Nov. 30, 1965 C. SNELLING 3,220,324

PHOTOCONDUCTIVELY CONTROLLED CORONA CHARGING

Filed Nov. 12, 1963

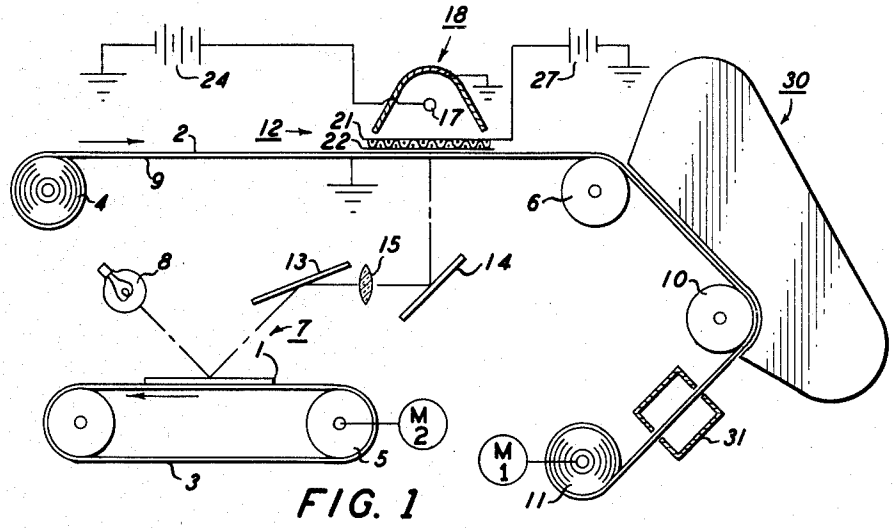

FIG. 1

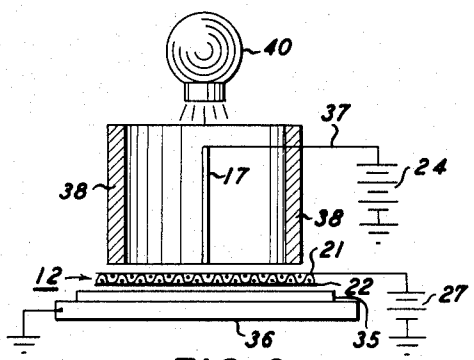

FIG. 2

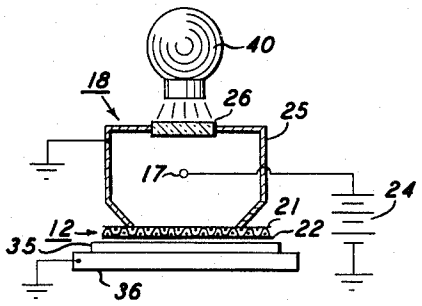

FIG. 3

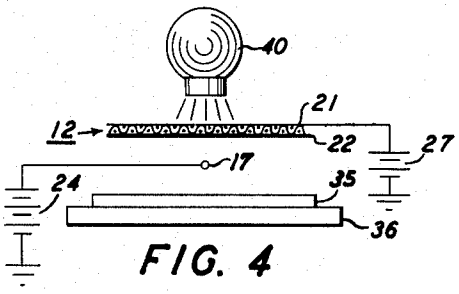

FIG. 4

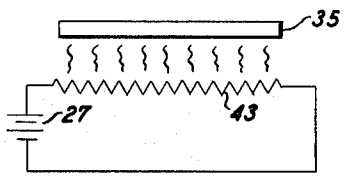

FIG. 5

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PHOTOCONDUCTIVELY CONTROLLED CORONA CHARGING

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This invention relates to image reproduction, and particularly to the formation and utilization of an electrostatic charge pattern on a chargeable surface.

One of the fields in which this invention may be directly applied is that of xerography. Xerographic image reproduction has become widely known, and has achieved commercial acceptance in fields such as office copying.

