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[72] Inventor **Yasuo Tamai**
Asaka-shi, Japan

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[73] Assignees **Xerox Corporation**
Rochester, N.Y.

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[31] **43-1832 and 43-2463**

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[54] **IMAGING SYSTEM UTILIZING AN ELECTRODE TREATED WITH A MIXTURE OF A HYGROSCOPIC MATERIAL AND A HYDROPHILIC BINDER**
15 Claims, 3 Drawing Figs.

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[51] **Int. Cl.** **H01j 1/14**
[50] **Field of Search** ..... 313/355, 313, 353, 357; 250/49.5 GC, 49.5 ZC, 49.5 TC; 117/230, 224, 93; 204/323; 29/25.14, 25.17

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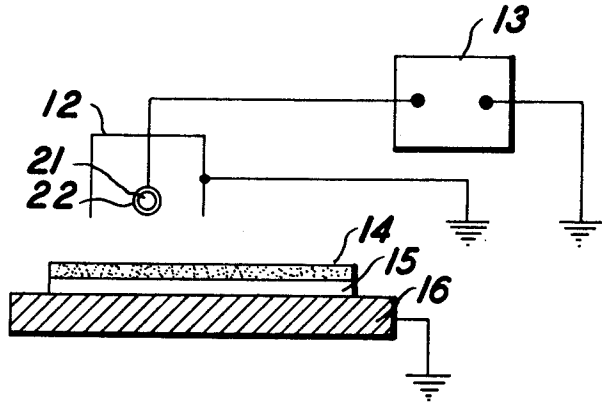
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Primary Examiner—James W. Lawrence
Assistant Examiner—P. C. Nelms
Attorneys—James J. Ralabate, Albert A. Mahassie and Peter H. Kondo

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ABSTRACT: A corona discharge system comprising a filament treated with a hygroscopic material or a mixture of a hygroscopic material and a hydrophilic binder is employed for charging electrophotographic imaging surfaces.



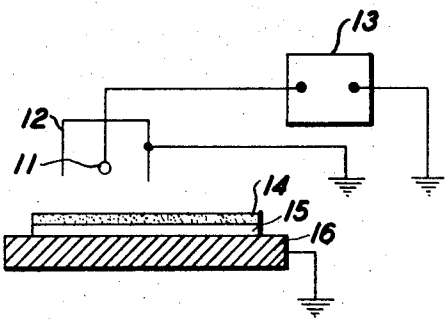


FIG. 1

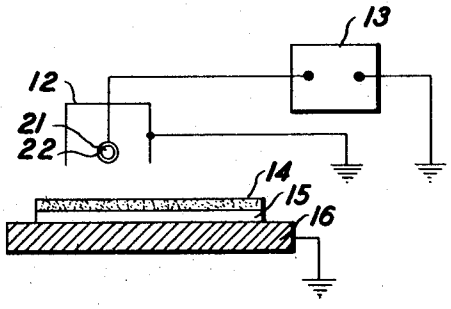


FIG. 2

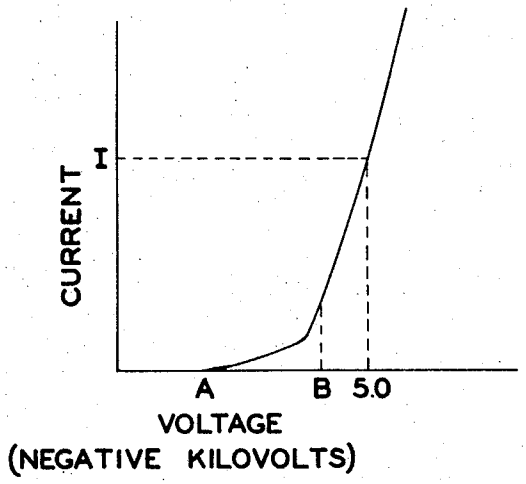


FIG. 3

INVENTOR.
YASUO TAMAI
BY
ATTORNEY

IMAGING SYSTEM UTILIZING AN ELECTRODE TREATED WITH A MIXTURE OF A HYGROSCOPIC MATERIAL AND A HYDROPHILIC BINDER

BACKGROUND OF THE INVENTION

This invention relates to imaging systems, and more particularly, to an improved system for electrically charging an insulating layer.

