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EXPOSURE CHARGED ELECTROPHOTOGRAPHY

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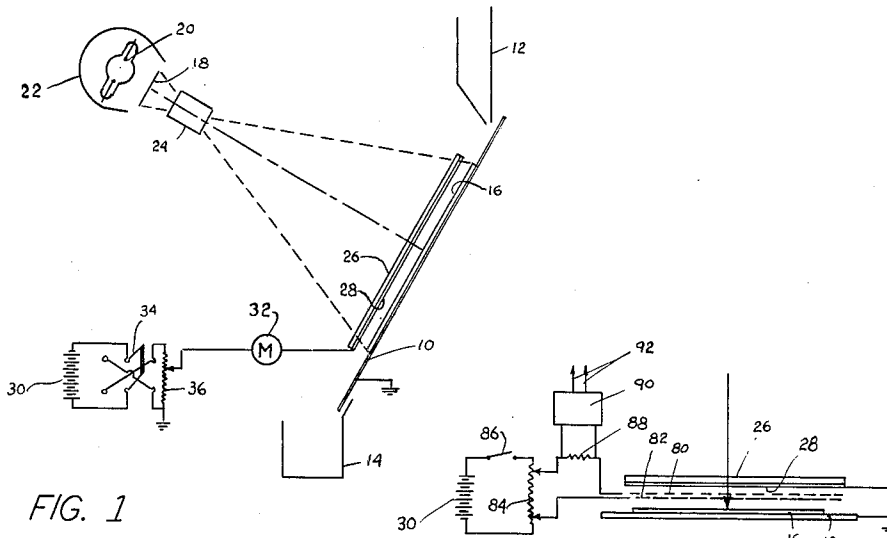
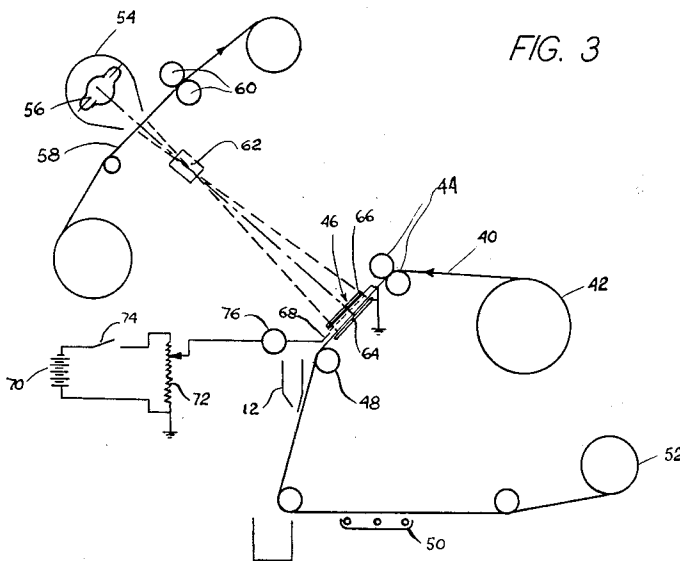


FIG. 3



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EXPOSURE CHARGED ELECTROPHOTOGRAPHY
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This invention relates to electrophotography of the type in which photographs are produced by the employment of an electrostatic latent image.

The use of certain photoconductors such as selenium, anthracene, zinc oxide, etc. to produce electrophotographs by means of xerography and Electrofax is well known. In the usual method a thin layer of the photoconductor is given an electrostatic charge and the charged plate or sheet is exposed in a camera or printer. Wherever light strikes the surface the charge leaks off in proportion to the amount of light, with the result that a latent image of varying electrostatic potentials is produced on the plate surface. This latent image is next developed through the use of a finely divided, usually pigmented, material which by selective electrostatic attraction to the plate produces a visible powder image. The powder image may be fixed on the plate or sheet by various means well known in the art, or it may be transferred to another surface and there fixed.

The present invention differs from conventional electrophotography in that instead of discharging a uniformly charged surface through the action of light it employs an initially uncharged surface and utilizes light for the purpose of selectively charging portions of such a surface to produce the latent electrostatic image. The present method of electrophotography may be described as exposure-charged as compared with conventional electrophotography which is exposure-discharged.

Radiation-charge or exposure-charge electrophotography preferably employs a layer of ionizable gas as disclosed in my copending application Ser. No. 568,805 filed March 1, 1956. In the practice of radiation-charged electrophotography the surface upon which the electrostatic latent image is to appear is initially uncharged and is in proximity to an ionizable gas layer, the layer lying between the image surface and a source of potential. Upon exposure of the gas layer to an ionizing light source a latent image of electrostatic potentials appears on the initially uncharged surface.

One of the objects of this invention is to eliminate the usual pre-exposure charging step in the practice of electrophotography.

Another object of this invention is to provide a simplified method of electrophotography utilizing relatively uncomplicated and low cost apparatus.

Still another object is to provide a photographic method and apparatus which requires no dark chamber or dark-room.

Still another object is to provide a method of electrophotography which permits flexibility of exposure and printing control.

