

Dec. 24, 1957

R. E. HAYFORD ET AL

2,817,765

XEROGRAPHIC METHOD

Filed Jan. 3, 1956

2 Sheets-Sheet 1

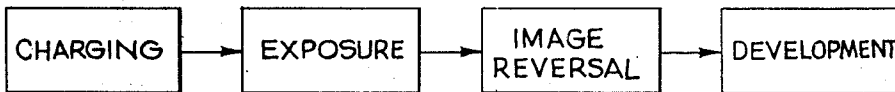


Fig. 1

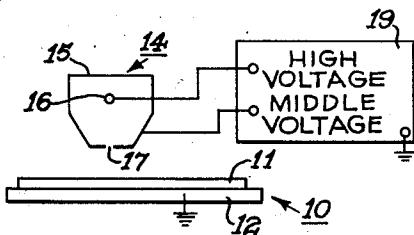


Fig. 2

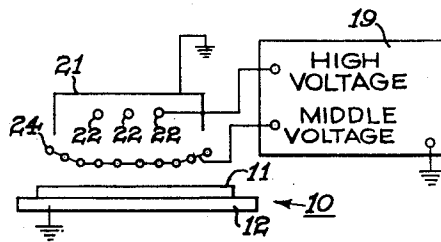


Fig. 3

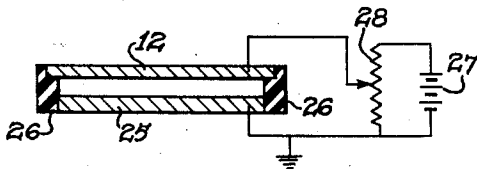


Fig. 4

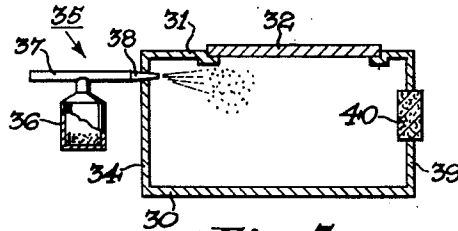


Fig. 5

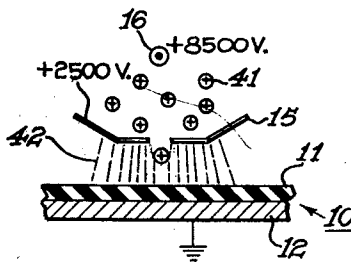


Fig. 6

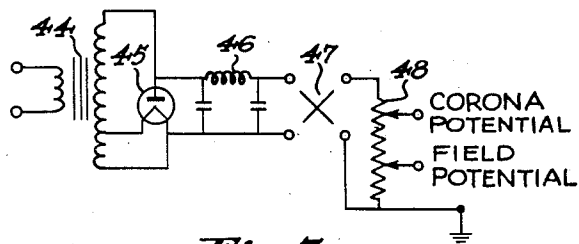


Fig. 7

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2 Sheets-Sheet 2

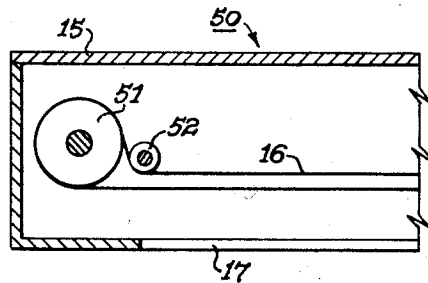


Fig. 8

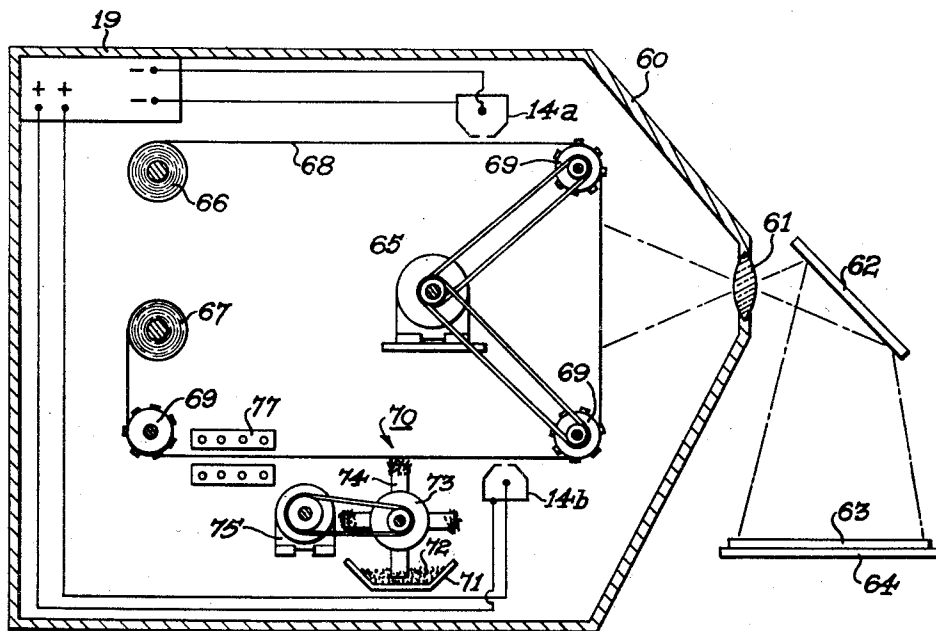


Fig. 9

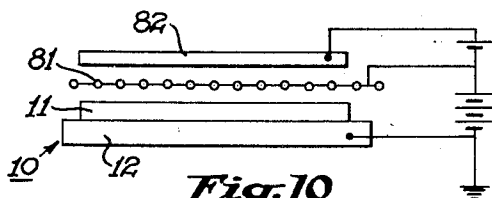


Fig. 10

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2,817,765

XEROGRAPHIC METHOD

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Application January 3, 1956, Serial No. 556,869

5 Claims. (Cl. 250—65)

This invention relates in general to the art of xerography and, in particular, to the production of reversal xerographic images.

In xerography it is usual to form an electrostatic latent image by applying an electric charge to the surface of a photoconductive insulator and selectively dissipating the charge by exposure to a pattern of light and shadow to be recorded. Thus, in present commercial practice, it is conventional to place a positive polarity electric charge on the surface of a photoconductive selenium layer and to form an electric image by exposing the charged layer, optionally, through a suitable projection system, to a document, scene, or other image to be reproduced. The resulting electric image is thereupon developed by dusting it with oppositely charged powder which adheres to the charged portions of the selenium surface. In this manner there is formed a reproduction of the original being photographed or copied.

By the operation just described, it is apparent that there is formed a dust image corresponding to a direct positive reproduction of the original. Thus, the portions of the original that are white or light in tone are reproduced as an essence of deposited powder, whereas the dark portions of the original are reproduced by a heavy pattern deposit. In order to produce a xerographic picture it is usual to employ a dark colored powder and to transfer it ultimately to a white support base such as a sheet of white paper. Occasionally, however, it is desired to employ xerography for the reproduction of reversal or negative images in which the original being produced in itself corresponds to a tone reversal of an original scene or document. For example, if it is desired to make a photographic print from a conventional photographic negative it is necessary to reverse the blacks and whites. Accordingly, the present invention has as an object a new and improved method, means and apparatus for such xerographic reversal of blacks and whites.

