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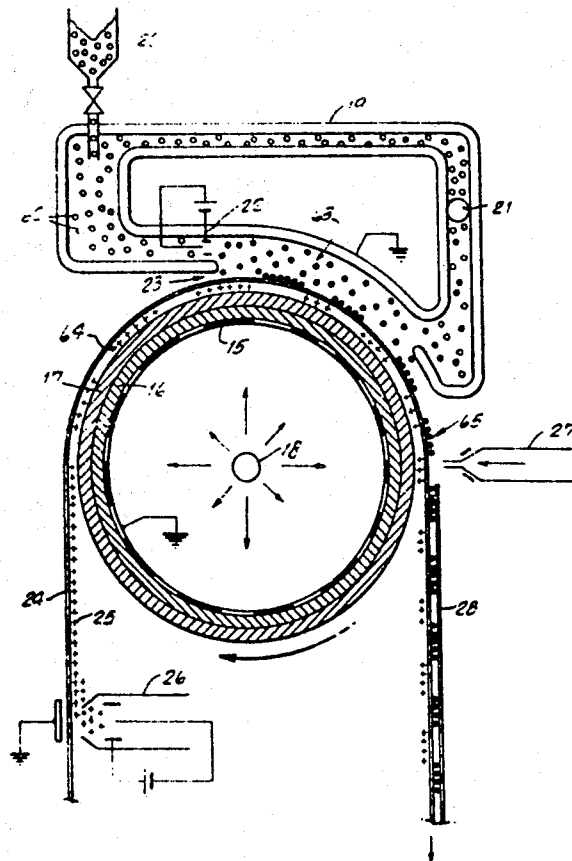
[54] **COPYING SYSTEM USING
ELECTROGASDYNAMICS**
10 Claims, 9 Drawing Figs.

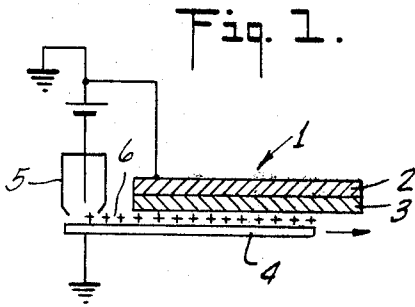
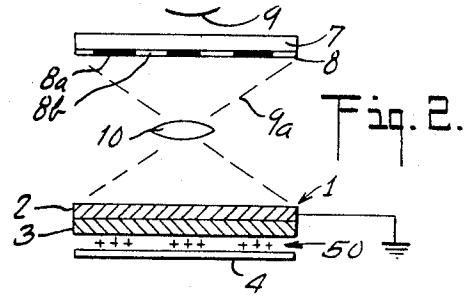
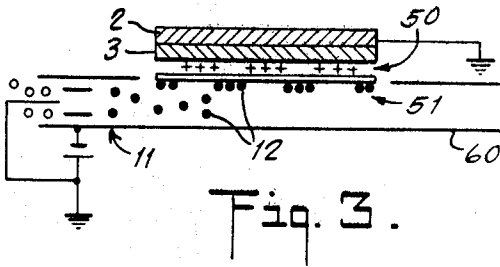
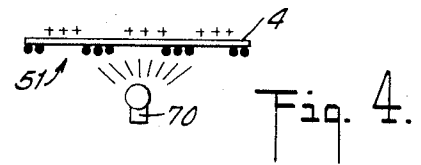
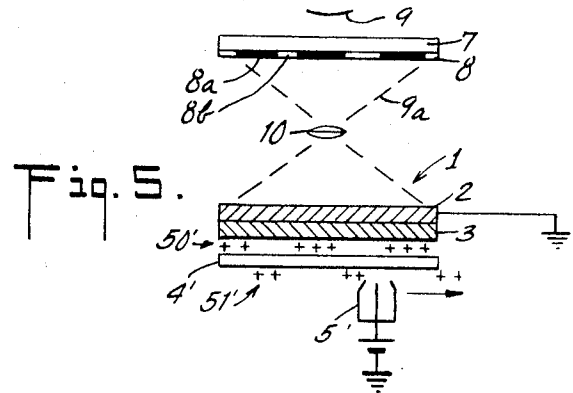
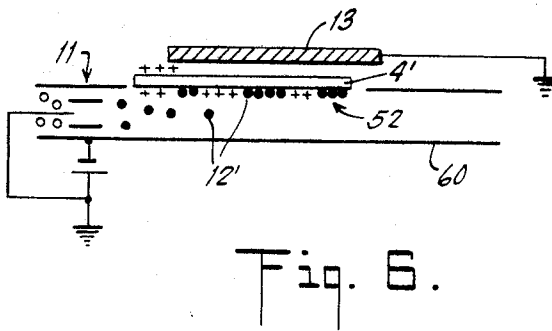
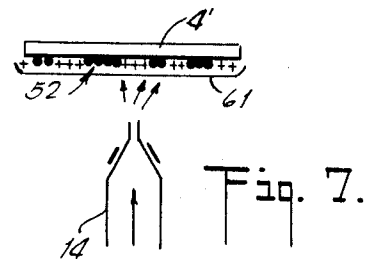
[52] U.S. Cl. 355/17,
96/1
[51] Int. Cl. G03g 5/02
[50] Field of Search 355/10, 15,
17; 96/1