These and other objects of the invention will become apparent from the specification and drawing in which

FIG. 1 shows diagrammatically one arrangement for producing electrophotographs from transparent originals.

FIG. 2 shows diagrammatically an electrophotographic printer for continuous printing on a web of material.

FIG. 3 shows an alternative arrangement of the electrode structure.

The printer of FIG. 1 employs as its main member, a supporting frame 10 of electrically conducting material, such as sheet metal, held in an inclined position as shown. A reservoir 12 of electroscopic developer powder is positioned above the frame and a receiving chamber 14 is positioned below the frame for collecting the used powder.

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A sheet 16 of paper or other suitable material on which the image is to be formed is supported on the frame by clips or other suitable means. The transparent original 18 to be reproduced is held in a projection head comprising an ultra-violet light source 20, reflector 22 and projection lens 24. The light source 20 may be of the metal vapor type or of the gaseous discharge type. It may be operated continuously, with exposure control by means of a suitable shutter at or near the lens, or, if of the instantaneous discharge or flash type, may be operated intermittently as required for exposure. Lens 24 must transmit ultraviolet light and accordingly may consist of quartz and fluorite elements or may employ mirrors with or without additional refracting elements to provide a large relative aperture.

The sheet 16 may comprise any good coated paper, transparent cellulose sheet, cellulose coated paper, plastic sheet, or resin impregnated paper. Almost any electrically insulating material of fairly uniform thickness and having a calendered or otherwise smooth surface which will not smudge with developer is suitable.

A sheet 26 of material transparent to ultraviolet light, such as certain glasses and organic materials, carries a similarly transparent electrically conducting electrode layer 28. The electrode layer may be formed on sheet 26 by application of a fused metal oxide layer or by evaporation of a thin layer of metal. Electrode conductivity is not critical, and resistances of 100,000 ohms per square or less are suitable. The electrode layer is parallel to sheet 16 and is spaced therefrom a distance of 0.1 to 1.5 millimeters. A source of potential 30 is connected to electrode 28 and to frame 10, the latter being grounded as shown. The electrode potential may vary from 500 to 5000 volts depending upon the spacing of electrode 28 from sheet 16, the wavelength of light, exposure time and the characteristics of the gas layer between the electrode and sheet 16. The desirable potential ordinarily is one somewhat below that required to produce a charge transfer when the apparatus is in non-exposing condition. A microammeter 32 may be employed to determine the charging rate and thereby to provide the basis for exposure. A reversing switch 34 may be employed for changing the polarity of the charging electrode after exposure in order to reduce image degradation. A potentiometer 36 provides the means for controlling charging potential.

In operation of the printer of FIG. 1 the sheet 16 and transparency 18 are positioned at their respective stations, switch 34 is closed, and lamp 20 is energized. During exposure the ultra-violet image ionizes the air in its path, including that portion between the electrode and the sheet of paper, and causes the charge on electrode 28 to leak to the surface of sheet 16 in proportion to the intensity of the image, resulting in the appearance on the sheet of the customary electrophotographic latent image comprising varying electrostatic potentials. After exposure is completed, a condition which can be determined by observing the rate indicated by meter 32, the light source is deenergized, and switch 34 is opened. In order to prevent deterioration of the electrostatic image by virtue of retained post-exposure ionization of the air layer, the polarity of the electrode may be reversed by means of switch 34, and electrode 28 can be moved away from sheet 16, with or without a scavenging air stream. It is also desirable, for the purpose of avoiding deterioration of the electrostatic image from residual ionization, to apply the electroscopic developer immediately following exposure. Development is achieved by cascading developer from reservoir 12 over the plate, producing a powder image in a manner well known in the electrophotographic art. The powder image is then fixed by heat, solvent or other suitable means at a fixing station, not shown.

Obviously the arrangement of FIG. 1 could be modified for the production of images from opaque originals by such means as shown in my copending application Ser. No. 568,805 aforementioned. It is also possible to produce contact prints by placing a suitable transparent copy to be reproduced on top of sheet 26 and illuminating the latter with collimated light from an ultra-violet source. Clearly, also, other means of development, particularly that known in the art as powder cloud, could be employed advantageously.

FIG. 2 shows a continuous printer for producing strip copies from a transparent strip original. Paper 40 from a reel 42 passes between a pair of feed rolls 44 to an exposure station indicated generally at 46, and over roll 48 to a developing station having a reservoir 12 of carrier developer or otherwise provided with suitable means for rendering the image visible. The web of paper moves past a fixing station 50 and is wound on take-up reel 52.

Exposure station 46 receives its image from a projection head 54 which is provided with a suitable ultraviolet light source 56. The original transparency is moved uniformly in the direction shown by a pair of drive rollers 60 driven synchronously with rolls 44 at such a speed that the image of the moving film as produced by lens 62 is stationary with respect to the moving paper at exposure station 48. A grounded electrically conducting plate 64 supports the paper at its back. The exposure station in this modification comprises a grounded transparent electrode 66 and a wire electrode 68 spaced between the transparent electrode and the paper as shown. Electrode 68 comprises a series of very fine wires in either a parallel or grid arrangement. The diameter of the wire is sufficiently small, relative to its spacing from the paper and to the aperture of the projection lens, so that it neither casts a noticeable shadow nor degrades the image by diffraction or otherwise. Electrode 68 is connected to a source of potential 70 through a potentiometer 72 or other suitable means to permit regulating its voltage, and a switch 74. A meter 76 indicates the rate of charging of the image.