In the art of xerography it is usual to deal with electrical procedures and terms and likewise to deal with photographic procedures and terms. This brings about a certain degree of inconsistency of language since the term "negative" in electrical operation refers to a polarity of charge or potential, whereas in photographic operation the term "negative" refers to a reversal of blacks and whites. For simplicity of understanding, therefore, the terms "positive" and "negative" will be used in their electrical sense to denote electrical polarities, and the terms "direct" and "reversal" will be employed to denote as direct reproduction the photographic concept of reproducing a black original as a black copy and a white original as a white copy and as reversal reproduction the interchange of black and white.

It is another object of the invention to provide means, methods and apparatus for changing the polarity of an electrostatic latent image whereby the image may be directly developed to form a xerographic print corresponding to a photographic reversal of the original exposure.

It is another object of the invention to provide a method,

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means and apparatus for reversal xerographic reproduction by changing the electric polarity of a xerographic latent image.

It is a particular object of the invention to provide reversal xerographic methods, means and apparatus in which a positive xerographic latent image is converted to a negative xerographic image and it is a further particular object of the invention to provide reversal xerographic methods, means and apparatus in which a negative xerographic latent image is converted to a positive xerographic image.

In general, the objects of the present invention may be accomplished by first forming a xerographic latent image by usual methods and subsequently applying uniform charge increments of opposite polarity to all points of the image surface, whereby the image configuration is maintained and the image polarity is reversed.

The general nature and scope of the invention having been set forth, the invention will now be described with reference to the following specification and drawings in which:

Fig. 1 is an operational flow sheet illustrating the successive stages of operation according to one embodiment of the invention.

Fig. 2 is a diagrammatic view of charging and charge reversal apparatus according to one embodiment of the present invention.

Fig. 3 is a diagrammatic view of charging apparatus according to another embodiment of the invention.

Fig. 4 is a diagrammatic view of a development zone according to one method and means of xerographic image development.

Fig. 5 is a diagrammatic view of development means according to another embodiment.