[56] **References Cited**
UNITED STATES PATENTS

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ABSTRACT: An apparatus and method for reproducing an image on a dielectric sheet, such as paper or the like, comprising the use of an electrogasdynamic generator as a spray gun for producing a space charge cloud of ionized ink in the vicinity of one side of the dielectric sheet whose other side has been provided with an electrostatic charge image produced through the use of a conventional xerographic plate and process, whereby an improved quality ink image is produced on the sheet by virtue of the tendency of electrogasdynamically produced particles to achieve a uniform charge distribution on the dielectric surface. Undesirable fringing effects are avoided and the process is speeded up over the conventional xerographic process by reducing the number of mechanical operations required, such as, eliminating the need for cleaning toner from the xerographic plate. The method may be adapted to produce either negative or positive images and for use with high-speed printing systems.





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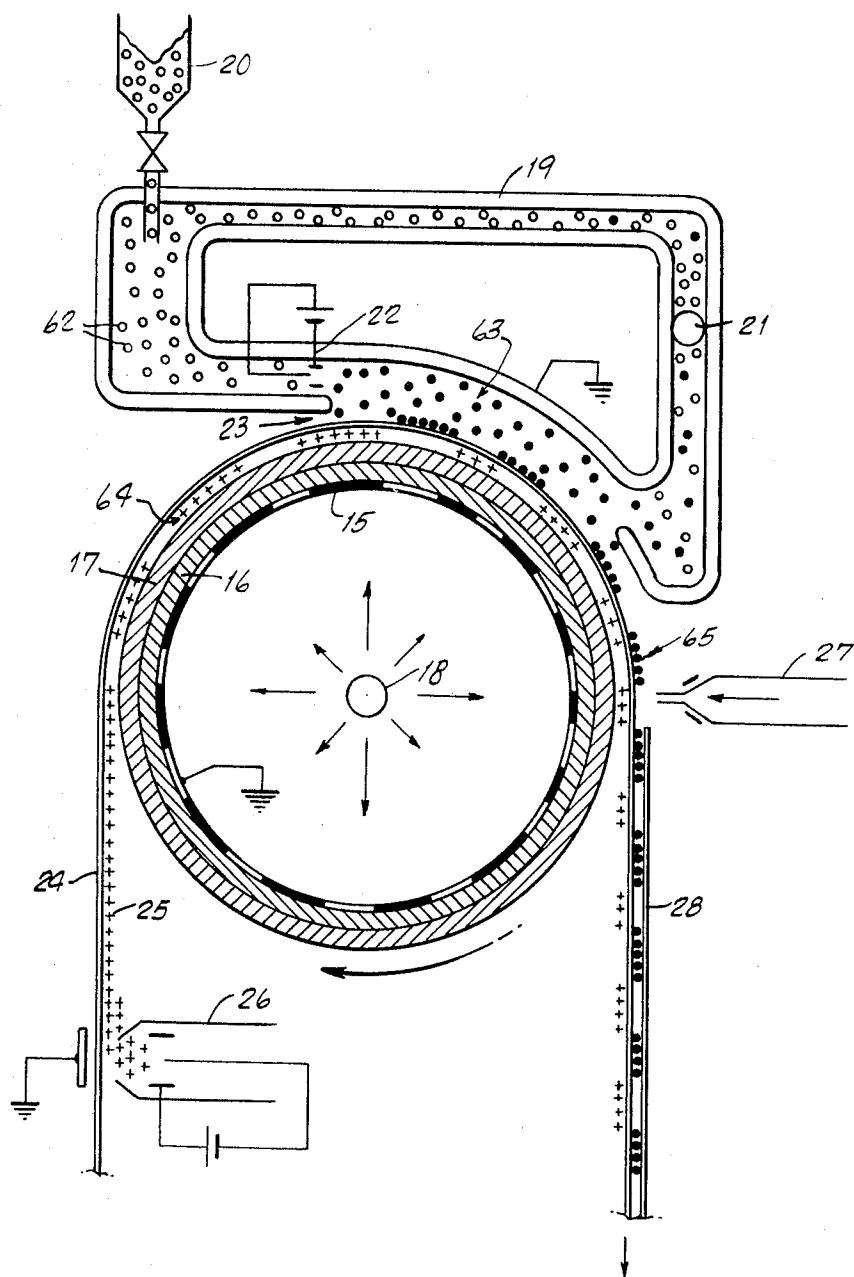