One commercially available xerographic system involves a first step of uniformly charging a reusable xerographic plate comprising a photoconductive layer overlying a conductive backing member. The uniformly charged plate is then exposed to an optical image conforming to an original document, photograph, scene, or the like. Selective discharge of the plate in light struck areas produces a latent electrostatic image conforming to the original. This latent image is then typically made visible by dusting with electrically attractable resinous toner particles. After the toner image thus formed is transferred to another member, such as paper, the xerographic plate may be cleaned and recycled in the described system.

Another commercially available system utilizes a disposable xerographic plate, such as paper coated with a layer comprising photoconductive material and an insulating binder. Since the plate serves as the final image support, the separate transfer step is eliminated in this system.

Both of these systems involve the use of a xerographic plate which is first uniformly charged and then selectively discharged by exposure to an optical image. The present invention, however, contemplates the formation of an electrostatic image directly on a chargeable surface. As described herein, the present invention dispenses with the need for the conventional xerographic plate, and may therefore be used for xerographic image reproduction without the separate steps of uniform charging followed by selective discharge of the xerographic plate.

Accordingly, an object of the present invention is an improved image reproduction system. Methods and apparatus for image reproduction without a xerographic plate are also objects of this invention. The rapid formation of an electrostatic charge pattern on a chargeable surface is an additional object of this invention. Other objects of the present invention will be apparent to those skilled in the art by a reading of this specification and the appended claims.

In the present invention, an optical image is projected onto a control screen in association with a corona discharge device. The screen responds to the optical image, and controls the deposition of electrostatic charge on a target member. As applied to xerography, this invention permits the direct formation of a latent charge pattern on a dielectric member which pattern may be made visible by any suitable developing technique known to the art. Of course, once formed on the chargeable member, the charge pattern may be used in other ways. If desired, for instance, it may be used to activate a sensing device. Also, the regulated charge may be used to produce images on electro-sensitive paper, or the like.

The present invention is described with reference to the drawings in which:

FIG. 1 schematically illustrates image reproduction on a flexible light-transmitting web;

FIG. 2 schematically illustrates one embodiment for the formation of an electrostatic charge pattern on a dielectric surface;

FIGS. 3 and 4 illustrate alternate modes for forming electrostatic charge patterns; and,

FIG. 5 illustrates image development applicable to a thermoplastic member.

Reference is made to FIG. 1 for a general description of the present invention. The illustrated embodiment includes various system components for the reproduction of document **1** on web **2**.

Web **2** and endless belt **3**, respectively, are driven in the directions of the arrows by conventional drive means, such as motor M1 connected to roller **11** and motor M2 connected to roller **5**. For purposes of this embodiment, the respective drive means should by synchronized to drive belt **3** and web **2** at the same linear speed. Web **2** is fed from roller **4** and guided through various process stations by means of rollers designated **4**, **6**, **10** and **11**.

To reproduce document **1**, document **1** is placed on belt **3** which transports it through projection station **7** where it is illuminated by lamp **8**. The optical image reflected therefrom is projected onto control screen **12** by means of mirrors **13** and **14** and lens system **15**.

Although the illustrated projection station **7** is suitable for opaque documents, other means of projecting an optical image on screen **12** may be used instead. For instance, light may be projected through a microfilm transparency, or the like, and focused on screen **12**.

Control screen **12** comprises a conductive screen **21** of for instance, interwoven conductive strands, copper mesh, metallic screening, or the like, at least one side of which is coated with photoconductive insulating layer **22**. A perforated metallic plate, grille, or planar screen may similarly be used as screen **21**. Photoconductive layer **22** may be incorporated by oxidizing at least one side of conductive screen **21** and applying a coating of selenium, or other photoconductive material. In this configuration better control is provided by positioning screen **12** with the photoconductive layer **22** facing web **2**. Since the apparatus shown in FIG. 1 is intended for the continuous operation mode, it is highly preferable to use a photoconductive layer having a significantly reduced light fatigue. For example, selenium processed in accordance with U.S. Patent No. 3,077,386 can be expected to yield better results than the vitreous selenium typically used in xerography.

