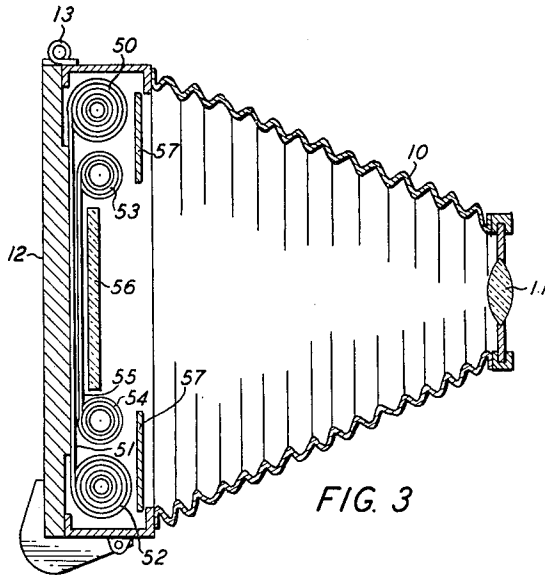


FIG. 3

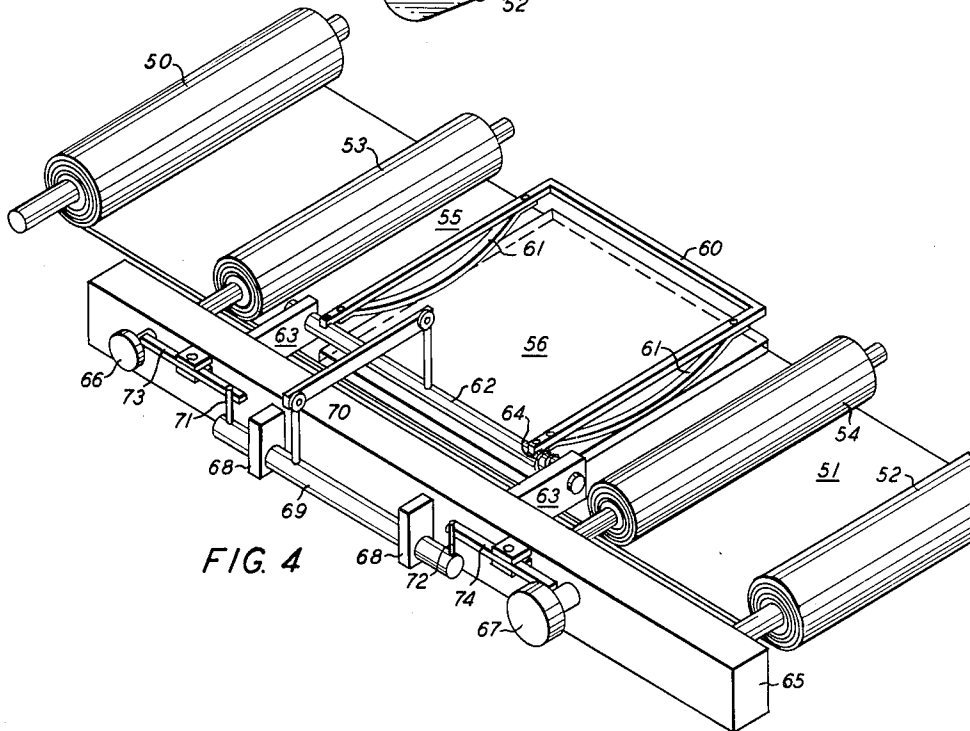


FIG. 4

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3,237,197

IMAGE METHOD FOR ELECTROSTATIC RETENTION IN PHOTOCONDUCTIVE LAYERS

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Original application Oct. 29, 1958, Ser. No. 770,543, now Patent No. 3,057,275, dated Oct. 9, 1962. Divided and this application Dec. 22, 1961, Ser. No. 161,700

1 Claim. (Cl. 346—1)

This application is a division of application Ser. No. 770,543, filed Oct. 29, 1958, now U.S. Pat. 3,057,275, issued Oct. 9, 1962.