Fig. 8.

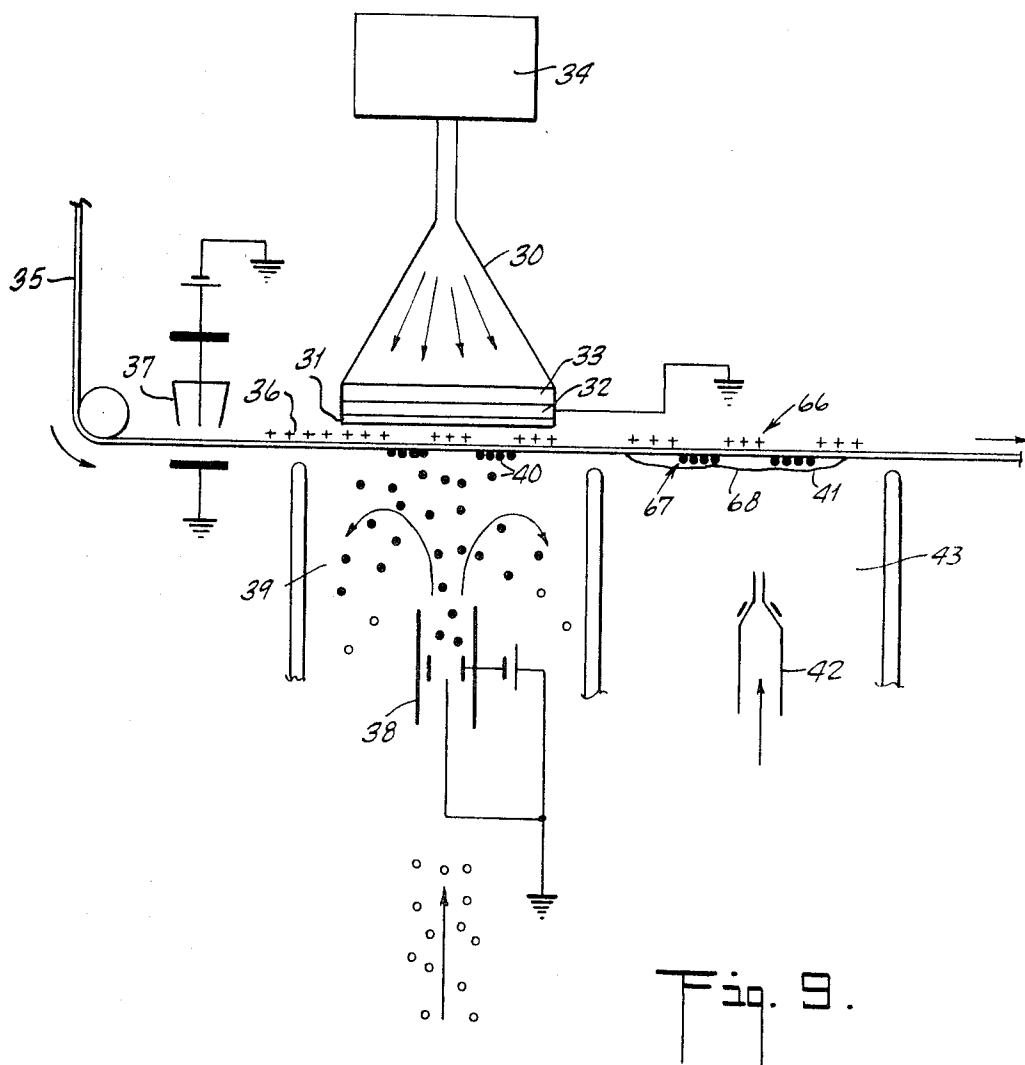


Fig. 9.

insulating layer 3 in the corresponding areas so that an electrostatic charge pattern 50 is produced on the dielectric sheet 4 which positively corresponds with the image 8 to be reproduced.

The third step of the improved method is shown in FIG. 3. An electrogasdynamic generator used as an EGD spray gun 11, is positioned adjacent the dielectric sheet 4 and produces a space charge cloud of ionized ink particles 12 in the vicinity of the surface of the dielectric sheet 4 opposite the surface containing the electrostatic image layer 50. The cloud of particles 12 may be confined within a grounded channel 60 which is an extension of the EGD gun 11 but such a component is not necessary for the proper operation of the process. The white circles indicate the uncharged ink particles and the black circles indicate the ink ions.

As more fully explained in my previously cited copending application, Ser. No. 763,854, electrogasdynamically produced ions in a space charge cloud tend to distribute themselves uniformly over a dielectric surface so that the ink ions 12 will be deposited uniformly on the dielectric surface 4 in the regions opposite the uncharged areas. However, as the ions 12 will be repelled by the fields produced by the charged areas, the deposition of ink on the areas of the surface opposite the charge image 50 will occur only until a uniform charge distribution occurs over the entire surface. The ion concentration in the cloud determines the maximum potential of the surface and the resulting maximum surface charge which is deposited. The ink ions 12, therefore, distribute themselves over the surface of the dielectric sheet 4 until a maximum or equilibrium condition is achieved. At equilibrium, the longitudinal component of the electric field on the dielectric surface and in the dielectric sheet 4 is zero. Thus, the ink particles 12, which are high charged, tend to concentrate themselves in the uncharged areas and will not adhere to the highly charged areas so that an ink image 51 is produced which directly corresponds to the distribution of the electrostatic image although in a negative sense.