The formation and development of images on the surface of photoconductive materials by electrostatic means is well known. One conventional process involves placing a uniform electrostatic charge on a photoconductive insulating layer comprising zinc oxide powder and a resinous binder carried on a conductive paper substrate, exposing the layer to a light-and-shadow image to dissipate the charge in the areas of the layer exposed to the light and developing the resulting electrostatic latent image by depositing on the image charged toner particles. The charged toner particles may be suitably colored and may have a polarity of charge identical or opposite to that of the latent image to be developed.

Generally, the uniform electrostatic charge is formed on the photoconductive insulating layer by means of corona discharge. The corona discharge device normally comprises an ion-producing source, such as one or more filaments or needles adjacent to but spaced from a photoconductive insulating layer backed by a conductive plate. When a sufficiently high voltage is applied between the ion-producing source and the plate backing, the air between the ion-producing source and the plate backing becomes ionized and allows an electric charge to be deposited on the photoconductive insulating layer surface. The ion-producing source generally employed in conventional corona discharge devices consist of at least one fine filament made of metal such as stainless steel or molybdenum.

Although many advantages are derived from the use of metal filaments in corona discharge devices, difficulties are encountered because the fine metallic filaments are very fragile and are frequently broken during installation or use. Further, these metal filaments are expensive, easily bent and require considerable time to install in the corona discharge device. In addition, exceptionally high voltages are required in order to adequately charge photoreceptor surfaces with metal wire corona discharge devices. For example, it is customary to employ a voltage in the order of minus 7,000 to minus 8,000 volts to a stainless steel wire having a diameter of about 0.1 millimeter to adequately provide a negatively charged surface to a photoreceptor. This relatively high potential is necessary to insure the formation of an adequate discharge current from the filament or wire to the photoreceptor surface. If a photoreceptor surface is not charged to a sufficient potential, the electrostatic latent image obtained upon exposure will be relatively weak and the resulting deposit of electrostatically attractable material, such as a powder, during development of the image will be small. However, if the photoreceptor surface is overcharged, other difficulties are encountered. One serious result of overcharging is the permanent damage to the photoreceptor surface by the creation of small spots or areas on the plate which are so altered that they are not thereafter capable of holding a charge even after recharging the plate. Hence, the applied potential must be sufficiently above the corona threshold potential to provide enough corona current to adequately charge the photoreceptor surface and yet remain below the potential which will cause electrical breakdown of the photoreceptor layer. Thus, there is a continuing need for an improved imaging system.

SUMMARY OF THE INVENTION

It is therefore, an object of this invention to provide an imaging system overcoming the above-noted deficiencies.

It is another object of this invention to provide a means to impart an electric charge to a surface with reduced applied potential.

It is a further object of this invention to provide a means for more rapidly charging an insulating surface.

It is still another object of this invention to provide a charging means which avoids electrical breakdown of insulating surfaces during charging.

It is another object of this invention to provide a more durable corona discharge electrode.

It is a further object of this invention to provide an imaging system superior to those of known systems.

The above objects and others are accomplished by providing a system utilizing a corona discharge electrode comprising a filament treated with a hygroscopic material or a mixture of a hygroscopic material and a hydrophilic high molecular weight material.

Any suitable synthetic or natural filamentlike material may be employed in the core of the corona discharge electrode of this invention. Typical filament materials include cotton yarn, silk yarn, rayon yarn, nylon-cotton yarn, stainless steel, molybdenum and the like. The filaments may be of any suitable configuration and may comprise, for example, a monofilament or a plurality of monofilaments or fibers twisted or braided together. A filament core diameter of about 0.1 millimeter is preferred for maximum strength and optimum corona discharge characteristics. However, smaller diameter filaments can be used at lower voltage potentials and similarly, larger diameter filaments can be used at higher voltage potentials. Satisfactory results are obtained with filament diameters less than about 0.25 millimeters. Since the corona potential necessary to produce the required corona current increases with an increase in filament diameter, the filament diameter should be less than that diameter at which arcing would occur.