Fig. 6 is a fragmentary diagrammatic view illustrating a possible method of operation of the device in Fig. 2.

Fig. 7 is a wiring diagram for a power supply source suitable for operation according to the invention.

Fig. 8 is a diagrammatic fragmentary view of an embodiment of a modified charging apparatus according to this invention.

Fig. 9 is a diagrammatic view of an embodiment of an automatic machine according to this invention.

Fig. 10 is a diagrammatic view of another embodiment of the invention.

According to present methods of xerographic operations a reversal image is most suitably formed by one of two procedures. According to the first procedure, a xerographic developer consisting of relatively larger carrier particles carrying on their surface fine developer powder particles, is cascaded across the image surface. By proper selection of the surface electrification properties of the carrier particles and the developer powder, it is possible to produce a developer which, as desired, may contain positive or negatively charged powder particles. Since conventional operation of xerography generally produces an electrostatic latent image of positive polarity, it is possible through the use of a positively charged powder in the developer mixture to produce reversal development of the electrostatic latent image. This method of operation has been reasonably satisfactory for certain purposes such as, for example, the production of line copy images particularly where few, if any, large densely black areas are being developed.

According to a second method of reversal, xerography is particularly useful for the reproduction of continuous tone images. The xerographic latent image is formed by conventional methods and then disposed closely adjacent to a parallel conductive electrode spaced apart from the image surface by a distance generally in the order of $\frac{1}{40}$ ". The conductive surface or development electrode, as it is called, is raised to an electric potential

of the same polarity as the xerographic latent image and of a voltage very closely equal to the highest residual potential on the image surface. With this bias potential applied to the development electrode, developer powder of the same polarity as the xerographic latent image is introduced between the electrode and the image surface, whereby it is deposited selectively on the discharged areas of the image surface. If, in fact, the development electrode is biased at almost exactly the highest potential areas of the xerographic latent image, then there will consequently be substantially no developer powder deposited on these areas. Because of other advantages associated with xerographic development in combination with the development electrode as described, this method of reversal development has heretofore been the preferred method.

One of the problems in reversal development in general and, particularly, with respect to reversal development with a biased development electrode, is the relatively critical necessity of biasing the electrode at almost exactly the highest residual potential on the image surface. Under certain operating conditions this may not be a serious problem, but where the xerographic plate being employed is characterized by having rapidly changing potential characteristics it can become most serious. For example, it has been the usual experience that xerographic plates having fast photographic speed or superior light sensitivity are also characterized by a property known as high dark decay in which the potential on the plate surface diminishes rapidly upon standing, even in the absence of light. It is apparent, therefore, that it is difficult with this type of xerographic plate to keep a development electrode constantly biased at the changing potential of the most highly charged areas on the image surface.

A further disadvantage with both of the prior methods of reversal xerography has been that certain preferred xerographic materials and methods seem inherently best suited to developers and developing methods that are incompatible with reversal development. Thus, for example, if the selenium plate now employed generally in commercial xerographic operations is replaced with other xerographic plates having different surface electrification properties, it has been found difficult to devise a satisfactory reversal developer to be utilized in conjunction with the cascade method of development. In addition, for reasons independent of image development, it sometimes is necessary to obtain an electric image of polarity opposite to that which is electrically consistent with preferred sensitizing operations.

It is therefore apparent that the need exists for xerographic development method, means and apparatus that are independent of the variations encountered in the present reversal development systems.

In Fig. 1 there is generally illustrated a simplified series of operations according to one embodiment of the invention. In accordance with this illustration a suitable xerographic plate or photosensitive member including a photoconductive insulating layer or surface is sensitized by charging the surface or, in other words, depositing electrostatic charge on the photoconductive surface. Thus, for example, if the xerographic plate comprises a vitreous selenium layer on a conductive backing surface it is sensitized immediately prior to use by passing across the surface a corona discharge electrode adapted to deposit on the plate surface positive charge in the order of about several hundred volts. The charged or sensitized xerographic plate is then subjected to an exposure operation in which it is exposed by suitable contact or projection means to an image to be reproduced. For example, the plate may be placed in a camera and exposed through a lens system to a scene to be photographed, a document to be reproduced, or a photographic negative to be copied. In particular, where it is desired to reverse the photographic tone of the original, as in copying a photographic negative, the operations of the present invention may

most conveniently be utilized. In prior art operations the xerographic plate after exposure bears an electrostatic latent image or xerographic latent image which is passed directly into a development operation. According to the present invention, however, the xerographic plate bearing the latent electrical image is passed to an image reversal operation in which uniform increments of electric charge of opposite polarity are applied to the image surface until the highly charged image areas have been reduced to substantially zero potential and the image areas of relatively low charge have been reversed in potential and raised to a potential of opposite polarity. Thus, illustratively, if a xerographic latent image consists of three electrical tones corresponding to highly charged areas of about 400 volts positive polarity, middle areas of about 200 volts and background of about zero volts, the entire image surface is treated with charged increments to charge its potential to the extent of about 400 volts negative polarity. In this manner, the highly charged areas are reduced to substantially zero potential, the middle areas are inverted to substantially 200 volts negative polarity and the background areas are raised to a potential of substantially 400 volts negative polarity.