As a result of the even distribution of charge, fringing effects are avoided at the areas of greatest contrast and, further, since electrogasdynamically produced ions carry a high charge, the ink particles 12 will avoid those areas already charged to maximum potential giving improved definition and resolution to the ink image 51. A variety of inks or paints may be used in this process due to the versatility of the EGD spray gun in charging aerosols, and the use of water-based inks is particularly of advantage in avoiding air pollution problems during the fixing step.

FIG. 4 shows the fixing step of the improved process wherein a heating means 70 is applied to cure the ink, however, various lacquers and other fixing media may be used depending on the type of ink comprising the image.

It will be seen that this process produces an improved quality image over that achieved by the conventional xerographic process and requires fewer mechanical operations resulting in greater speed or reproduction than the conventional xerographic process. The image 51 which results from this process is a negative image of the master image 8 to be reproduced and so is suitable for use in many applications in the printing industry. However, where image copying is concerned a positive image is usually desirable.

If a positive image is required, the above method may be modified to produce such an end result. An improved process for producing a positive image on the dielectric sheet is shown in FIGS. 5-7. The first step of this process is identical to that of the first described process wherein, as shown in FIG. 1, a layer of electrostatic charge 6 is deposited by the corona discharge device 5 on one surface of a dielectric sheet 4' and the charged surface is positioned against the insulating layer 3 of the xerographic plate 1. Of course, alternatively in both cases the charge layer may be deposited directly on the layer 3 of the plate 1 and the sheet 4' then placed against them but the described method is preferred to minimize the number of moving parts required.