Simultaneously with the projection of an optical image onto screen **12**, as described, corona discharge electrode **17** of corona device **18** is raised to a corona discharge potential by means of power supply **24**. As shown in FIG. 1, conductive shield **25** is preferably electrically grounded, as is transparent conductive layer **9** of web **2**. In this and other embodiments of the present invention corona device **18** may include one or more electrodes **17**. A single-electrode device is used for purposes of illustration only and it is not intended that other corona devices known to the art be excluded from the scope of this invention.

In response to the optical image, photoconductive layer **22** becomes selectively more conductive in the illuminated areas. As a result, the deposition of electrical charge on web **2** is regulated such that a latent electrostatic image conforming to document **1** is formed on web **2**.

Web **2** may comprise any one of a number of suitable materials capable of retaining an electrostatic charge pattern on its surface. Such materials include plastics, cellulose acetate, polyethylene terephthalate, and the like, although other materials incorporating at least a non-conductive surface layer, such as non-pigmented paper coated with non-conductive plastics, may also be used.

For adequate charge accumulation, the image surface of web 2 is backed by an electrically grounded surface. This may be accomplished by including a transparent conductive layer 9 of tin oxide, tin chloride, copper iodide, or the like, as shown in FIG. 1. In the illustrated embodiment, web 2 is also flexible, although modification of the system components to reproduce an image on a rigid member would be within the skill of the artisan.

Although the threshold potential for corona discharge is a function of the diameter of electrode 17, it has been found preferable to operate corona device 18 at a potential somewhat above threshold. Adverse effects of electrode non-uniformity are thereby effectively reduced, and charging is more readily controlled. An electrical potential of approximately 6500–7500 volts for an electrode diameter of about .0035 inch is especially suitable for the present invention, although a wide range of variation is permissible.

Web 2 is moved through developing station 30 after the electrostatic latent image conforming to document 1 has been formed in the manner described. At developing station 30 the latent image is made visible by any of the developing processes known to the art of xerography. For instance, a two component developer of finely divided resinous toner particles mixed with larger carrier particles may be cascaded across the surface of web 2, as more fully described in U.S. Patent No. 2,638,416. The attractable toner particles adhere to web 2 in image configuration thereby forming a faithful reproduction of document 1.

The visible toner image formed on web 2 is optionally fixed at fusing chamber 31 to render the image more permanent. At fusing chamber 31, the toner image is exposed to vapors which are a solvent for the resin particles causing them to soften and coalesce. Upon removal from fusing chamber 31, the resin rehardens and clings tenaciously to web 2. Other fusing methods known to the art, such as heat fusing, may also be employed if desired.

The embodiment of FIG. 1 produces an image which may be viewed directly, or by projection on a viewing screen, or the like. Roller 6 provides convenient storage means, if desired. Corona electrode 17, if positioned as illustrated on the opposite side of web 2, must be transparent or sufficiently translucent to permit projection of the optical image onto screen 12. The present invention, however, is not restricted to transparent or translucent image recording members.

FIG. 2 illustrates an embodiment of the present invention suitable for image reproduction independent of the transparency or flexibility of the image recording member. In this embodiment, recording member 35 may be transparent, translucent or opaque. At least one surface of member 35 must be sufficiently insulating to retain an electrostatic charge in image configuration. As shown in FIG. 2, member 35 is supported on grounded electrically conductive table 36 during the formation of the electrostatic image in accordance with the present invention.

As an alternative arrangement, member 35 could be electrically conductive, and incorporate a non-conductive surface for image formation. Member 35 could then be electrically grounded, thus obviating the conductivity of table 36.

Suitable materials for member 35 of FIG. 2 include glass, paper, cellulose acetate, Mylar polyester film, paper overcoated with a thin layer of insulating materials such as methyl styrene, and the like. Although imaging is independent of transparency or flexibility, the optical image is reflected rather than projected directly onto the screen in the illustrated embodiment. Thus, the surface of member 35 must be light reflecting, or, if member 35 is transparent, the optical image may be reflected by table 36 instead.