The result of this image reversal operation is a xerographic latent image of opposite or, in this case, negative polarity, containing areas of high negative charge corresponding to original image areas that had been highly discharged through the action of light or radiation. Thus, if a positively charged xerographic plate has been exposed to a photographic negative, the charged areas in the photographic negative become substantially neutral in the reversed xerographic latent image and the transparent areas in the photographic negative become highly charged to negative polarity. This reversed xerographic latent image is then passed to a development operation in which positively charged developer powder is supplied to the image surface by any of various means and methods to produce an image deposit corresponding to a reversal xerographic print.

In Fig. 2 is illustrated a general assembly for original charging or reversal charging of xerographic plate or image surface. Illustrated in the figure is a xerographic plate generally designated 10 comprising the photoconductive insulating layer 11 on a conductive backing member 12. The plate is so mounted as to be electrically grounded. Positioned above the xerographic plate and adapted to be movable over the plate surface is a corona discharge electrode 14 of specially designed construction so as to accomplish the purpose of the present invention. This electrode is further described in co-pending application Serial Number 556,930. In general, the corona discharge electrode comprises a shield 15 surrounding one or more corona discharge wires 16. The shield consists of a metallic or other conductive material surrounding the corona wire or wires on all sides except for a small slit or opening 17 running generally parallel with the wire. The slit is preferably positioned directly between the corona discharge 16 and the surface to be charged, such as the plate 10, and preferably is positioned relatively close to the surface being charged.

The corona discharge electrode 14 is connected to a high voltage source 19. As illustratively indicated, the high voltage source has at least one high voltage pole conductively connected to the corona discharge wire and at least one middle voltage conductively connected to the shield. The high voltage pole is maintained at a corona generating potential with respect to the middle voltage pole, such as to cause corona emission from the corona wire 16. The middle voltage pole, on the other hand, is at a potential moderately high with respect to ground potential or, in this instance, with respect to the potential on the xerographic plate, but, nevertheless, is at a voltage substantially low, compared with the corona generating potential. As expressed hereinafter, the corona generating potential between the corona discharge wire

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16 and the shield 15 is in the order of several thousand volts, such as, for example, between about 4,000 to 10,000 volts and preferably about 5,000 volts. The potential of the middle voltage pole, with respect to the backing plate 12, is determined by operating conditions and desired results. In the first place, this potential is correlated with speed of travel of the corona discharge electrode with respect to the surface being charged, so as to produce the desired ultimate potential on the surface. More particularly, however, the middle voltage potential is of the same polarity as the charge to be applied to the xerographic plate and is substantially higher than the original or final voltage on the plate by a factor of at least about four times and preferably about 10 to 20 times, but not in excess of the breakdown voltage between the shield and the image surface or plate. Thus, if the xerographic plate is to be charged to a potential of about +500 volts, the shield is placed at a potential of at least about 1,600 volts and, preferably, substantially higher. According to optimum operating conditions, the bias potential applied to the shield, with respect to the conductive backing plate, is as high as is both consistent with operator safety and wholly free from corona discharge between the plate and shield.

In accordance with these principles a xerographic plate comprising a 20 micron layer of vitreous photoconductive insulating selenium disposed on a metal surface was charged by passing across its surface a corona discharge electrode of the type illustrated in Fig. 2. The corona discharge electrode consisted of a single .0035 inch wire maintained at a potential of 7,300 volts positive polarity with respect to ground. This corona wire was surrounded on all four sides by a shield substantially square in cross-section and having a cross-sectional area of about 1 inch square. In the lower face of the corona discharge electrode directly adjacent to the xerographic plate was a slit $\frac{1}{32}$ inch wide, extending across the surface being charged. This slit was maintained $\frac{3}{8}$ inch above the xerographic plate. The shield was biased at a potential of 2,500 volts positive with respect to ground. The corona discharge electrode was moved across the plate in two passes, one in forward and the other in reverse direction, at a rate of travel of 2.5 inch per second. The plate was thus charged to a potential of approximately 150 volts positive polarity.

The thus charged xerographic plate was exposed to a three-step gray scale consisting of substantially black, substantially white, and an intermediate gray. The charging procedure was then repeated with the same charging electrode construction and operation with the corona discharge wire being held at -7,200 volts and the shield at -2,370 volts with respect to ground. An electrometer scan of the plate indicated that the plate areas corresponding to the dark areas of the gray scale were now at substantially zero volts and the light areas were at substantially -150 volts. The plate was then developed according to conventional xerographic methods to yield a reversal xerographic print of the three-step gray scale.

Illustrated in Fig. 3 is a modified xerographic charging electrode. In this figure is a xerographic plate, generally designated 10, comprising a photoconductive insulating layer 11 on a photoconductive support 12. Positioned above the plate is a backing shield 21, below which are mounted three corona discharge wires 22. Mounted between the corona discharge wires and the plate are a plurality of relatively coarser control wires 24. The corona discharge wires are operably connected to a high voltage pole and a high voltage power supply 19 and the control wires are operably connected to a middle voltage pole in the same power supply. The corona discharge assembly disclosed in this figure, as described hereinafter, is useful for the charging of a xerographic plate, particularly where the plate is intended for use in the image reversal system of the present invention.

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Illustrated in Fig. 4 is a development zone such as may be used for the development of a xerographic image formed in accordance with the present invention. Essentially, this development zone includes a conductive plate or development electrode 25 mounted between support insulating members 26. These insulating support members 26 are adapted to receive a xerographic plate 12, face downwardly and spaced from the electrode 25 at a distance in the order of about $\frac{1}{40}$ inch. A power supply 27, such as, for example, a D. C. power source as a battery, is operably connected to supply a bias potential between xerographic plate and the development electrode. For example, the power supply may be connected through a potentiometer 28 to ground, with a variable lead from the potentiometer in turn operably connected to the xerographic plate or to the development electrode. Developing apparatus of the sort illustrated in Fig. 4 has been disclosed in a co-pending application, S. N. 244,556, now U. S. Patent No. 2,725,304.

Illustrated in Fig. 5 is modified development apparatus used in developing the xerographic latent images produced by the present invention. Illustrated is a box or chamber 30 having a top panel 31 with an opening over which is positioned a xerographic plate 32. In one side panel 34 of the box is mounted spray means generally designated 35 which may include a powder reservoir 36, a spray supply feed 37 and a powder spray nozzle 38. Positioned in a side panel and optionally in the opposite side panel 39 is a filter 40 adapted to permit escape of air or gas from the chamber and to entrap developer powder material. The powder spraying means thereby is adapted to spray charged finely-divided developer powder in a billowy cloud into the box or chamber and thereby to deposit this charged powder material on the xerographic plate in configuration corresponding to the xerographic latent image.

One of the problems encountered in operating according to the present invention is the fact that xerographic plates comprise an extremely thin photoconductive insulating layer supported on a conductive backing surface such that the free or exposed surface of the photoconductor and the surface of the conductive backing material form, in effect, parallel plates of an extremely thin and high capacitance condenser. As a result of this, the potential to which the xerographic plate surface is charged is critically dependent on the uniformity of the xerographic plate since, obviously, an equal quantity of electric charge applied across different thicknesses of the photoconductive insulating layer results in substantially varying electric potential. It is apparent, therefore, that if the xerographic plate is wholly and exactly uniform in its construction the addition of uniform charge increments to different plate areas will cause uniform change in potential. If, on the other hand, the xerographic plate is not of exactly uniform thickness in different areas, then uniform increments of charge will cause non-uniform changes of potential. In conventional xerographic operation this problem is obviated by the fact that charging of the plate has previously been performed to produce substantially uniform potential rather than uniform charge density while charge dissipation by exposure is substantially directly proportionate to charge potential rather than to charge density. Similarly, development has been found to be substantially proportionate to potential rather than density to the extent that non-uniformity could be readily detected. If, however, image reversal is accomplished by depositing on the plate surface increments of charge at different potential on the plate surface, it is apparent that the inevitable irregularities of the xerographic plate will be reflected in correspondingly greater irregularities of the reversed electric image. Instead of compensating each other, the effect accumulates additively. In order to overcome this result, the original charging of the xerographic plate is produced by a corona discharge electrode conforming with the electrode illustrated in Figs. 2 or 3. Thus, in operation according to

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Fig. 2, a xerographic plate is charged to an average potential equal to the average potential that may be desired, although thinner plate areas will obviously be more highly charged in terms of potential than are thicker plate areas. This will be true even though these plates are charged to equal charge density. Similarly, according to Fig. 3, the xerographic plate will be charged to a substantially uniform charge density and, therefore, to a permissibly non-uniform charge potential depending on the uniformity of the photoconductive insulating layer.

It is apparent that the xerographic plate, charged in accordance with Fig. 2 or Fig. 3, when exposed to a light image, will partially retain in its charge potential pattern any of its non-uniformity of potential. On the succeeding step, when the image potential is reversed, the addition of equal increments of charge on all areas of the plate will substantially compensate for and neutralize these non-uniformities of the original charge potential. In accordance with the present invention, therefore, effects caused by non-uniform thickness of the photoconductive insulating layer are substantially eliminated, and it is, accordingly, an object of this invention to accomplish such resultant improved uniformity.

In this section it is observed that the corona discharge electrode of Figs. 2 and 3 can be considered as being relatively equivalent for the purpose of original charging of the xerographic plate. When a xerographic plate is charged according to prior art methods, there is substantial potential equalization across the surface of the xerographic plate, whereby a tendency toward excessive charge potential on thin plate areas is automatically compensated by the tendency of such invested charge potential to cause charge to be repelled from these more highly charged areas. In other words, as the deposition of equal increments of charge on non-uniform areas tends to build up non-uniform charge potential, this non-uniformity automatically becomes self-correcting. As one area becomes charged to a higher potential there occurs a lateral electric field or equalization field tending to cause ions to deposit selectively in the areas of lower potential. In effect, therefore, prior methods of applying charge produced equal potential rather than equal charge density and, by so doing, caused erasure of charge images on the surface being charged. Basic to the present invention, however, is the concept of overcoming this tendency of a xerographic plate to selectively accept charge of uniform potential rather than charge of uniform density.

For the purposes of image reversal, however, the electrode assembly in Fig. 2 differs from that in Fig. 3, and one embodiment and purpose of this invention is to provide a new and improved corona discharge electrode as illustrated in this figure.

In accordance with the present invention, uniform increments of charged density are deposited on relatively non-uniform surfaces and on surfaces already holding an electrostatic charge pattern. This is accomplished by maintaining between the conductive backing plate 12 and the shield of the corona charging electrode a potential difference far in excess of that of the original or final charge on the surface. Thus, for example, in the specific example described hereinbefore, an average potential of about 150 volts was placed on the plate, and to achieve this potential there was employed a potential difference of about 2500 volts between the shield and the backing plate. In this example, as illustrated, the potential difference between the shield and the backing plate was at least more than four times the potential found on the xerographic plate surface and was, in this instance, approximately fifteen to twenty times that potential. Thus, even a gross non-uniformity between adjacent plate areas could account for an effective equalization field equal to only a fraction of the charging field between the shield and the backing plate. Consequently, charge is directed toward the plate essentially by the charging field with a minimum of lateral direction due to charged non-uniformity. In

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the same manner, when the electrode was employed for image reversal, a potential difference of less than 150 volts between image and background areas was minimized by the comparatively greater difference of 2,500 volts between the shield and the conductive backing.

It is to be observed, also, that a relatively narrow charging area was achieved and, in effect, a directed beam of corona discharge emerged from the shield and was, in effect, focused onto the xerographic plate at the point directly opposite or below charging slit 17. In Fig. 6 is illustrated diagrammatically the operation of the electrode of Fig. 2 in effectively focusing the deposition of charge on the surface of the xerographic plate or other surface being charged. There is shown a section of xerographic plate 10 comprising an insulating or photoconductive insulating layer 11 on a conductive support 12. Positioned over the plate is the corona charging electrode comprising a shield 15 (shown in part) largely surrounding a corona discharge wire 16. Illustrated within the electrode shield are a plurality of positive air ions 41 that have been generated by a corona discharge electrode and are still contained within the shield.

It is observed that a corona generating potential difference is maintained between the shield 15 and the wire 16, this difference being in the order of about 6,000 volts, and that an electric field potential is maintained between the shield and a xerographic plate, this potential being in the order of about 2,500 volts. The result of this field potential is an intense electric field perpendicularly between the shield and the plate as illustrated by the broken lines 42 representing lines of force. It is further observed that in the area of closest spacing between the shield and the plate, and particularly in the area directly adjacent to the electrode slit, the field of force is particularly intense and is so directed as to accelerate positive ions rapidly toward the xerographic plate. Thus, ions within the electrode shield 15 that migrate toward and finally through the slit are driven rapidly and directly toward the xerographic plate. In this manner, they are caused to deposit on the plate in uniform charge density substantially independently of any variation in potential that might exist on the surface of layer 11. In particular, if there is image irregularity on the surface of the layer, the ions have picked up sufficient direction and momentum prior to coming within the effective field of such image potential so that their direction and, thus, their deposition is almost completely unaffected by such image field.

For the purposes of completeness of illustration, in Fig. 7 is shown diagrammatically an electric circuit adapted to supply the corona discharge potential and bias or field potential. This circuit is essentially conventional and comprises, for example, a high voltage transformer 44 adapted to be connected to an A. C. potential source such as, for example, a 60-cycle 110-volt source. A rectifier or diode 45 is connected to the high voltage output of the transformer to produce rectified A. C. which then passes through a filter circuit 46 such as an induction-capacitance combination and, optionally, to a reversing switch 47 adapted to reverse the polarity of the output. The output is then fed to a potentiometer 48 provided with a high voltage or corona generating potential output and a middle or field voltage potential output. Obviously, if desired, there may be employed, instead of the reversing switch, a center tapped system having both positive and negative corona generating and field voltage outputs.

In Fig. 8 is illustrated a modified electrode assembly. According to this illustration of corona discharge electrode assembly, generally designated 50, includes an electrode shield 15 with a corona wire 16 disposed therein and having an outlet slit 17 along its output surface. The corona wire 16 in this case is an endless wire passing at each end around a drive pulley 51 and a guide pulley 52. Desirably, one or the other of these pulleys 51 and

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52 is electrically connected to the corona generating potential pole of the high voltage source. Suitable drive means, optionally external from the electrode shield 15, operates to rotate drive wheel 51. In this manner, the operative portions of the corona discharge wire, being those portions disposed above the electrode slit 17, are moved longitudinally during operation. It is further observed that there are two parallel sections of the corona generating wire, which parallel sections are simultaneously moved in opposite directions. It has been found that corona discharge from a fine wire is sometimes characterized by end-to-end non-uniformity believed to conform with minute non-uniformity of the relatively fine wire. As the two segments of wire are moved in opposite directions while the corona electrode is operating, this end-to-end non-uniformity of output is substantially eliminated.

In Fig. 9 is illustrated diagrammatically a step and repeat xerographic machine adapted for copying documentary information or the like onto a flexible xerographic plate. Such a plate may, for example, comprise a binder coating of a photoconductive material such as zinc oxide or the like on a moderately conductive paper backing. Illustrated in the figure is a housing 60 enclosing the operating portions of the machine on all sides except for a lens 61. Positioned in front of the lens may be a rectifying mirror 62 adapted to reflect light from copy 63 on copy holder 64 into the lens 61 and thus to the focal plane. Positioned within the housing is a feed roll 66 and a take-up roll 67, one or the other of which may be driven by appropriate drive means such as motor 65. The web from the feed roll such as, for example, a xerographically sensitive flexible plate is passed around suitable guide and/or drive rolls 69 optionally connected to motor 65, to carry the web through the xerographic cycles and to the take-up roll. Desirably, the web may be notched along its edges and the drive or guide rolls may be provided with teeth mating with such notches. At one position along its path of motion the xerographic web 68 passes along the focal plane where the image of copy 63 may be focused on the surface.

Along the path of motion of the web 68 is a charging electrode 14a of the type illustrated in Figs. 2 and 6, this electrode being positioned between the feed roll and the focal plane. Beyond the focal plane is a second electrode 14b of the same type. Next in the direction of passage of the web is a development zone generally designated 70 wherein xerographic developer may be deposited on the surface of the web. This may, for example, include an open hopper 71 containing a developer mixture 72 such as, desirably, a mixture of a magnetic powder material such as iron filings and a pigmented powder. Operating in conjunction with such a developer is a rotating roller 73 having a plurality of bar magnets 74 around its circumference, these magnets being positioned to pass through the supply of developer material and to carry such mixture into brushing contact with the xerographic web. Suitable drive means 75 may be supplied to rotate the developer roll.

The developed xerographic web then optionally passes through an oven or fusing device 77 wherein, if desired, the developer powder may be fused onto the web surface or, alternatively, the web surface may be fused to receive and encase the powder thus forming a permanent fixed image.

As illustrated in the figure, electrodes 14a and 14b are conductively connected to a high voltage power supply 19 preferably positioned within the housing 60. Desirably, the power supply 19 contains both positive and negative, high and middle voltage poles, the negative poles being connected to electrode 14a and the positive poles to electrode 14b. In this manner, and in accordance with Fig. 2, the xerographic web 68 receives a charge of uniform negative charge density on passing under the

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electrode 14a. The charged web is exposed at the focal plane and then receives uniform increments of positive charge density to form a reversed electric image upon passing under electrode 14b. This image made in this manner, may be developed at the development zone and fixed to form a permanent reversal xerographic image.

In Fig. 10 is illustrated another embodiment of the invention wherein there is shown another form of ion producing source and means for applying an intense field to the surface of the image-bearing layer. Illustrated in this figure is an image-bearing plate generally designated 10 comprising an insulating or photoconductive insulating layer 11 disposed on a conductive backing support 12. Positioned above the image layer 11 is a conductive electrode 81 such as, for example, a wire mesh or screen or the like. This electrode 81 desirably comprises an array of conductors interspersed with openings or spaces to accommodate the flow of ions therethrough. Positioned above the screen 81 is a radioactive ion source 82 such as, for example, a metal plate or electrode having a coating of a radioactive source, preferably an alpha source, such as polonium, radiothorium, or the like. A suitable D. C. power supply is connected to the backing plate 12, the screen 81, and the ion source 82 such as to apply a low potential field from the ion source to the screen, and an intense field from the screen to the backing plate. This may, for example, be a power supply adapted to apply a potential of one or several hundred volts between the ion source and the screen and adapted to apply a potential of one of several thousand volts from the screen to the backing plate 12. If desired, the screen 81 may be omitted and the intense field applied directly from the ion source to the backing plate.

In use and operation the ion source 82 is placed in position above the image-bearing surface and the intense field applied substantially perpendicular to the image surface to cause substantially direct-path ion flow to the image surface. As in the previously illustrated cases, this field is relatively intense with respect to the image forces so as to cause constant current flow to the various portions of the image surface substantially independent of image potential.

It is apparent that many modifications and variations may be made within the scope of the present invention. For example, the operating principles of the invention may be utilized in individual devices or may be combined together in an automatic or semiautomatic machine. Likewise, the reversed electric image may be developed by suitable development means and apparatus such as the type electrode in Figs. 4, 5, and 9 or, alternatively, by other developing means as may be desired. Similarly, in a machine illustrated in Fig. 9 the step and repeat action may be employed or may be replaced by continuous operation including slit projection or the like. In the event that step and repeat action is employed, means may be provided to interrupt the corona discharge from electrodes 14a and 14b or, if desired, such interruption circuits may be obviated by placing these electrodes between the areas of successive xerographic plates. Likewise, the step and repeat functions may be obviated by motion stopping exposure such as, for example, stroboscopic lighting. Similarly, instead of oven 77 there may be provided other fixing means such as, for example, solvent applying means to form a permanent image by solvent action on either the developer or the xerographic web surface. These and numerous other modifications can be made within the scope of the invention, and the scope, therefore, is not to be limited to the specific illustrations.

What is claimed is:

1. An improved method in xerography comprising reversing the electrical polarity of an electrostatic latent image on an insulating image-bearing surface while retaining its image configuration by placing above the surface an ion source while applying an intense field from the ion source toward the image surface, the potential of said

field being at least four times the highest potential of said image and of the same polarity as the electrostatic latent image to deposit uniform increments of opposite polarity charge on said surface to substantially neutralize the charge on the image areas of highest original charge density.

2. An improved method in xerography comprising reversing the electrical polarity of an electrostatic latent image on an insulating image-bearing surface while retaining its image configuration by passing across the surface an ion source while applying an intense field from the ion source toward the image surface, the potential of said field being about 10 to 20 times the highest potential of said image and of the same polarity as the electrostatic latent image to deposit uniform increments of opposite polarity charge on said surface to substantially neutralize the charge on the image areas of highest original charge density.

3. An improved method of xerography wherein an electrostatic latent image is reversed in polarity, said method comprising depositing uniform charge increments on an electrostatic charge pattern, said pattern comprising relatively high and relatively low electric potential areas in image configuration corresponding to a developable xerographic latent image of a first electric polarity, to form a reversed electrostatic charge pattern comprising low potential areas corresponding in position to said original high potential areas of the first polarity and relatively higher potential areas of polarity opposite to said first polarity corresponding in position to original areas of low potential, said charge increments being of polarity opposite to said first polarity.

4. An improved method of xerography wherein an electrostatic latent image is reversed in polarity, said method comprising depositing uniform negative charge increments on an electrostatic charge pattern, said pattern comprising relatively high and relatively low electric potential areas in image configuration corresponding to a developable positive polarity xerographic latent image to form a negative polarity electrostatic charge pattern comprising low potential areas corresponding in position to said original high positive areas and relatively higher negative potential areas corresponding in position to original areas of low potential, the negative charge increments being of sufficient charge density to substantially completely neutralize the original high positive potential areas.

5. An improved method of xerography wherein an electrostatic latent image is reversed in polarity, said method comprising depositing uniform positive charge increments on an electrostatic charge pattern, said pattern being relatively high and relatively low electric potential areas in image configuration corresponding to a developable negative polarity xerographic latent image to form a positive polarity electrostatic charge pattern comprising low potential areas corresponding in position to said original high negative areas and relatively higher positive potential areas corresponding in position to original areas of low potential, said positive charge increments being of sufficient charge density to substantially completely neutralize the original high negative potential areas.

No references cited.