In the second step, however, as shown in FIG. 5, while the xerographic plate 1 is being exposed to the light image a corona discharge device 5' is used to place a positive charge on the opposite side of the dielectric sheet 4' so as to produce an electrostatic image 51' which is the converse of the image 50' resulting on the first side from the discharging action of the photoconductive plate 3.

The developing step is shown in FIG. 6 wherein the first side of the sheet 4' is discharged by means of a grounded conductor, such as a metal plate 13, and a positive image 52 is developed on the opposite side of the sheet 4' by the application of a cloud of ionized ink 12' produced by the EGD spray gun 11. The ionized ink 12' in this instance will tend to distribute itself evenly over the charged surface of the sheet 4' by clinging to the uncharged areas and being repelled by the positive charges until a uniform potential and evenly distributed charge layer is reached. An improved positive image 52 is thus produced which may then be fixed in any conventional manner and particularly as shown in FIG. 7 by a polymer coating 61 using a free radical generator 14.

It should be noted that the major components in both of the above-described systems are a xerographic plate, corona discharge device, and a small EGD generator which is driven by a small compressor and operated intermittently by electrically controlled solenoidal valves (not shown). Thus, the only moving mechanical parts required are in the means for moving the dielectric sheet, and the second discharge device 5' in the positive image process.

CONTINUOUS HIGH-SPEED PRINTING SYSTEM

As previously mentioned, the negative image-producing method initially described may be adapted for use in many applications in the printing industry. An apparatus for adapting this method for use in continuous high speed printing of magazines, newspapers and the like is shown in FIG. 8.

A negative image of the page to be reproduced is first cut on a master such as a mask of opaque plastic or metal 15. The master may be cut automatically as the original material is being typed. The master 15 is inserted inside a glass cylinder 16 with a thin xerographic plate 17 on its surface. A light source 18 is disposed at the center of the cylinder 16 and continuously exposes the xerographic plate 17 through the mask 15. The cylinder 16 is rotated in a clockwise direction.

The ink to be used for printing is sprayed into an atomizing chamber 19 from a reservoir 20. The droplets of ink 62 in the chamber 19 are circulated in a counterclockwise direction by a fan 21. An EGD spray gun 22 is positioned at the chamber opening 23 adjacent the upper surface of the cylinder 16 and ionizes the passing ink droplets 62 to produce an electrogasdynamic space charge cloud 63 in the region of the opening 23.

The dielectric sheet 24, which in this case is the paper on which the page is to be continuously printed, is fed from a roll (not shown) over the top of the rotating cylinder 16 and the steps of the process are carried out continuously in the following manner. A layer of electrostatic charge 25 is deposited on one surface of the paper 24 by a suitable discharge device 26. The layer of charge 25 will be brought into contact with the xerographic plate 17 as the paper 24 is fed over the rotating cylinder 16. The light from source 18 is continuously shone through the negative image of the page on master 15 so that the xerographic plate 17 is constantly conductive in the pattern of this image and will accordingly discharge the charge layer 25 to produce a corresponding latent electrostatic image on the surface of the paper 24. The electrostatic image 64 thus formed on a particular portion of the paper 24 passes into the region 23 where the electrogasdynamically produced space charge cloud 63 is maintained and the ionized ink particles 62 of the cloud will develop on the exterior side, the latent electrostatic image 64 on the opposite side of the paper 24. The developed image 65 is then fed past a free radical generator 27 which applies a polymer coating 28 to fix the image 65 on the surface of the paper 24.

COPYING SYSTEM USING ELECTROGASDYNAMICS

BACKGROUND OF THE INVENTION

The present invention relates to the image reproduction art and more particularly to an image-copying apparatus and method using an electrogasdynamic generator in cooperation with a conventional xerographic plate.