In operation, the printer of FIG. 2 first charges the strip of paper as it passes exposure station 48 to produce a latent image of electrostatic potentials. The electrostatic image is then successively developed and fixed and the web wound on reel 42. The action is similar to that of the printer of FIG. 1, except that the shield and wire electrode is more efficient in transferring the charge. In order to insure uniformity of charge in the electrostatic image it is desirable to move wire electrode 68 during exposure. If the wires are in a parallel arrangement the electrode can be oscillated in a direction perpendicular to the wires. If a grid electrode is employed the entire electrode is preferably circularly oscillated around a radius approximately equal to half the diagonal of the individual squares of the grid.

Because of the fact that over-charging of the paper and even arcing can occur easily once the air is ionized it is advisable to employ a positive control over the exposure action. In the arrangement of FIG. 1, for example the electrode potential may be rapidly reduced to zero or even reversed for a number of cycles during the exposure period. A preferred arrangement is shown in FIG. 3 in which 10 is the electrically conducting supporting surface for the sheet 16 of paper on which the print is to be made. Here, as in FIG. 1, sheet 26 of transparent material carries a transparent electrode 28 except that both surface 10 and electrode 28 are grounded as shown. Spaced from each other and positioned between electrode 28 and surface 10 are a pair of electrodes 80 and 82. Electrode 80 is connected to a source of voltage 30 through resistor 88, potentiometer 84 and switch 86, and receives a potential varying from 1000 to 8000 volts. Electrode 82 is so connected to potentiometer 84 as to receive a voltage of from 200 to 600 volts, approximately, depending upon the intensity of the image and its spacing

from electrode 80 and sheet 16. Electrode 82 acts as a control grid to limit the charge which electrode 80 can impart to sheet 16. As the formation of the latent image on sheet 16 nears completion the current flow to electrode 80 diminishes, and this fact can be employed to automatize exposure. As current flow diminishes the voltage across resistor 88 drops, actuating relay 90 and causing circuit 92 which connects to the exposing lamp or shutter to modify or terminate exposure.

It is obvious that the invention can be practiced with the use of gases other than air, and that if desired the layer can be maintained at pressures other than atmospheric. The ionizable gas layer is adaptable for use in cameras for direct recording of an object where the radiation involved can produce an image and is capable of ionizing a gas.

Obviously one such adaptation of the invention is the production of xeroradiographs, inasmuch as the ionizing action of X-rays can for the purpose of this invention, be employed in a manner similarly to ultraviolet light. In the arrangement of FIG. 1, for example, an X-ray tube or other source of radiation can occupy generally the position of lamp 20, and the object to be radiographed can occupy a suitable position between the source and electrode 28. The practice of radiation-charged xeroradiography does not require a camera or other light-tight housing.

I claim:

1. A method of electrophotography employing ionizing radiation within the range of ultraviolet radiation and X-radiation for forming an electrostatic latent image on an image-receiving sheet of electrically insulating material whose conductivity and chemical properties remain substantially unaffected during the process, said method comprising placing in contact with one surface of said sheet an electrode surface maintained at a given electrical potential, positioning parallel to and in spaced relation to the other surface of said sheet an electrode transparent to said radiation, applying to said transparent electrode a potential higher than that of said contact electrode, maintaining between said transparent electrode and said sheet a layer of gas ionizable by said radiation, exposing through said transparent electrode and to said gas layer with said radiation an image of a subject to be reproduced, creating thereby within said layer corresponding ionized areas through which charges migrate from said transparent electrode to said sheet producing thereon an electrostatic latent image corresponding to said subject, and developing said electrostatic latent image to visible form by the application of an electroscopic developer.

2. A method of electrophotography as claimed in claim 1, the spacing between said transparent electrode and said sheet being in the range between 0.1 millimeters and 1.5 millimeters.

3. A method of electrophotography as claimed in claim 1, the potential difference between said transparent electrode and said contact electrode being in the range between 500 volts and 5000 volts.

4. A method of electrophotography as claimed in claim 1, including the step of varying the potential difference between said transparent electrode and said contact electrode during exposure to thereby prevent excessive current flow to said sheet.

5. A method of electrophotography as claimed in claim 1, including the step of reversing the potential of said transparent electrode subsequent to exposure to thereby reduce post-exposure diffusion of the latent electrostatic image.

6. A method of electrophotography as claimed in claim 1, including the step of controlling the intensity of ionizing radiation in accordance with the accumulation of charge on said image receiving sheet to thereby limit the total exposure.

7. A method of electrophotography as claimed in claim 1, including the step of limiting charge accumulation on

the charge receiving surface by controlling the potential of the transparent electrode.

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