This invention relates to the preservation of electrostatic latent images in xerography and related arts.

In xerography and related arts it is customary to form an electrostatic latent image by one of several methods. According to one method, an electric charge is first placed on the surface of a photoconductive insulating member which charge is then selectively dissipated by exposing the photoconductive insulating member to a pattern of light and shadow in image configuration. In a second method, a pre-existing electrostatic charge pattern on a photoconductive insulating member is transferred to an ordinary insulator not having photoconductive properties. In still another method a charge pattern is formed on an insulating member through the action of high voltage pulses applied to adjacent shaped conductive electrodes. Many other methods for forming electrostatic latent images are known and may be used in connection with the present invention. One such additional method will be discussed later. These electrostatic latent images, however formed are subsequently made visible through known xerographic development techniques or otherwise used, as by reading the charge pattern with an electrometer or the like.

It is always essential that the member which carries the electrostatic image have sufficient resistivity to retain the charge pattern until it is to be utilized. Charge patterns usually decay in an exponential fashion with the characteristic decay time being given by the equation $\tau = \rho \epsilon$ where τ is the time constant, ρ is the resistivity of the image bearing member and ϵ is the dielectric constant of the member, all quantities being expressed in MKS units. The available resistivities in suitable image bearing members have heretofore limited the length of time during which it has been possible to retain an electrostatic image. This has been particularly true with photoconductive insulating materials where it has generally been necessary to develop the charge pattern very soon after its formation. Ordinary insulating materials can be obtained with resistivities higher than those of most photoconductive insulators, but here also the resistivity is often inadequate to support the charge for a desired length of time.

It is accordingly an object of this invention to provide methods for preserving electrostatic latent images for extended periods of time.

The invention will be further described in connection with the figures in which:

FIG. 1 shows one form of xerographic apparatus embodying the invention;

FIG. 2 shows another form of xerographic apparatus embodying the invention;

FIG. 3 shows still another form of xerographic apparatus embodying the invention; and,

FIG. 4 is a detailed view of an element of the apparatus of FIG. 3.

FIG. 1 shows a xerographic camera capable of recording three separate xerographic color separation images with a single exposure. It is more fully described in co-pending application Serial No. 581,912, now U.S. Patent No. 2,962,374, issued Nov. 29, 1960. As illustrated, there

is a camera housing, including, for example, bellows 10 supporting exposure means such as a lens 11 with suitable shutter mechanism (not shown) as is conventional in the camera art. Positioned to make a light shield with the bellows is a rear panel 12 operably mounted on a hinge 13 and secured by a catch 14. Mounted on a hinge 15 adjacent to the back panel is a xerographic plate 16 adapted to be positioned closely adjacent to the back panel. Xerographic plate 16 has first photoconductive layer sensitive to a first color facing the lens 11, and a second photoconductive layer sensitive to a second color on the opposite side. Positioned in front of plate 16 is a transparent conductive electrode 17. On the inside surface of rear panel 12 is a photoconductive layer 18 sensitive to a third color. Passing between this photoconductive layer and the xerographic plate 16 is a first insulating web 19 fed from a conductive feed roll 20 and a second web 21 fed from feed roll 22. The surface of web 19 which contacts web 21 is coated with a transparent conductive coating. A third web 23 held on a conductive feed roll 24 passes between the xerographic plate 16 and electrode 17. The surface of web 23 which contact electrode 17 is coated with a transparent conductive coating. Webs 19, 21 and 23 pass out of the camera housing through a slot at the bottom and are wound up on take-up spools 25, 26 and 27 respectively. These take-up spools can be operated in unison by operating handle 28 which is attached to shaft 29 which is journaled in supports (not shown) and carries along its length three worms 30, 31 and 32, which engage worm wheels 33, 34 and 35 respectively which in turn are mounted on take-up spools 25, 26 and 27 respectively. In addition, there is a roll 36 of conductive foil which is mounted so that the foil is interleaved with web 21 as it is rolled up on take-up spool 26. As is shown in the figure, suitable power supply means are operably connected to the rear panel 12, conductive electrode 17 and to the conductive surfaces of the webs through conductive feed rollers 20 and 24.

In use and operation the camera of FIG. 1 is suitably aimed and focused and the shutter mechanism is released while operating electric potentials are applied to the electrode members. This results in the formation of developable electrostatic xerographic latent images on the three webs. The image bearing webs are then rolled up on take-up spools 25, 26 and 27 by operating handle 28. This puts the camera in condition for taking another exposure. Many such exposures can be taken and when the webs are completely rolled up on the take-up spools the spools may be removed from the camera and carried to suitable developing apparatus where the charge patterns thereon may be made visible.

As the insulating webs emerge from the camera they carry on their surfaces electrostatic charge patterns which may have potentials ranging up to several hundred volts. However, as webs 19 and 23 are rolled onto their respective take-up spools the image bearing surface of each web comes into contact with the conductive coating on the opposite side of the web. The potential on the surface of the web before it is rolled up is given by the relation $V = Q/C$ where V is the voltage, Q is the charge per unit area and C is the capacitance per unit area. This capacitance is essentially that of the web itself which separates the charge on one of its surfaces from the conductive coating on the other surface. As the charge carrying surface is rolled against the conductive coating, however, the capacitance as seen at the charge carrying surface is multiplied many times because the conductive coating on the next turn on the web is in virtual contact with the charge carrying surface layer rather than being separated therefrom by the thickness of the web. Accordingly, the potential at the charge carrying surface of the web is reduced nearly

to zero. As will be discussed subsequently, the charge on the web does not jump the nominal gap separating the charge from the adjacent conductive coating. As a matter of fact, this nominal or infinitesimal gap is found to have very excellent insulating qualities. The situation involved in rolling up webs 19 and 23 may be likened to that which occurs when a large capacitor with a very long time constant is connected in parallel with a smaller charged capacitor with a shorter time constant. In that situation most of the charge on the small capacitor would be transferred to the large capacitor and the time constant of the combination would be largely determined by the time constant or resistance of the larger capacitor. Obviously, the larger capacitor corresponds to the capacitance per unit area found between adjacent turns or layers as webs 19 and 23 are wound up and the smaller capacitor corresponds to the capacitance per unit area through webs 19 and 23. When each web is subsequently unrolled the capacitance at the charge carrying surface is restored to its former low value and the charge pattern reappears essentially as it was before the web was rolled up. Since web 21 does not have a conductive coating, a thin conductive layer such as a metal foil 36 is interleaved in web 21 as the web is rolled up. This accomplishes the same result as the conductive coatings on webs 19 and 23.

FIG. 2 shows a different type of xerographic camera apparatus embodying a different form of the present invention. Again there is shown a camera body having a bellows 10, a lens 11 and a back 12 supported on hinge 13 and held closed by catch member 14. Mounted inside the camera is a feed roller 40 carrying a supply of a xerographic web plate 41. Plate 41 may take several forms. It may comprise a thin metal foil coated with a layer of vitreous selenium or other photoconductive material, or it may comprise a web of foil coated with a lacquer coating of a photoconductive pigment such as zinc oxide dispersed in a resin binder. In some cases the metal foil may be replaced by a strip of slightly moistened paper. The photoconductive insulating layer should face the lens. Various other combinations of the photoconductive insulating materials and support materials are known in the art and may also be embodied. A corona charging device 42 is mounted within the camera to apply an electrostatic charge to plate 41 as it passes charging device 42 which is connected to a source of high potential 43 through a switch 44. Also mounted within the camera is a supply roll 45 carrying a web of thin conductive foil 46. Any thin flexible material having at least one conductive surface may be used for foil 46. A knife blade 47 is positioned adjacent to the camera to enable plate 41 and foil 46 to be cut and detached from the camera.

To operate the camera switch 44 is closed and a suitable length of plate 41 and foil 46 are withdrawn from the camera. The length withdrawn should be substantially comparable to the length of the focal plane of the camera. Plate 41 is electrostatically charged as it passes beneath the corona charging device 42 and there results a charged length of plate 41 lying in the focal plane of the camera. Switch 44 may then be opened and, assuming that the first exposure is yet to be made, plate 41 and foil 46 are severed at knife 47 and discarded. The camera is then aimed and focused and the shutter mechanism is released to project a pattern of light and shadow onto plate 41 and thereby to form an electrostatic latent image thereon. After the exposure is completed the exposed length of plate 41 is withdrawn from the camera. Normally, switch 44 will be closed while plate 41 is being withdrawn in order to prepare the camera for a second exposure. As plate 41 is withdrawn, an adherent covering of foil 46 is withdrawn with it. Foil 46 will adhere tightly to the surface of plate 41 by electrostatic attraction. Thus, once the leading edge of foil 46 is brought into contact

with plate 41, foil 46 will continue to feed from the supply roll 45 into contact with plate 41 whenever a length of plate is withdrawn from the camera. After the exposed length of plate is withdrawn, the plate together with its foil covering may be severed by tearing against knife 47 to form a single piece of electrostatic latent image bearing xerographic plate which may conveniently be stored. When a number of such pieces of plate have been exposed, they may be carried to a suitable development apparatus and there developed after removal of the adherent foil covering.

As plate 41 comes into contact with foil 46 upon removal from the camera, the capacitance at the charge bearing surface of the plate is very greatly increased and the potential at the plate surface is greatly reduced. Since the capacitance appearing between the plate 41 and web 46 is very large and since this capacitance is associated with a very high resistance or a very long time constant, in spite of apparent contact between the conductive foil and the plate, the charge pattern on plate 41 can be preserved for very long periods of time. Thus, there is no need to develop each exposure as soon as it is made, but instead many exposures can be made and then developed later at the operator's convenience. For this reason it is not necessary to carry conventional heavy and bulky development apparatus with the camera. When the adherent conductor foil is removed prior to development, the electrostatic charge pattern on plate 41 is restored substantially to the form and magnitude it had before the foil was applied.

Foil 46 also performs an entirely different, but equally useful function. Since plate 41 is sensitive to light, it would ordinarily be necessary to keep it in darkness at all times between exposure and development to prevent the electrostatic latent image from being destroyed by light. However, where an opaque foil 46 is used as described herein, the photosensitive surface of the plate is protected from light, and from abrasion as well, at all times after it is withdrawn from the camera. Thus, the exposed pieces of plate can be handled with the same ease as ordinary pieces of paper and no special light tight plate holders or carrying containers are required.

FIG. 3 shows a schematic representation of a simplified xerographic camera embodying the present invention. The camera of this figure, like those of FIGURES 1 and 2, includes a bellows 10, lens 11, rear panel 12, hinge 13 and catch 14. It need not, however, have a conventional shutter associated with lens 11. Mounted within the camera is a feed roller 50 carrying a xerographic web plate 51 which is wound up on a take-up spool 52 also within the camera. Web plate 51 may be any of the types already discussed in connection with web plate 41 of FIG. 2. As in FIG. 2, the photoconductive insulating layer should face the lens. Web plate 51 supplied from feed roller 50 is in a precharged condition. Thus, at some prior time the length of web plate 51 may have been carried past a charging device, such as a corona charging device and then wound up on feed roll 50 where, in accordance with the present invention, it will retain its charge for an extended period of time. Feed roller 50 is then mounted inside the camera and web plate 51 threaded onto take-up spool 52 to prepare the camera for use. Rollers 53 and 54 are also mounted inside the camera adjacent to web plate 51 and carry between them a conductive web 55. This web which may preferably comprise a thin strip of metal such as brass shim stock, contains at least one aperture which is uniform in its dimension parallel to the length of the web and extends nearly, but not quite, across the width of the web and which can be wound up on either roller 53 or 54. Thus, web 55 together with rollers 53 and 54 constitutes a focal plane shutter as is well known in the photographic art, and this shutter may be provided with a conventional operating mechanism, not shown in this figure. There is also provided a glass plate 56 with releasable pressure means, not shown in this figure, to urge conduc-

tive web 55 against web plate 51. Light shields 57 are also provided to prevent light from lens 11 reaching web plate 51 except through the aperture in conductive web 55. Between picture-taking operations, the aperture in conductive web 55 is rolled onto either roller 53 or 54 and web plate 51 is protected, in accordance with this invention, against loss of charge where it is rolled up on feed roller 50, where it is contacted by conductive web 55, and where it is rolled up on take-up spool 52. The small unprotected regions of web 51 between rollers 50 and 53 and 54 and 52 may lose their charge, but this is unimportant since these regions are merely used to separate successive exposures.

FIG. 4 is a perspective view of certain portions of the camera of FIG. 3 together with certain additional features not shown in FIG. 3. Rollers 50, 52, 53 and 54; xerographic plate 51; and glass plate 56 are identical with the correspondingly numbered elements in FIG. 3. Certain journaling means for the rollers have been omitted for simplicity. Glass plate 56, as shown, is mounted on a frame 60 by means of leaf springs 61. Frame 60 in turn is mounted on shaft 62 which is journaled in blocks 63. A coil spring 64 is provided on shaft 62 to bias the shaft in a direction to apply downward pressure on glass plate 56. Blocks 63 are mounted on shutter operating mechanism 65. Mechanism 65, which is shown in schematic form, is the usual type of mechanism found on cameras with focal plane shutters. It includes a button 66 for tripping the focal plane shutter as well as a knob 67 which when rotated simultaneously winds a pre-determined length of xerographic web plate 51 onto take-up spool 52 as well as acting on rollers 53 and 54 to rewind the shutter. As is common in focal plane cameras, knob 67 is ineffective until it has been depressed. Also attached to the shutter operating mechanism 65 are a pair of blocks 68 in which is journaled a shaft 69 which is connected by a system of links 70 to shaft 62. One outboard end of shaft 69 has mounted therein a radial pin 71 while the other end has a pin 72. A rocking lever 73 is mounted between button 66 and pin 71 so that when button 66 is depressed the rocking lever 73 pushes against pin 71, thus rotating shaft 69, and through link 70 shaft 62 as well, thereby lifting glass plate 56. A similar rocking lever 74 is mounted between winding knob 67 and pin 72 so that depressing knob 67 also raises glass plate 56.

To make an exposure with the camera of FIGURES 3 and 4, button 66 is depressed, thereby releasing the pressure on glass plate 56 allowing conductive web 55 to separate slightly from web plate 51 and simultaneously operating the focal plane shutter mechanism to permit the exposure aperture in conductive web 55 to pass from one of rollers 53 or 54 to the other, thereby exposing web plate 51 and forming an electrostatic latent image thereon. Next, winding knob 67 is depressed and rotated. This winds a length of plate 51 from feed roller 50 onto take-up spool 52, rewinds the focal plane shutter and removes the pressure from glass plate 56 while these operations take place. When knob 67 is released, pressure is re-applied to glass plate 56 and the camera is again in a quiescent condition, ready either for a long delay or for immediate additional picture-taking.

When the entire length of web plate 51 has been exposed, take-up spool 52 with web plate 51 wound thereon may be removed from the camera and the electrostatic latent images on the plate may be developed later and elsewhere at the convenience of the operator. There is thus provided a portable xerographic camera which requires no electrical power supply and no charging or developing apparatus or other heavy, bulky, complicated equipment. This camera may be used in the same manner as an ordinary photographic camera; i.e., the operator may purchase an already-charged supply of web plate 51 and after it has been exposed he may simply send it away to be developed. It has the additional benefit of producing positives immediately without an intermediate negative

and the positive, if desired, may be used as a master to produce xerographically any additional number of positive prints.

A simplified form of the camera shown in FIGURES 3 and 4 may be constructed by omitting elements 53, 54 and 55, comprising the focal plate shutter, and substituting instead a conventional between-the-lens shutter 80. If such a substitution is made glass plate 56 should be replaced by a glass or other transparent plate 81 having a transparent conductive coating 82, such as tin oxide, on the surface thereof adjacent to web plate 51, and a connecting linkage 83 should be provided between button 66 and the between-the-lens shutter. In such a camera, as in that of FIGURES 3 and 4, glass plate 56 or its equivalent exerts a pressure against web plate 51 at all times except during exposure or film advance. Thus, the conductively coated element substituted for glass plate 56 performs the same charge preservation functions as does the conductive web 55 in FIGURES 3 and 4.

While the invention has been described up to this point in terms of mechanical apparatus, it is apparent that it can also be carried out equally well by manual means. Thus, by way of example, rather than limitation, where a conventional rigid xerographic plate is charged and exposed a conductive member may be manually placed in contact with the image bearing surface of the plate in order to preserve the electrostatic latent image for future use.

While the invention has previously been described solely in terms of placing a conductive member directly into contact with an electrostatic image bearing member, it is also possible and within the scope of the invention to very slightly separate the conductive member from the electrostatic image bearing member. This may conveniently be done, for example, by applying a very thin layer of insulating lacquer to the conductive member before it is placed into contact with the surface carrying the charge pattern. In order to achieve the desired result of image preservation, however, it is necessary both that the insulating layer which separates the conductive member from the charge carrying surface should be substantially thinner than the insulating material which carries the charge pattern and also that the insulating lacquer or other insulating material have a very high resistivity. In general, the use of such lacquers or other insulating spacers is neither necessary nor desirable in carrying out the invention.

It is apparent that the working of this invention depends upon the fact that when a conductive member is placed in contact with a charge carrying insulator no charge will flow between the insulator and the conductor. The conditions under which charge will not flow are more fully set forth in copending patent application Serial No. 718,247. In accordance with the teachings set forth therein, no transfer of charge will take place in connection with this invention where the electrostatic latent images have potentials on the order of several hundred volts as is the usual situation, and where the applied conductive member such as foil 26 or web 44 is at the same potential as the conductive coating or backing of the insulating or photoconductive insulating material which carries the electrostatic charge pattern. In accordance with the teachings of the above referenced application, it may be necessary to apply a potential to the conductive member where it is desired to preserve very high potential charge patterns having potentials of the order of about 700 volts or greater. It is obviously not feasible then in that situation to use the apparatus of FIG. 1. In the apparatus of FIG. 2, however, it is quite simple to apply the desired voltage to foil 46 through supply spool 45. Where the use of a voltage on the conductive member is indicated this voltage should be applied when the conductive member is brought into contact with the charge bearing surface and when it is separated therefrom, but need not be maintained at other times.

What is claimed is:

A method of retaining a latent electrostatic image for an extended period of time on the photoconductive insulating layer of a flexible web having a photoconductive insulating layer and an electrically conductive layer in back-to-back relationship with each other, comprising forming said latent electrostatic image upon said photoconductive insulating layer and then rolling said web upon itself into a tight spiral, the said photoconductive surface carrying said latent electrostatic image being brought into direct contact with said electrically conductive layer whereby the electrical capacity of said photoconductive layer is raised and the potential of the latent electrostatic image thereon is greatly reduced.

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