A number of image reproduction systems have been developed in recent years, including xerography, electrostatic photoconductive printing, smoke printing and the like, which have met with varying degrees of success in attempting to produce satisfactory image reproductions while reducing the speed and complexity of the operations required. One of the most successful is the xerographic process wherein six basic steps are usually followed in the reproduction of an image on paper. The six steps include: (1) the charging of a xerographic plate, i.e., one comprising an insulating photoconductive layer and a transparent conductive layer, with a layer of electrostatic charge on the insulating side; (2) then exposing the plate to light in the image pattern to be reproduced causing the insulating layer to become conductive in the areas exposed to the light and thus neutralizing the layer of electrostatic charge in those areas; (3) the resulting latent electrostatic image is then developed by the application of a triboelectrically charged layer of powder or toner whose oppositely charged particles are attracted by and adhere to the charged areas on the surface of the plate forming a powder image in accordance with the electrostatic image; (4) the powder image is then transferred to a sheet of paper adjacent the imaged side of the plate and producing a voltage between the two by distributing a layer of charge on the opposite side of the paper; (5) the powder image is then fixed on the paper by any of a number of well-known methods, such as by heating; and (6) the remaining powder is cleaned from the surface of the xerographic plate in preparation for rerunning the process.

The many practical improvements which have been developed in connection with this process have been primarily directed to improving the quality of reproduction and increasing the speed of performance. Improvements in speed have been limited by the number of mechanical operations required in the basic process. Also quality has been limited in image reproduction because of the tendency of the images to develop heavily where contrast is greatest due to fringing effects which produce uneven distribution in the electrostatic charge image. As a result, although the xerographic process has been used widely in certain commercial applications, it has been found to be of little use in high-speed reproduction areas such as in the printing industry.

Although various other reproduction techniques have been developed which reduce the number of mechanical operations required, still all have suffered from loss of quality of reproduction and the need for special materials.

The present invention offers a system which improves upon the speed of reproduction capable of being achieved with the conventional xerographic process while concomitantly improving on the quality of the image obtained.

SUMMARY OF THE INVENTION

The apparatus and method of the present invention comprises the use of an electrogasdynamic, or EGD, generator as a spray gun, to produce a space charge cloud of ionized ink particles that is deposited on the surface of a dielectric sheet, such as paper, on which the image is to be printed.

It has been observed that it is a peculiar quality of charges in an electrogasdynamically produced cloud to tend to become uniformly distributed over a dielectric surface and the amount of surface charge that can be acquired has a particular limit under given conditions. The ion concentration in the cloud determines the maximum potential of the dielectric surface and the maximum surface charge. An explanation of this phenomenon is more fully set forth in my copending application, Ser. No. 763,854, filed Sept. 30, 1969.

This peculiar phenomenon results in the production of an improved quality image by eliminating the fringing effects which occur in conventional xerographic reproduction and gives greater resolution of the image in halftone areas. The use of such an ion cloud for developing an electrostatic image also avoids the need for the transfer and toner cleaning steps in the conventional xerographic process. In addition, this improved process is readily adaptable for use in high-speed printing systems.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows the first step in the improved process of the present invention wherein a layer of charge is placed on a dielectric sheet;

FIG. 2 shows the second step of the process wherein a light image is projected onto a xerographic plate and the adjacently disposed charged sheet;

FIG. 3 shows the third step of the process wherein a negative of the image is developed on one side of the dielectric sheet by a space charge cloud produced by an EGD spray gun;

FIG. 4 shows the last step of the method wherein the developed image is fixed on the dielectric sheet;

fig. 5 shows the second step of an alternate method for producing a positive of the image on the sheet wherein a charge layer is placed on the surface of the dielectric sheet during the exposure step;

FIG. 6 shows the third step in the alternate method wherein the image is developed on the dielectric sheet using an EGD spray gun;

FIG. 7 shows the fixing step of the alternate method;

FIG. 8 shows a continuous high-speed printing system incorporating apparatus and method of the present invention; and

FIG. 9 shows a discontinuous high-speed printing system incorporating the apparatus and method of the present invention.