Electrode 17 comprises a fine wire or needle which is electrically connected to power supply 24 by lead 37. Lead 37 may also serve to support electrode 17 within cylindrical conductive shield 38 in vertical position as shown. Control screen 12, comprising a conductive screen 21, one side of which includes photoconductive layer 22, is electrically biased by power supply 27. As an optical image is projected from projector 40, it has been found that electrical charge conforming to the dark areas of the optical image is built up on member 35, and that the accumulation of charge at areas corresponding to the light areas is appreciably less or negligible. A developable electrostatic charge pattern conforming to the optical image is thus formed on member 35. Again, conventional xerographic techniques may be employed to render the charge pattern visible. Since light fatigue is of less significance than it is in the continuous mode of FIG. 1, the photoconductive layer 22 of FIGS. 2–4 need not comprise specially processed material. Photoconductive materials well known to the art of xerography may be suitably employed in these embodiments.

Control of charge accumulation on member 35 has been successfully achieved by the application of various electrical potentials to screen 12 of FIG. 2. With screen 12 positioned approximately 1/16 inch from member 35, a bias of 100–150 volts demonstrated the greatest degree of charge contrast between the illuminated and non-illuminated conditions. Approximately 6500–7000 volts were applied to electrode 17 and various potentials ranging from zero to several hundred volts were applied to screen 12 which comprised a copper mesh having about 150 lines per inch (about 26% open area) and a selenium layer 22 having a thickness of about 80 microns. Charge contrast adequate for xerographic development of electrostatic images was demonstrated, with peak contrast in the potential range indicated. If the charge contrast resulting from a bias of zero potential is satisfactory in a particular application of the present invention then the bias power supply may be eliminated by merely grounding screen 12.

Another embodiment of the present invention is illustrated in FIG. 3. This embodiment completely dispenses with the bias power supply and includes a corona device which is a modification of the corotron disclosed in U.S. Patent No. 2,836,725. Electrode 17 is partly surrounded by conductive shield 25 which is provided with window 26, preferably of glass coated with a conductive layer, for the projection of an optical image onto control screen 12 by means of projector 40. In this embodiment control screen 12 is shown attached to grounded conductive shield 25 and is accordingly operated at zero potential. Although charge contrast is somewhat reduced, developable electrostatic images may be formed by means of this embodiment.

As explained in connection with FIG. 2, light is reflected from member 35 onto screen 12 corresponding to the optical image. Thus, photoconductive layer 22 is made selectively relatively conducting, resulting in the control of charge accumulation on member 35.

Without intending to limit the present invention to a particular mechanism, the control charge accumulation is believed due to ion decelerating field components which build up between the surface of the recording member and screen 12 as the recording member surface potential approaches the screen potential. As already indicated, the screen potential varies from point to point in response to the light reflected or projected onto photoconductive layer 22.

Thus, more effective charge control in the reflex modes of FIGS. 2 and 3 can be expected with screen 12 spaced closely preferably about 1/16 inch or less, to member 35. Diffuse reflection from member 35 then varies the conductivity of layer 22 and a latent electrostatic image corresponding to the optical image projected from projector 40 is thereby formed on member 35.

FIG. 4 illustrates another direct projection mode of the present invention. In this embodiment screen **12** is positioned between projector **40** and electrode **17**. Simultaneously with the projection of the optical image thereon, screen **12** is electrically biased through connection of plate **21** with power supply **27**, and electrode **17** is raised to a corona discharge potential by power supply **24**.

Recording member **35** may comprise conductive material if it incorporates an insulating chargeable surface. More conveniently, however, recording member **35** comprises insulating material provided it is positioned between conductive table **36**, usually grounded, and corona electrode **17**.

Again, a potential (preferably of approximately 100–150 volts) is applied to screen **12** to regulate the accumulation of charge on member **35**. The resultant electrostatic image may then be developed by methods known to the art of xerography, or otherwise used as desired.

It is of course noted that the embodiments of FIGS. 2–4 may be modified to make use of direct projection rather than reflection. Thus, by using a transparent recording member **35** and a transparent table **36**, of, for instance, glass coated with tin oxide or the like, projector **40** may be positioned on the opposite side of member **35** from that illustrated.

It will be obvious to those skilled in the art that various methods may be employed to convert the latent electrostatic image formed as herein described into a visible image. In addition to the cascade development method referred to in connection with FIG. 1, other techniques for applying electroscopic toner are known. With the proper selection of materials it is also possible to reproduce other than toner images according to the present invention.

For instance, a latent electrostatic image may be formed as herein explained on a recording member **35** comprising a deformable plastic such as Staybelite, Piccolastic, or the like. After formation of the latent image it is developed by a softening process, such as exposure to solvent vapors, or by heating, as illustrated in FIG. 5.

In FIG. 5, electrically energized heating element **43** is shown below member **35** bearing a latent electrostatic image. As member **35** is softened, the image bearing surface is enabled to flow in response to the electrostatic forces acting upon it. Member **35** thereby develops a microscopically uneven surface, in image configuration, having a frosted appearance. The resultant image is sufficiently light diffusing to be viewed directly or by means of a suitable projector.

Another instance of image reproduction in accordance with the present invention involves the use of a recording member **35** which comprises electro-sensitive paper. Such material entirely eliminates the separate developing step because the visible image is formed directly in response to the presence of the latent electrostatic image.

These and other embodiments of the present invention will be obvious to those skilled in the art, and no limitation on the present invention is intended by the disclosure of specific embodiments. Accordingly, it is intended that the claims be interpreted broadly to encompass the disclosed embodiments of the present invention and all reasonable equivalents thereof.

What is claimed is:

1. Apparatus for forming an electrostatic charge pattern conforming to an optical image on a chargeable member including:

a corona discharge device disposed in charging relation to the chargeable member;

means, including,

an electrically conductive screen having a photoconductive layer thereon and

a source of electrical potential connected to said screen

to selectively prevent charging of the chargeable member when an optical image is focused on said photoconductive layer;

means to focus an optical image on said photoconductive layer; and,

means to energize said corona device when an optical image is focused on said photoconductive layer.

2. Apparatus for forming an electrostatic charge pattern conforming to an optical image on a chargeable member including:

a corona generator disposed in charging relation to the chargeable member;

a control means, including,

a copper mesh having a photoconductive selenium layer thereon, said copper mesh being substantially uniformly spaced from a surface of the chargeable member and

electrical bias means connected to said copper mesh

to selectively prevent deposition of electrical charge on a surface of the chargeable member when an optical image is focused on said selenium layer;

means to focus an optical image on said selenium layer; and,

a source of electrical potential to cause said corona generator to emit corona discharge when an optical image is focused on said photoconductive layer.

3. Apparatus for forming an electrostatic charge pattern conforming to an optical image on a chargeable member including:

a corona generator having one or more corona electrodes connected to a source of electrical potential;

electrically grounded means to support the chargeable member in charging position relative to said generator;

control means, including,

an electrically conductive screen coated with photoconductive material, and,

electrical bias means connected to said conductive screen,

positioned relative to the chargeable member to control the deposition of electrical charge on a surface thereof in response to an optical pattern; and

means to direct an optical pattern onto said control means to effect charge control response thereof.

4. Apparatus for forming an electrostatic charge pattern conforming to an optical image on a chargeable member including:

a corona generator;

a source of electrical potential to energize said corona generator;

electrically grounded means to support the chargeable member in charging position relative to said corona generator;

means including,

an electrically conductive screen substantially uniformly spaced from a surface of the chargeable member and having a photoconductive layer thereon, and,

electrical bias means connected to said screen to control accumulation of electrical charge from said corona generator on said surface of the chargeable member when an optical image is focused on said photoconductive layer; and,

means to project an optical image on said photoconductive layer.

5. Apparatus according to claim **4** wherein said conductive screen is positioned between said corona generator and the chargeable member.

6. Apparatus according to claim **4** wherein said corona generator is positioned between said conductive screen and the chargeable member.

7. Apparatus to reproduce an optical image on a transparent dielectric web comprising:

(a) an electrostatic image formation station comprising:

(1) a corona generating device positioned on one side of said web in charging relation thereto;

(2) a conductive screen at least one side of which is coated with a layer of photoconductive material, positioned between said corona generating device and said web to control the deposition of electrical charge on said web in response to an optical image;

(3) means to project an optical image conforming to an original to be copied through said web and onto said photoconductive layer;

(4) a source of high electrical potential connected to said corona generating device; and,

(5) means to electrically bias said screen;

(b) a xerographic developing station including means to apply resinous toner particles to the electrostatic image formed on said web at the aforesaid station to form a toner image conforming to said optical image;

(c) a toner image fusing station including means to expose said toner image to solvent fumes therefore; and,

(d) means to move successive portions of said web through said image formation station, said xerographic developing station and said toner image fusing station respectively.

8. In the process of xerography including forming an electrostatic latent image conforming to an optical image on a chargeable surface and developing said latent image to form a visible image, the improvement comprising:

raising to corona discharge potential a corona generator in charging relation to the chargeable surface, and, simultaneously therewith,

focusing the optical image onto a conductive control screen having a photoconductive layer thereon, said screen being positioned to selectively prevent charging of the chargeable surface in response to the optical image,

whereby the electrostatic latent image is formed directly on the chargeable surface.

9. The process according to claim **8** in which the conductive screen is electrically biased.

10. The process of claim **8** in which said photoconductive layer comprises selenium.

11. The process of claim **8** in which the optical image is focused onto said control screen by projection through said chargeable surface.

12. The process of claim **8** in which focusing the optical image onto said control screen includes reflecting said optical image from said chargeable surface.

13. Apparatus to reproduce an image on a thermoplastic dielectric member comprising:

(a) means to form an electrostatic image on said member comprising:

(1) a corona generating device;

(2) a light responsive control screen for selectively preventing the accumulation of electrical charge from said corona discharge device on said dielectric member;

(3) means to project an optical image on said control screen;

(4) means to apply an electrical potential to said control screen; and,

(5) a high voltage power supply to raise said corona generating device to a corona discharge potential; and,

(b) means to heat said thermoplastic dielectric member to render visible the electrostatic image formed on said member by the aforesaid means.

14. Apparatus to reproduce an image on a softenable dielectric member comprising:

(a) means to form an electrostatic latent image on said member comprising:

(1) a corona discharge device in operative proximity with an electrically grounded support surface;

(2) a light responsive control screen for selective prevention of charge accumulation on said softenable member positioned on said grounded support in accordance with an optical image;

(3) means to project an optical image on said control screen;

(4) means to electrically bias said screen; and,

(5) a source of electrical potential connected to said corona discharge device to apply a corona discharge potential to said device; and,

(b) means to soften said softenable member after said electrostatic image has been formed thereon.

15. The apparatus according to claim **14** in which said means to soften said softenable member comprises an electrical heating element.

16. The apparatus according to claim **14** in which said means to soften said softenable member comprises a chamber containing solvent vapor for said softenable member.

17. An improved corona generator for use in xerography, including:

at least one corona discharge electrode;

an electrically conductive shield partly surrounding said electrode; and,

control means, including,

an electrically conductive screen coated with photoconductive material, and

electrical bias means connected to said conductive screen,

which control means is positioned to selectively prevent, in response to an optical image projected thereon, deposition of electrostatic charge on a chargeable surface held in charging relation to said electrode.

18. A generator according to claim **17** in which said photoconductive material comprises selenium.

19. An improved corotron comprising:

a corona discharge electrode;

an apertured electrically conductive shield partly surrounding said electrode and forming a longitudinal channel oriented to permit ions from said electrode to be emitted therethrough, said shield comprising an electrically conductive screen coated with photoconductive material.

20. A corotron according to claim **19** with an additional element including means to apply an electrical potential to said conductive screen.

No references cited.

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