Any suitable hygroscopic material may be employed to treat the electrode core of this invention. Typical hygroscopic materials include deliquescent compounds such as lithium chloride, iron chloride, magnesium chloride, phosphorus pentoxide, calcium chloride, zinc chloride and caustic alkalis as well as glycerine, silica gel, active alumina and mixtures thereof. All of these hygroscopic materials readily take up and retain moisture from the atmosphere.

Any suitable organic hydrophilic high molecular weight material may be employed with the hygroscopic material of this invention. Typical hydrophilic high molecular weight materials include gelatin, casein, egg albumin, starch polyvinyl alcohol, polyvinylbenzene potassium sulfonate, polyvinylbenzene sodium sulfonate, copolymers of maleic anhydride and a vinyl monomer such as maleic anhydride-vinylmethylether copolymer, arginic acid, pectins, dextran, sodium alginate, water soluble polyamide resins, polyvinyl pyrrolidone, carboxymethylcellulose, polyethyleneimine propionic acid, copolymers of maleic acid and a vinyl monomer, polyacrylic acid, polymethacrylic acid, salts and partial esters of acidic high molecular weight material, partial amides, quarternary amines such as poly (vinylbenzyltrimethyl ammonium chloride) poly N-N-dimethyl-N-benzylamine-ethyl-acrylate chloride) and mixtures thereof. As is well known, hydrophilic compounds and mixtures are characterized by strong affinity for water and are readily wetted when contacted with water. The organic hydrophilic materials employed in the treating mixtures of this invention should possess a molecular weight sufficient to allow the material to behave as binders in order to provide optimum durability and corona discharge characteristics.

Various additives may be employed in the filament treating mixtures to increase or otherwise enhance the hygroscopic properties thereof and include, for example, additional hygroscopic inorganic salts, conventional antistatic agents, surfactants, polyhydric alcohols, glycerol, pentaerythritol, mannitol, trimethylol propane, polyethylene glycol and mixtures thereof. Considerable latitude exists as to the thickness of the ultimate coating of treating material on the filament core. Satisfactory results are obtained with coating thicknesses of from about 0.5 micron to about 200 microns. Generally, smaller diameter electrodes can be used at lower voltage potentials and larger diameter electrodes can be used at higher voltage potentials.

When the filament cores are metallic, improved corona discharge characteristics are achieved even if the treating mixture does not contain the hydrophilic high molecular weight component. Thus, for example, increased corona current at reduced potentials are obtained with a filament core which is merely dipped in an aqueous solution of a hygroscopic metal slat such as lithium chloride. However, greater stability and durability are achieved when the hygroscopic materials are admixed with the hydrophilic binder material.

In general, corona charging may be accomplished in a variety of ways in accordance with the requirements of a particular application. For example, a corona discharge device may comprise a single filament or series of parallel filaments that are fed from a high-voltage source, relative to which a photoreceptor surface may be moved at a uniform rate of speed to place an electrostatic charge thereon. Conversely, the photoreceptor surface may be held stationary and the corona discharge unit may be moved relative to the surface to deposit a charge thereon. In other devices, it is expedient to hold both the photoreceptor surface and the discharge device stationary during the charging operation. For some applications, it may be desirable to employ the treated filaments of this invention in corona electrodes in the form of pointed needles. In one embodiment, a row of these pointed needles may be arranged perpendicular to the surface to be charged and provided with an insulating support and means to connect the needles to a high-voltage source.

BRIEF DESCRIPTION OF THE DRAWINGS

The advantages of the improved imaging system of this invention will become even further apparent upon consideration of the following disclosure of the invention, particularly when taken in conjunction with the accompanying drawings wherein:

FIG. 1 is a schematic sectional view of an electrophotographic imaging apparatus illustrating a conventional corona discharge system.

FIG. 2 is a schematic sectional view of an electrophotographic imaging system employing an embodiment of the corona discharge electrode of this invention.

FIG. 3 is a graph illustrating the contrast between measured results obtained in charging photoconductive insulators with conventional electrodes and with electrodes of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIGURE 1, reference character 11 is a fine conductive corona discharge wire which is stretched within a conductive housing 12. A sufficient electrical potential supplied from a high-voltage DC power supply 13 is applied to conductive wire 11. The corona discharge produced by conductive wire 11 results in the deposition of an electrical charge on photoreceptor layer 14. Photoreceptor layer 14 is secured to a conductive backing layer 15 which is in turn supported by a conductive plate 16 during charging. As is well known in the art, the corona threshold at which corona discharge occurs is generally in the order of about minus 4,000 volts when a metallic wire is employed for negative charging. However, a potential in excess of the corona threshold potential is necessary in order to achieve a corona current which will adequately provide the level of charge necessary for satisfactory development. Where conductive wire 11 consists of a stainless steel wire having a diameter of about 0.1 millimeter, a voltage in the order of about minus 7,000 volts to about minus 8,000 volts is normally required to adequately charge the surface of photoreceptor layer 14.

In FIG. 2, a fine metallic corona discharge wire core 21 is coated with a layer 22 comprising a treating mixture of this invention. This coated wire is connected to a source of high potential 13 in the same manner as conductive wire 11 illustrated in FIG. 1. Comparative data illustrating the improvement in performance achieved with the treated wire core 21 is presented in the examples below.

The following examples further define, describe and compare preferred methods and materials of the present invention. Parts and percentages are by weight unless otherwise indicated.

EXAMPLE I

A corona charging device is positioned over a conductive metal plate according to the arrangement illustrated in FIG. 1. The corona wire is a stainless steel filament having a diameter of about 0.1 millimeter. The wire is spaced about 1.5 centimeters from the metal plate. The surface of the corona wire is wiped clean with a cloth impregnated with xylene and thereafter dried. The voltage applied to this wire is increased incrementally while the electric current flowing between the wire and the metal plate is concurrently measured. The voltage at which a corona current is initially measurable is shown at A in the graph of FIG. 3. The threshold voltage at B is obtained by extrapolation of the voltage-current data. The value of the electric current I flowing between the corona discharge wire and the metal plate at an applied potential of about minus 5,000 volts is also measured. It is found that for the clean untreated stainless steel wire described above, the potential at which a corona current is initially measurable A is about minus 3,100 volts, the threshold potential B is about minus 4,500 volts and the corona current I at an applied potential of about minus 5,000 volts is about 30 microamperes.

EXAMPLE II

The corona wire of Example I is coated with a 10 percent toluene solution of polyvinyl acetate which upon drying at room temperature has a thickness of about 20 microns. It is found that when the coated stainless steel wire is tested in the manner described in Example I, the potential at which a corona current is initially measurable A is about minus 2,950 volts, the threshold potential B is about minus 4,100 volts and the corona current I at an applied potential of about minus 5,000 volts is about 65 microamperes. However, upon repeated use, the performance of the coated wire degrades rapidly and upon reaching the fourth test cycle, the performance of the wire is substantially the same as the results obtained with the untreated wire described in Example I.

EXAMPLE III

Another corona wire substantially identical to the wire described in Example I is coated with a solution containing about 20 grams polyvinylbenzene potassium sulfonate, about 0.05 grams surfactant and sufficient water to increase the total weight of the solution to about 100 grams. The thickness of the coating upon drying at room temperature is about 30 microns. When tested in the manner described in Example I, it is found that the potential at which a corona current is initially measurable A is about minus 1,450 volts, the threshold potential B is about minus 4,400 volts and the corona current I at an applied potential of about minus 5,000 volts is about 29 microamperes. However, the performance values obtained from the wire in the fifth cycle is substantially the same as the values obtained in Example I.

EXAMPLE IV

A stainless steel corona wire substantially identical to the wire described in Example I is coated with a 15 percent aqueous solution of lithium chloride. It is found that when this coated stainless steel wire is dried and thereafter tested in the manner described in Example I, the potential at which a corona current is initially measurable is about minus 2,700 volts, the threshold potential B is about minus 4,350 volts and the corona current I at an applied potential of about minus 5,000 volts is about 36 microamperes. The performance values obtained with this coated wire are satisfactorily reproducible through numerous test cycles.

EXAMPLE V

A stainless steel corona wire substantially identical to the wire described in Example I is coated with a solution containing about 20 grams maleic anhydride-vinylmethylether copolymer, about 20 grams glycerine, about 10 grams lithium chloride, about 0.05 gram surfactant, about 20 grams acetone, and sufficient water to adjust the solution to a total weight of about 200 grams. It is found that when this coated stainless steel wire is tested in the manner described in Example I, the potential at which a corona current is initially measurable A is about minus 2,200 volts, the threshold potential B is about minus 3,500 volts and the corona current I at an applied potential of about minus 5,000 volts is about 73 microamperes. These numerical values remained substantially unchanged even after many repeated test cycles. Satisfactory charging of photosensitive zinc oxide layer is achieved with this treated wire.

EXAMPLE VI

A corona wire is treated with a solution containing about 20 grams polyvinyl alcohol, about 20 grams glycerine, about 5 grams maleic anhydride-vinylmethyl ether copolymer, about 5 grams lithium chloride and sufficient water to bring the total weight of the mixture to about 100 grams. Satisfactory charging of a photosensitive zinc oxide binder layer is achieved with this treated wire.

EXAMPLE VII

A corona electrode is coated with a mixture containing about 10 grams polyvinylbenzene sulfonic acid, about 10 grams glycerine, about 3 grams silica gel and sufficient water to form a mixture weighing about 100 grams. A photosensitive cadmium sulfide layer is satisfactorily charged with this electrode.

EXAMPLE VIII

A corona electrode is coated with a solution containing about 2 grams of a conductive polymer (Conductive Polymer 261, available from Calgon Corporation), about 8 grams polyvinyl alcohol and sufficient water to bring the total quantity of the mixture to about 50 grams. Satisfactory charging of a photosensitive zinc oxide layer is achieved with this electrode.

EXAMPLE IX

A silk yarn is dipped in a treating solution containing about 20 grams vinylmethylether-maleic anhydride copolymer, about 20 grams glycerine, about 10 grams lithium chloride, about 0.1 gram surfactant, about 35 grams acetone and sufficient water to adjust the total weight of the mixture to about 200 grams. Upon removal from the solution, the treated thread is dried at room temperature. The treated thread is cut to a length of about 35.7 centimeters and placed in a corona discharge device similar to that illustrated in FIG. I. The spacing between the treated thread and the metal plate is about 1.5 centimeters. It is found that when the treated thread is tested in the manner described in Example I, the potential at which a corona current is initially measurable A is about minus 2,000 volts, the threshold potential B is about minus 4,400 volts and the corona current I at an applied potential of about minus 5,000 volts is about 20 microamperes. When a paper sheet coated with a zinc oxide binder layer is charged in the dark with this treated corona discharge wire, the zinc oxide binder layer acquires a surface potential of about minus 320 volts.

EXAMPLE X

The procedure described in Example IX is repeated with a cotton yarn substituted for the silk yarn. Results similar to that obtained with the silk yarn of Example IX is obtained when the treated cotton yarn is tested in the manner described in Example IX.

EXAMPLE XI

A silk yarn is treated with a solution containing about 20 grams polyvinyl alcohol, about 20 grams glycerine, about 5 grams lithium chloride and sufficient water to adjust the total quantity of the mixture to about 150 grams. Satisfactory results are obtained when this treated yarn is tested in the manner described in Example IX.