DETAILED DESCRIPTION

FIGS. 1 through 4 show an apparatus and steps of the present invention. In FIG. 1, a conventional xerographic plate 1 comprising a transparent conductive layer 2 and an insulating photoconductive layer 3 is shown in combination with a dielectric sheet 4 on which the image is to be printed and a suitable corona discharge device 5 which produces a supply of electrostatic charges or ions 6. The dielectric sheet 4 may be of paper or some similar material suitable for reproduction purposes and the corona discharge device 5 may be a conventional coratron or like device well known to those skilled in the art.

The first step of the method comprises the deposition of the layer of electrostatic charge 6 by the corona discharge device 5 on one surface of the dielectric sheet 4 and the placing of this charged surface adjacent to the insulating photoconductive layer 3 of the xerographic plate 1.

FIG. 2 shows the second step of the method wherein the charged surface of the dielectric sheet 4 is placed in contact with the insulating layer 3 of the xerographic plate 1, and a member 7 containing the image 8 to be reproduced is placed above the transparent layer 2 of the xerographic plate 1. The conductive transparent layer 2 is grounded and light 9a from a source 9 is shone through the image 8 and directed onto the surface of the transparent layer 2 by an appropriate optical system such as the objective lens 10. The opaque areas 8a of the image 8 prevent the passage of the light so that only light falling on the translucent areas 8b of the image 8 is permitted to reach the transparent layer 2. The intensity of the light reaching the layer 2 is in accordance with the degree of translucence of the respective areas of the image 8. This light passes through the transparent layer 2 and causes the photoconductive insulating layer 3 to become conductive only within the areas on which it falls and to an extent corresponding to the light intensity. The electrostatic charge 6 on the dielectric sheet 4 is then discharged by the conduction of the

It will be seen from the operation of this embodiment that the reproduction system of the present invention is readily adaptable to high-speed reproduction and may be used in a wide variety of printing applications.

DISCONTINUOUS HIGH-SPEED PRINTING SYSTEM

A further embodiment illustrating this point is shown in FIG. 9 wherein different pages of a magazine or newspaper can be printed in sequence at high speed. This operation, which may be continuous or discontinuous, is accomplished by using an optical signal on the face of an electron beam tube 30 as the image to be reproduced.

The face of the tube 30 comprises an insulating photoconductive layer 31, a grounded conductive layer 32, and an image producing layer 33. The image producing layer 33 may be formed from optical fibers or very fine electrically insulated wires, or any means capable of transmitting an image signal which is fed from a suitable computer or electronic data-handling system 34. The tube 30 may be fabricated as an integral unit, or a xerographic plate can be mounted on the face of a TV tube to achieve the same result.

In operation, a dielectric sheet such as paper 35, on which the images are to be printed, is provided with a layer of charge 35 by a suitable discharge device 37 and is fed past the face of the tube 30 with the charge layer 36 adjacent the xerographic plate 31, 32. The charge layer 36 is discharged in accordance with the image on the plate 31, which image may be sequentially changed line by line in the manner of a television picture or in some similar manner. The sheet feeding means (not shown) may be operated continuously or intermittently at a rate synchronized with the image production.

An EGD spray gun 38 is disposed adjacent the uncharged surface of the paper 35 opposite the tube 30 and electrostatically produces a space charge cloud 40 which is maintained in the region by a suitable enclosure, such as chamber 39 or the like. The ionized ink particles 40 develop the image 67 on the opposite side of the sheet 35 from the charge image 66 and the developed image 67 is fixed by the deposition of a polymer coating 68 or the like provided by a free radical generator 42 disposed in an adjacent chamber 43. Thus, with a negative image on the face of tube 30, only a single step is required to produce a positive image on the paper 35 as the exposure and developing are performed simultaneously.

It will be seen from the preceding description that an improved apparatus and method for reproducing an image on a dielectric sheet is provided which produces improved fidelity of reproduction and at higher speeds than the systems of the prior art. In addition, the number of moving parts is minimized and a wide variety of printing inks and dyes may be used. In this latter regard, it should be understood that the term "ink" as used herein is meant to refer to any material such as an ink, a dye, a powder, or the like which is capable of use as a printing medium and may be ionized in an electrostatic generator.

