Feb. 28, 1967 L. F. BEAN 3,307,034

TWO-WIRE CORONA DISCHARGE SYSTEM FOR SINGLE-STEP ELECTROSTATIC IMAGE FORMATION

Filed Dec. 9, 1963 2 Sheets-Sheet 1

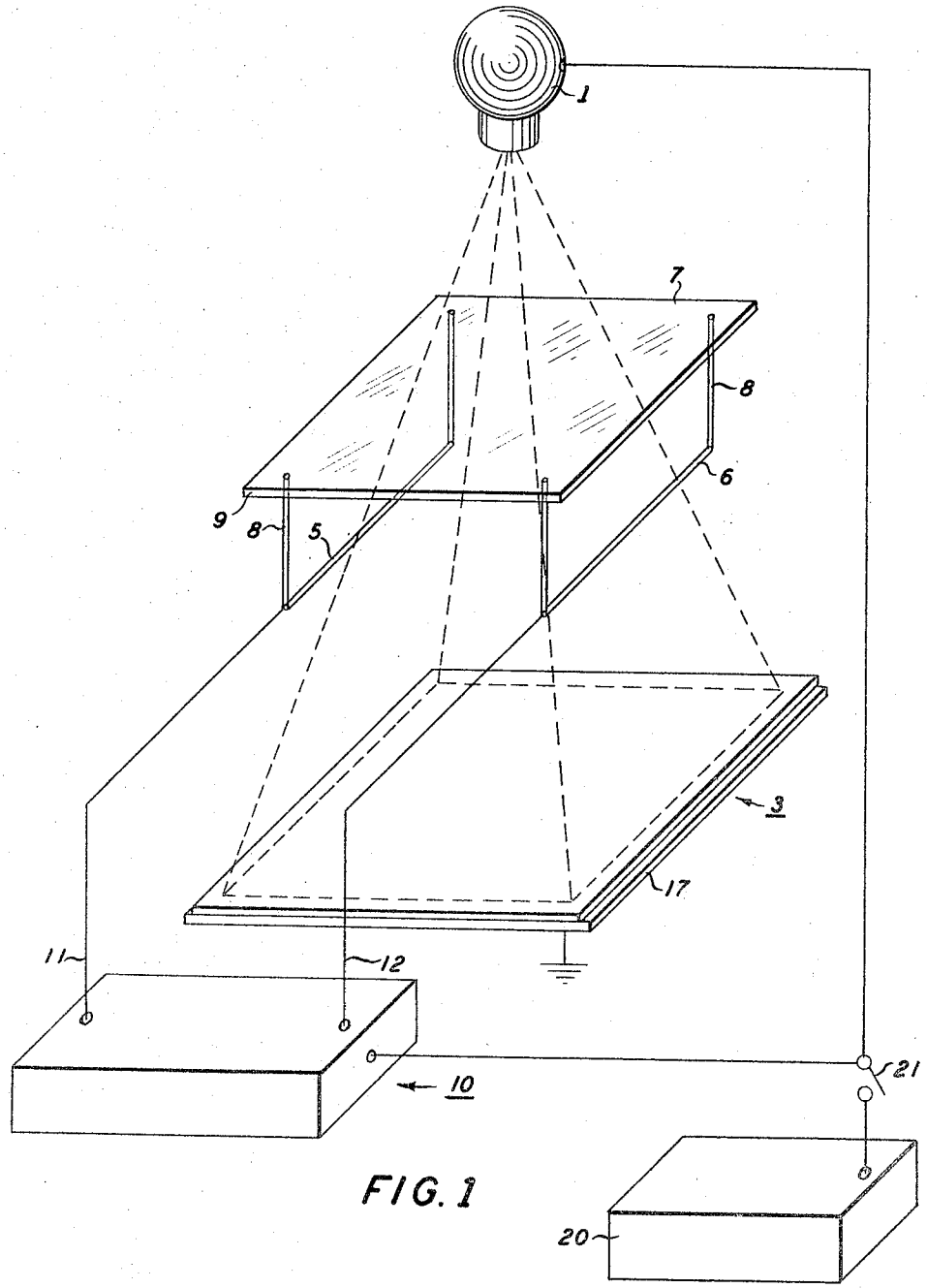


FIG. 1

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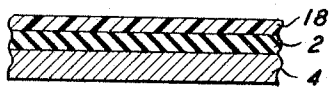


FIG. 2

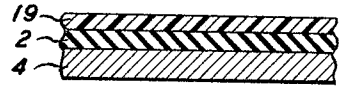


FIG. 3

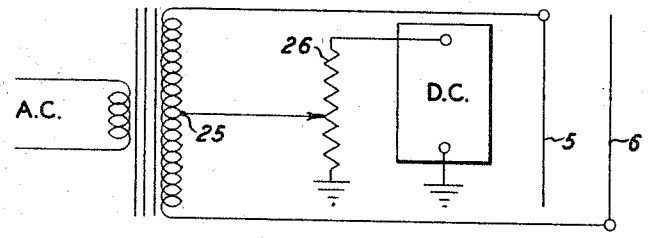


FIG. 4

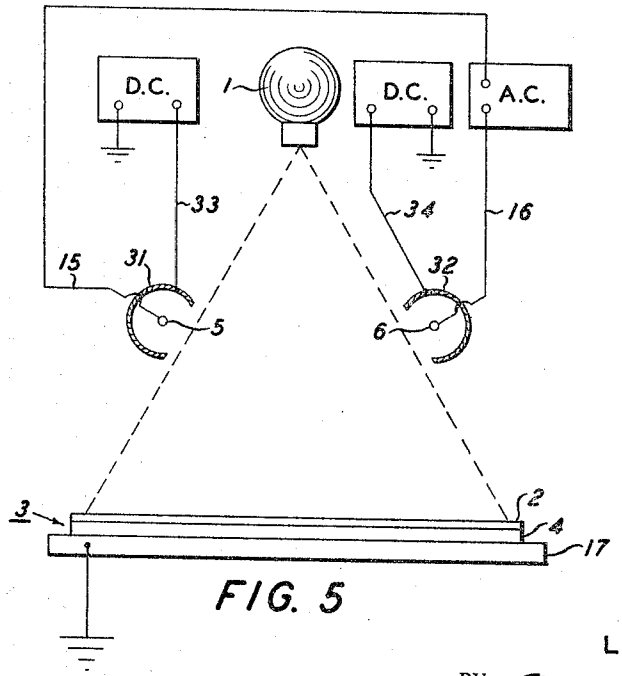


FIG. 5

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3,307,034

TWO-WIRE CORONA DISCHARGE SYSTEM FOR SINGLE-STEP ELECTROSTATIC IMAGE FORMATION

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4 Claims. (Cl. 250—49.5)

This invention relates to improvements in apparatus and methods for electrostatically charging a chargeable member, and is especially useful in the field of xerography for the formation of a developable electrostatic charge pattern on a xerographic plate.

In xerography, a visible reproduction of an optical image may be made by forming and developing an electrostatic charge pattern on a xerographic plate. Generally, formation of the developable electrostatic charge pattern is a two-step process: a uniform electrostatic charge is applied in darkness to a xerographic plate, and then the plate is selectively discharged by exposure to the optical image.

Various developing techniques are known to those skilled in the art of xerography. For example, electroscopic resinous powder may be applied to the charge pattern to form a toner image, or, if suitable materials are used, the image member itself may be deformed under the influence of the electrostatic charge pattern to produce a visible frost-like replica of the optical image.

In commercially available equipment, the first step of uniformly charging the xerographic plate is typically accomplished by means of a corona generator comprising one or more conductive strands partly surrounded by an electrically grounded conductive shield. By raising the conductive strands to a sufficiently high electrical potential, the corona generator is made to deposit electrostatic charge on a closely-positioned xerographic plate. Because the charging effectiveness of the conductive strands is limited to a relatively small area of the xerographic plate, uniform charging of the plate generally requires moving the plate relative to the corona generator at a pre-determined speed. Corona generators for use in apparatus designed for relative movement between the corona generator and plate are disclosed, for example, in U.S. Patent No. 2,777,957 and U.S. Patent No. 2,836,725.

Relative movement between plate and corona generator may be avoided through the use of an "in-place-charging" device comprising, for example, a plurality of conductive strands positioned in a plane parallel to the plate. When raised to a high electrical potential, this array of conductive strands emits corona sufficient, if enough strands are used, to charge the entire plate surface.

For in-place charging a device of the type described in U.S. Patent No. 2,932,742 may be employed. However, such device is preferably used with an additional wire array functioning as a control electrode to prevent overcharging of the xerographic plate. Overcharging is an important consideration, since it is likely to permanently reduce the charge retention capability of the photoconductive layer.

This consideration has been effectively met by the charging apparatus disclosed in U.S. Patent No. 3,076,092. That apparatus comprises two or more substantially parallel corona electrodes arranged so that adjacent electrodes are connected to opposite terminals of an alternating current power supply. A direct current "bias" is also connected to the alternating current whereby corona emission is controlled by and made a function of the D.C. bias potential.

However, although the apparatus of U.S. Patent No. 3,076,092 effectively prevents overcharging, it does not

eliminate the above-stated second step in forming the developable electrostatic image. This step typically consists of selectively discharging the uniformly charged plate by exposing it to an optical image. The electrical resistivity of the photoconductive layer is significantly lowered where light impinges on it, and the resultant reduction of electrical charge in light-struck areas produces a latent electrostatic charge pattern in the form of discrete areas of charge and substantially no charge.

The present invention is an improvement on the charging apparatus disclosed in the aforementioned U.S. Patent No. 3,076,092, and teaches a novel modification thereof usable for single-step electrostatic image formation that does not require relative motion between the xerographic plate and corona generator.

Heretofore, attempts to combine the uniform charging and exposure steps in xerography have met with limited success. Because charging devices known to the art must be positioned relatively close to the plate, the electrodes have been found to interfere with the projected optical image when single-step electrostatic image formation is attempted by merely exposing and charging the plate simultaneously. It has been proposed to minimize the effect of shadows produced by the closely spaced electrodes by various mechanical means such as vibrating or agitating the electrodes during exposure. In addition to requiring additional equipment, this approach is obviously cumbersome. The use of "point source" corona electrodes has also been proposed, but these electrodes are effective over relatively small areas and require an unsatisfactorily high power input.

In addition to the shadows referred to above, use of "in-place-charging" devices having heretofore known electrode configurations have been known to produce developed images characterized by striations which detract from image quality.

Accordingly, apparatus for the rapid and economical formation of electrostatic charge patterns which can be used to produce striation-free developed images is an object of this invention.

Another objective of this invention is an improved charging apparatus that includes electrodes connected to opposite A.C. poles and biased by a D.C. potential, and an optical image projector for forming developable electrostatic image in a single step for use in xerography.

Additional objects include, among others: improved apparatus for "in-place-charging" for use in xerography; and, apparatus for directly forming an electrostatic charge pattern on a chargeable surface by the combined action of an optical image and corona emission.

In accordance with the present invention, an electrostatic charge pattern which can be used to produce high quality striation-free developed images may be formed on a xerographic plate in a single step. The desired result is achieved by projecting an optical image onto the xerographic plate while at the same time energizing a corona generating device comprising two electrodes connected to opposite terminals of an alternating current power supply. The electrodes are also connected to a direct-current power source which controls corona generation and determines the polarity of the charge emitted. As described herein in greater detail, proper positioning of the two electrodes relative to a conductive shield, to the xerographic plate, and to each other, determines the quality of results achieved. These variables are suitably coordinated in the present invention to achieve the above-stated objects as well as others that will be apparent to those skilled in the art.

The present invention is described in connection with the accompanying drawing, in which:

FIG. 1 is a schematic illustration of image formation apparatus according to the present invention;

FIGS. 2 and 3 illustrate xerographic plates usable with this invention;

FIG. 4 is an electrical diagram of xerographic charging apparatus; and,

FIG. 5 is an alternate embodiment of this invention.

As shown in FIG. 1, the present invention includes means to focus an optical image on a xerographic plate on which a charge pattern is to be formed. In the illustrated embodiment, such means are represented by projector **1** which is adapted to project an optical image on xerographic plate **3** positioned on grounded support member **17** in charging relation with corona electrodes **5** and **6**. Electrodes **5** and **6** are positioned at a predetermined distance from transparent screen **7**, for example, by suspension between insulator brackets **8** depending from screen **7**. Electrical leads **11** and **12** connect electrodes **5** and **6**, respectively, to corona power supply **10**. Although the location of electrodes **5** and **6** with respect to other elements of the apparatus will be described in greater detail, it may be noted that the electrodes are outside the cone of illumination emanating from projector **1**.

With the elements arranged as shown in FIG. 1, electrodes **5** and **6** may be raised to corona discharge potential while an unobstructed optical image is at the same time projected onto xerographic plate **3**. Synchronizing means are provided so that the energizing of electrodes **5** and **6** may be conveniently limited to coincide with the projection of an optical image on the xerographic plate. In the illustrated embodiment, projector **1** and corona supply power **10** are energized by the same alternating current source **20** through switch **21**, thereby permitting the charging and the projection elements to be operated simultaneously. Simultaneous operation is not essential, however, and, if desired, the elements may be energized sequentially.

Corona electrodes **5** and **6** comprise fine electrically conductive strands of substantially uniform cross-section. Steel wire having a diameter of 2.0 mil, which reaches corona threshold at approximately 3,000 volts, has been found suitable, but a reasonably wide range of wire sizes is permissible. Corona electrodes **5** and **6** are preferably positioned so that they are substantially parallel to a xerographic plate **3** placed in charging position. The electrodes are also substantially parallel to each other and to transparent shield **7**. Insulator brackets **8** are suitable for properly positioning the electrodes by means, for example, of electrically conductive threaded fittings which hold the electrodes in place and also couple them to electrical leads **11** and **12**. Accordingly, brackets **8** may comprise Bakelite or other suitable non-conductive, sufficiently rigid material, such as plastic or the like.

Shield **7** suitably comprises glass or other transparent material and, in the illustrated embodiment, incorporates a transparent electrically conductive layer **9** of, for example, tin oxide. However, if material which is itself electrically conductive is used for shield **7**, the separate conductive layer **9** may be dispensed with.

Xerographic plate **3** may be of any one of the many combinations of materials knowns to the art incorporating, generally, a photoconductive layer and a relatively conductive support, and, as described in numerous patents, periodicals and books, certain of these plates also incorporate one or more additional insulating layers or interlayers. It has been found that the simultaneous charge-exposure mode of the present invention is most suitably employed in xerographic techniques commonly associated with storage of electrostatic charge at a plate interface rather than with techniques involving substantially complete discharge through the relatively conductive support member. Accordingly, formation of toner developable electrostatic charge patterns on xerographic plates having an insulating overcoating is a typical application of the present invention, as is the formation of electrostatic charge patterns in conjunction with deformation development of the image member itself.

For example, FIG. 2 illustrates a xerographic plate particularly suitable for the formation of toner developable electrostatic charge patterns by means of the present invention. Plate **3** comprises conductive backing **4**, of aluminum or any similarly suitable conductive material, photoconductive layer **2**, and insulating film **18**. Such plate plate may be of the kind described in U.S. Patent No. 2,860,048 or any of its various equivalents known to the art.

Using properly selected developer materials, electrostatic charge patterns formed on xerographic plates incorporating an insulating film are also developable in the presence of ambient illumination. This technique is disclosed and more fully explained in co-pending application Serial No. 101,880.

FIG. 3 schematically illustrates a xerographic plate usable for deformation development of the electrostatic charge pattern. As there shown, photoconductive layer **2** of, vitreous selenium, or the like, overlies conductive backing **4**. Deformable layer **19** may comprise Staybelite, a partially hydrogenated rosin ester, or like material, which is characterized as normally solid and electrically insulating, but which may be temporarily softened by the application of heat, solvent vapors, or the like.

The present invention is by no means limited to applications associated with charge storage. Thus, xerographic plate **3** need not incorporate an overcoat layer or a deformable layer, but may comprise a photoconductive layer overlying a conductive backing. An electrostatic charge pattern formed on such plate may be developed by applying an electroscopic powder to form a visible powder image as is well-known to the art.

A schematic electrical diagram of the charging apparatus is given in FIG. 4. Line voltage alternating current which may conveniently be 110 volts, 60 cycles is shown connected to the primary side of step-up transformer **23**. High voltage alternating current is supplied to corona electrodes **5** and **6** from opposite terminals of the secondary windings through electrical leads **11** and **12** to produce corona discharge when the corona threshold is exceeded.

A direct current bias potential is connected to the alternating current at the secondary winding by means of a center tap **25**. The bias potential may be of either polarity, as desired. A properly selected bias has the effect of energizing the electrodes in phase shifting relation whereby corona of one predetermined polarity is emitted from both electrodes during alternate half cycles.

A high degree of flexibility is readily attainable by means of the described D.C. biased power supply, as more fully explained in U.S. Patent No. 3,076,092 referred to above. As explained therein, the characteristics of the corona emission are essentially a function of the bias so that accuracy of control is inherent and overcharging of the xerographic plate is readily prevented.

According to the present invention the proper spacing of various elements is essential to the formation of electrostatic charge patterns that will produce striation-free developed prints. Best results are achieved when the distance between corona electrodes is approximately equal to the distance between the electrodes and the xerographic plate. The following table shows the preferred range of electrode plate spacing for particular electrode spacing:

Distance between electrodes (in.):	Distance from plate to electrodes (in.)
1	¾–1
2	1¾–2¼
8	6½–8½

It has been found that an electrostatic image may be conveniently formed on a xerographic plate measuring approximately nine by fourteen inches by means of apparatus having electrodes spaced eight inches from each

other, and 6½ inches from the plate. This arrangement allows considerable flexibility regarding selection of a projection unit. The electrodes are positioned with ample space between them for unobstructed projection of an optical image. Although developable electrostatic images may be formed with a smaller distance between plate and electrodes, it has been found that print quality is impaired. Striations become noticeable when an eight inch spacing between electrodes is matched with a plate to electrode distance of less than 6½ inches.

As known to the art, the charging effectiveness of a corona electrode is also a function of its distance from a conductive shield and the electrical potential applied to the shield. In the given arrangement, therefore, electrode-to-shield spacing may be varied to suit the particular application. For instance, if shield **7** is grounded, it is preferably spaced about 4 inches from the electrodes. However, if a D.C. potential of 10,000 volts is applied to the shield instead, the spacing may be reduced to 2 inches without deleterious effect. Thus, an applied D.C. potential may be optionally applied to the screen for purposes of reducing the over-all dimensions of the apparatus, as illustrated in FIG. 3.

FIG. 5 schematically illustrates an embodiment of the present invention in which more closely positioned separate conductivbe shields partly surround the electrodes. Because of the closer positioning of the shields, an electrical potential is applied thereto for practical operation of the apparatus. It is also noted that the shields need not be transparent since they can be positioned outside the cone of illumination from the optical image projector.

Electrodes **5** and **6** of FIG. 5 are fitted with leads **15** and **16** for connecting them to opposite poles of an A.C. power source as described in connection with FIGS. 1 and 4. The electrodes are positioned so that the optical image projected by projector **1** onto photoconductive layer **2** of xerographic plate **3** will not be obstructed. Preferably, the distance between electrodes is approximately equal to the distance from the electrodes to the xerographic plate, and the eletcrodes should be substantially parallel to, and equidistant from, the plate.

Electrically conductive shields **31** and **32** are connected to D.C. power sources by means of leads **33** and **34**. The two power sources should apply the same potential to each shield, or, if desired, a single power source adapted to apply a potential of the same polarity to both shields may be employed.

As described in connection with FIG. 1, the embodiment of FIG. 3 may be used for the single-step formation of a latent electrostatic image. By raising electrodes **5** and **6** to corona discharge potential while photoconductive layer **2** is under the influence of an optical image projected from projector **1**, xerographic plate **3** will be charged in accordance with such optical image. Well-known xerographic developing techniques may then be employed to produce a striation free visible toner image on the plate.

Since the charging unit used herein is self-limiting, as described in U.S. Patent No. 3,076,092, the present invention makes practicable full-frame charge pattern formation without danger of damage to the xerographic plate.

Only two electrodes are required, and the need for equipment ordinarily used to impart relative movement between the corona generator and xerographic plate is dispensed with.

Description of the present invention in terms of specific embodiments is not intended by way of limitation. Rather, it is intended that the appended claims be interpreted broadly to give full scope to the present invention and encompass the described embodiments and all reasonably equivalents thereof.

What is claimed is:

1. Apparatus for electrostatically charging a xerographic plate in accordance with an optical image, including:

(a) two substantially parallel corona discharge electrodes positioned substantially parallel to and in charging relation with a xerographic plate, the distance between said electrodes and said plate being from about 0.81 to about 1.05 times the distance between said electrodes;

(b) electrically conductive shielding means for said electrodes adjacent said electrodes and substantially parallel thereto;

(c) a high voltage alternating current power source for raising said electrodes to corona discharge potential;

(d) control means including means to apply a predetermined direct current potential to said power source;

(e) projector means positioned to focus an optical image substantially unobstructed by said electrodes and said shielding means onto the xerographic plate; and

(f) means to energize said alternating current power source while said optical image is focused onto said surface.

2. The apparatus of claim **1** wherein said shielding means includes a single transparent electrically conductive member positioned between said projector means and said electrodes.

3. The apparatus of claim **1** wherein said shielding means includes electrically conductive members partly surrounding each of said electrodes.

4. The apparatus of claim **1** wherein the space between said electrodes is about 8 inches and the space between said electrodes and said plate is in the range of about 6½ to 8½ inches.

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