EXAMPLE XII

A silk yarn is treated with a mixture containing about 10 grams polyvinylbenzene potassium sulfonate, about 10 grams glycerine, about 3 grams of a 20 percent aqueous dispersion of silica gel and sufficient water to bring the total weight of the mixture to about 100 grams. Satisfactory charging is achieved when this corona electrode is tested in the manner described in Example IX.

The imaging technique of this invention, as may be clearly understood from the foregoing description, provides a more durable corona discharge electrode which allows a photoreceptor surface to be charged at an increased rate with reduced applied potentials. This improvement is realized by treating a filament with a hygroscopic material or a mixture of a hygroscopic material and a hydrophilic high molecular weight material.

Although specific materials and conditions are set forth in the foregoing examples, these are merely intended as illustrations of the present invention. Various other suitable hygroscopic materials, hydrophilic high molecular weight materials and filament core materials such as those listed above may be substituted for those in the examples with similar results. Other materials may also be added to the treating mixture or filament to sensitize, synergize or otherwise improve the imaging properties or other desirable properties of the system.

Other modifications of the present invention will occur to those skilled in the art upon a reading of the present disclosure. These are intended to be included within the scope of this invention.

What is claimed is:

1. A corona discharge electrode in a corona discharge device comprising a filament core treated with a composition comprising a hygroscopic material and a hydrophilic binder combined with a potential source connected to said electrode for generating corona discharge from said corona discharge electrode.

2. A corona discharge electrode according to claim 1 wherein said filament core comprises organic material.

3. A corona discharge electrode according to claim 2 wherein said filament core is a thread.

4. A corona discharge electrode according to claim 1 wherein said filament core comprises a conductive metal.

5. A corona discharge electrode according to claim 1 wherein said filament core has a diameter of less than about 0.25 millimeter.

6. A corona discharge electrode according to claim 5 wherein said diameter is about 0.1 millimeter.

7. A corona discharge electrode according to claim 1 wherein said hygroscopic material is a deliquescent compound.

8. A corona discharge electrode according to claim 7 wherein said deliquescent compound comprises lithium chloride.

9. A corona discharge electrode according to claim 1 wherein said hygroscopic material comprises a mixture of lithium chloride and glycerine.

10. A corona discharge electrode in a corona discharge device comprising a conductive metal filament core treated with a composition comprising a hygroscopic material combined with a potential source connected to said electrode for generating corona discharge from said corona discharge electrode.

11. A method of rapidly imposing an electrostatic charge on an electrostatographic insulating surface comprising supporting an imaging layer on a conductive backing member, said layer having an electrostatographic insulating surface on the opposite side of said layer from the interface of said layer with said conductive backing member, positioning at least one corona discharge electrode adjacent to but spaced from said electrostatographic insulating surface, said corona discharge electrode comprising a conductive metal filament core treated with a composition comprising a hygroscopic material, and applying a sufficient electrical potential between said corona discharge electrode and said conductive backing member to generate corona discharge from said corona discharge electrode thereby imposing an electrostatic charge on said electrostatographic insulating surface.

12. A method of rapidly imposing an electrostatic charge on an electrostatographic insulating surface comprising supporting an imaging layer on a conductive backing member, said layer having an electrostatographic insulating surface on the opposite side of said layer from the interface of said layer with said conductive backing member, positioning at least one corona discharge electrode adjacent to but spaced from said electrostatographic insulating surface, said corona discharge electrode comprising a filament core treated with a composition comprising a hygroscopic material and a hydrophilic binder, and applying a sufficient electrical potential between said corona discharge electrode and said conductive backing member to generate corona discharge from said corona discharge electrode thereby imposing an electrostatic charge on said electrostatographic insulating surface.

13. A method according to claim 12 wherein said filament core comprises organic material.

14. A method according to claim 12 wherein said hygroscopic material is a deliquescent compound.

15. A corona discharge electrode in a corona discharge device comprising a filament core having a diameter of less than about 0.25 millimeter covered with a coating consisting essentially of a hygroscopic material and a hydrophilic binder, said coating having a thickness when dry between about 0.5 and about 200 microns combined with a potential source connected to said electrode for generating corona discharge from said corona discharge electrode.