What I claim is:

1. A method of image reproduction comprising the steps of:
 - a. disposing a layer of electrostatic charge between and in contact with a surface of a photoconductive plate and one surface of a dielectric sheet;
 - b. exposing the plate to light in the pattern of an image to be reproduced thereby discharging portions of the charge layer in the pattern of the image; and
 - c. directing an electrostatically produced cloud of ionized ink against the opposite surface of the dielectric sheet to develop the charge layer pattern of the image.
2. A method of image reproduction comprising the steps of:
 - a. depositing a layer of electrostatic charge on one surface of a dielectric sheet on which sheet an image is to be reproduced;
 - b. placing the charged surface against the surface of a photoconductive plate;

- c. exposing the plate to light in the pattern of an image to be reproduced thereby discharging portions of the charged layer in the pattern of the image; and
- d. directing an electrostatically produced cloud of ionized ink against the opposite surface of the dielectric sheet to develop the charge layer pattern of the image.
3. A method as claimed in claim 2 wherein before the developing step a layer of electrostatic charge is deposited on the opposite surface of said dielectric sheet and the originally charged surface is discharged.
4. A method as claimed in claim 2 including fixing the developed image by coating with a polymer.
5. An apparatus for reproducing an image comprising:
 - a. a plate of insulating photoconductive material;
 - b. means for depositing a layer of electrostatic charge on a surface of said plate in contact with one surface of a dielectric sheet;
 - c. means for exposing said plate to light in the pattern of an image to be reproduced thereby discharging portions of the charge layer in the pattern of the image; and
 - d. means for electrostatically producing a cloud of ionized ink to be directed against the opposite surface of the dielectric sheet to develop the charge layer pattern of the image.
6. Apparatus as claimed in claim 5 comprising means for depositing a layer of electrostatic charge on the opposite surface of said dielectric sheet and means for discharging said charge layer on the other surface of said sheet prior to the directing of said ionized ink cloud.
7. A high-speed printing apparatus comprising:
 - a. a rotating cylinder having a photoconductive outer surface;
 - b. a light source disposed at the center of said cylinder;
 - c. means on the inner surface of said cylinder having light-conducting portions defining an image pattern;
 - d. means adjacent the outer surface of said cylinder for electrostatically producing an ionized ink cloud in the vicinity of the cylinder outer surface, which means is spaced from said outer surface to accommodate the passage of a dielectric sheet riding on said surface; and
 - e. means for depositing a layer of electrostatic charge on the inside surface of said dielectric sheet prior to the contact of said inside surface with the outer surface of said cylinder.
8. An apparatus as claimed in claim 7 comprising means for depositing a polymer coating on the outside surface of said dielectric sheet after said outside surface has passed said ionized ink cloud.
9. A high-speed printing apparatus comprising:
 - a. means for sequentially producing intelligence in the form of electromagnetic energy patterns;
 - b. means receiving said patterns and having a surface for sequentially reproducing the patterns in the form of conductive areas;
 - c. means for passing one surface of a dielectric sheet over said reproducing surface;
 - d. means for depositing a layer of electrostatic charge on said surface of the sheet prior to its passing over said reproducing surface; and
 - e. means for electrostatically producing and directing an ionized ink cloud against the opposite surface of said sheet upon its passing over said reproducing surface.
10. A high-speed printing apparatus comprising:
 - a. means having a surface for sequentially producing patterns of electrically conductive areas thereon;
 - b. means for passing a dielectric sheet over said conductive surface;
 - c. means for depositing a layer of electrostatic charge on the surface of said sheet which contacts said conductive surface prior to the contacting; and
 - d. means for electrostatically producing and directing an ionized ink cloud against a surface of said sheet after it has passed over said reproducing surface.

**UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION**

Patent No. 3,592,541

Dated July 13, 1971

Inventor(s) Meredith C. Gourdine

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 31, "paper adjacent" should read
--paper or other material by positioning one side of the
paper adjacent--;

Column 4, line 31, "CONTINUOUS HIGH-SPPED PRINTING
SYSTEM" should read --CONTINUOUS HIGH-SPEED PRINTING
SYSTEM--.

Signed and sealed this 5th day of November 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents