Jan. 29, 1974 MASAMICHI SATO ET AL 3,788,844

CHARGING METHOD FOR ELECTROPHOTOGRAPHY

Filed Oct. 5, 1971 2 Sheets-Sheet 1

FIG. 1

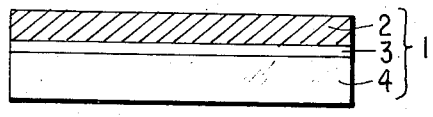


FIG. 2

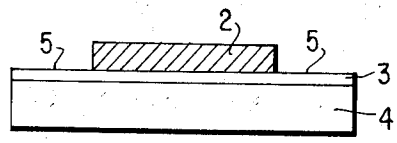


FIG. 3

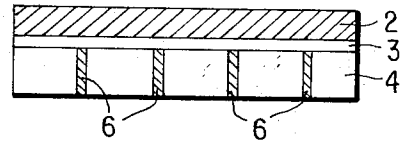


FIG. 4

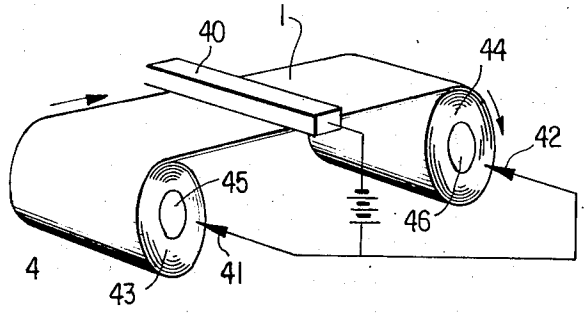


FIG. 5

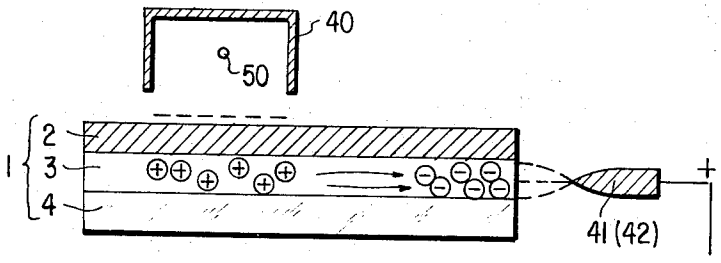


FIG. 6

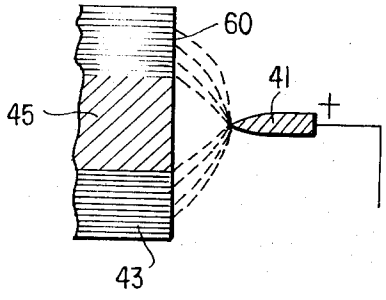
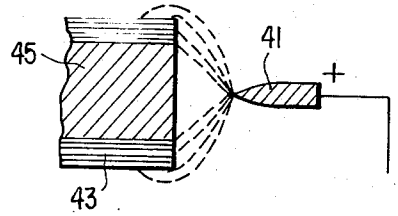


FIG. 7



INVENTORS.
MASAMICHI SATO
ISOZI TAKAHASHI

BY Ferguson & Baker

ATTORNEYS.

Jan. 29, 1974 MASAMICHI SATO ET AL 3,788,844

CHARGING METHOD FOR ELECTROPHOTOGRAPHY

Filed Oct. 5, 1971 2 Sheets-Sheet 2

FIG. 8

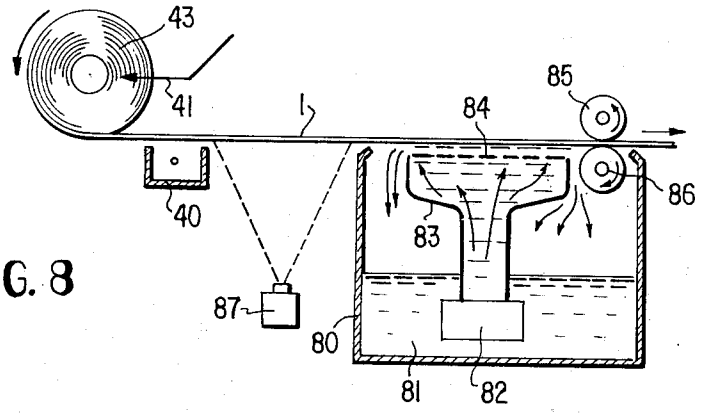


FIG. 9

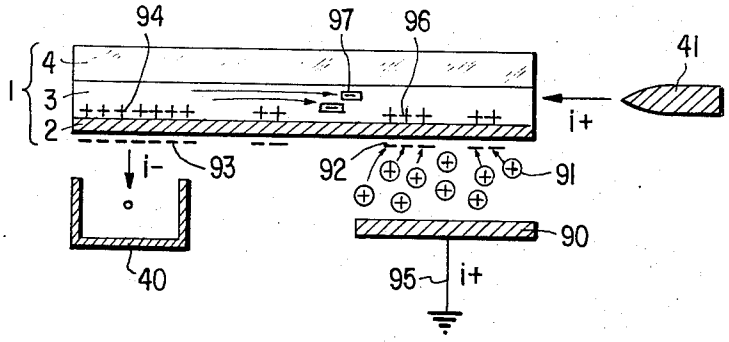
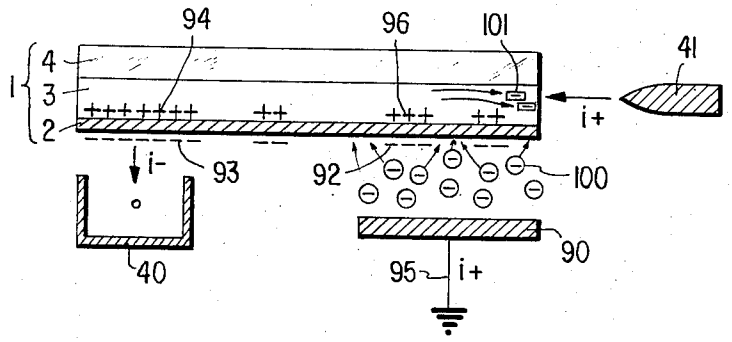


FIG. 10



INVENTORS.
MASAMICHI SATO
ISOZI TAKAHASHI

BY Ferguson & Baker

ATTORNEYS.

United States Patent Office 3,788,844 Patented Jan. 29, 1974

3,788,844

CHARGING METHOD FOR ELECTRO-PHOTOGRAPHY

Masamichi Sato and Isozi Takahashi, Asaka, Japan, assignors to Fuji Photo Film Co., Ltd., Kanagawa, Japan

Filed Oct. 5, 1971, Ser. No. 186,668
Int. Cl. G03g 13/02, 13/22
U.S. Cl. 96—1 C 15 Claims

ABSTRACT OF THE DISCLOSURE

An electrophotographic method for charging the surface of an elongated electrophotographic member wound upon at one roll, the member including a photoconductive insulating layer disposed on an ungrounded conductive substrate interposed between the photoconductive insulating layer and an electrically insulating substrate by simultaneously respectively applying high charging voltages of opposite polarities to a main corona discharge electrode disposed adjacent to the upper surface of the elongated member and a sub-discharge corona discharge electrode disposed adjacent the side of the roll.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1 to 3 are cross-sectional views of electrophotographic material.

FIG. 4 is a perspective view of the present invention.

FIG. 5 is a longitudinal side view showing a charging principle of this invention.

FIGS. 6 and 7 are longitudinal side views showing a side surface of rolled electrophotographic material being exposed to corona discharge of a corona discharge needle electrode.

FIG. 8 is a longitudinal side view of an apparatus practicing this invention during development.

FIGS. 9 and 10 are schematic longitudinal side views which indicate movement of the apparatus described in FIG. 8.

DETAILED EXPLANATION OF THE INVENTION

This invention relates to an electrophotographic method suitable for charging an elongated electrophotographic material provided with a photoconductive insulating layer on a conductice support interposed between the photoconductive insulating layer and an electrically insulating substrate. As the flexible elongated electrophotographic material those whose section is shown in FIGS. 1 to 3 are well known.

An electrophotographic material shown in FIG. 1 is comprised as follows: 1 designates electrophotographic material, 2 a photoconductive insulating layer such as amorphous selenium, mixture of photoconductive particle (zinc oxide, sulfide cadmium, etc.) with insulating resin, organic photoconductive material etc., 3 is a conductive layer such as metal plate layer, vacuum evaporation film, conductive metal compound (iodide copper, iodide silver, etc.) conductive high molecular material, conductive paint film (mixture of silver or conductive carbon particle with resin). 4 designates a highly insulating substrate such as polyethylene terephthlate, polyethylene, polyvinyl chloride, polypropyrene, polycarbonate, triacetyl cellulose. For charging a material as shown in FIG. 1 for example by corona discharge, the conductive layer 3 should be earthed.

On development, the conductive layer 3 is necessary to be earthed or connected to the power source. However, the thickness of the conductive layer 3 is 500 A. to several microns, so it is difficult to contact an electrode on the side of so thin a layer. Thus, the arrangements as shown in FIGS. 2 and 3 have conventionally been proposed.

FIG. 2 is a sectional view of the elongated electrophotographic material taken along the right angle of its proceeding direction, where 2 designates a photoconductive layer, 3 conductive layer and 4 highly insulating substrate. 5 is an exposed part of the conductive layer on both sides of the electrophotographic material. In order to expose both ends of the conductive layer, the photoconductive layer may be removed from both ends part of said material shown in FIG. 1 or the photoconductive layer may not be provided on both end part when disposed on the conductive layer. It is easy to contact an electrode with the exposed part of conductive layer 5.

FIG. 3 is sectional view of other electrophotographic material designed to make good connection with an electrode. 2–4 indicate the same material as the corresponding numerals in FIG. 1. 6 is a conductive pole joined with conductive layer 3 through substrate 4. The opposite side is exposed on the rear surface of substrate 4, where it is connected with an electrode (for example, earth electrode). The pole 6 is made by providing a hole through substrate 4 and putting conductive material into this hole, which is, for instance, preferable to plating with metal or flowing conductive paint or conductive high molecular material.

But, the manufacturing process of the electrophotographic material as shown in FIG. 2 or FIG. 3 is complex and the cost of material is high. A connection with the electrode is apt to be interrupted when an exposed photoconductive layer is injured. Side parts 5 in FIG. 2 are necessarily a part where an image is not formed, and thus both side parts are wasted.

This invention provides a novel electrophotographic method which is capable of favorably charging the electrophotographic material as shown in FIG. 1 without any special procedures.

FIG. 4 is a perspective view of the present invention. 40 is a main charging apparatus, 41 and 42 needle-like sub-discharging electrodes. 43 is a supply roll of elongated electrophotographic material and 44 a takeup roll. The main charge apparatus 40 is opposed to a photoconductive insulating layer of the elongated electrophotographic material 1. Each needle-like sub discharging electrode 41 and 42 is opposed to the side of supplying roll 43 and take-up roller 44. They more preferably to oppose near the core of each roll. The sub discharging electrode may be one of either electrode 41 or 42. The cores 45 and 46 are made of an insulating material, or is are insulated in the case they are made of conductive material. For example, an electrophotographic material is charged negatively when a negative corona discharge is provided from main charging apparatus 40 and corona discharging is provided from sub discharging electrodes 41 and 42. At supplying roll 43, corona ions deposit only on the side of said roll and thus, the surface of electrophotographic material is not charged positively, for the electrophotographic material is piled up, so the overall surface of the electrophotographic material is uniformly charged negatively.

FIG. 5 is a schematic cross-sectional view to explain a principle of this invention. 50 is a wire-like corona discharge electrode provided in the main charge apparatus 40. When a negative high voltage is applied to electrode 50 and positive high voltage to needle-like sub discharging electrode 41 or 42, positive corona ions from electrode 41 come toward the side surface of the electrophotographic material. Free electrons in conductive layer 3 move to neutralize this positive charge on the side surface. Consequently, positive charge remains in conductive layer 3, and negative corona ions move from electrode 50 of main charge apparatus 40 to the surface of the electrophotographic material, that is, earth effect is obtained. According to our experiences, use of sub-discharging elec-

trode **41** or **42** gives several ten to several hundred times the charge amount to the electrophotographic material in comparison to no use thereof.

FIGS. 6 and 7 shows the state of electrophotographic material given a corona discharge by sub discharging electrode **41** opposite the side surface of the supplying roll **43** shown in FIG. 4. **60** is the side surface of roll **43**. When an electrophotographic material is wound thickly around core **45** as shown in FIG. 6, most of the corona ions deposit the side surface **60** of roll because the electric line of force from needle-like sub discharging electrode **41** goes toward the side surface **60**. However, when electrophotographic material, as shown in FIG. 7, is spent and it decreases in thickness curled on core **45** of supplying roll **43**, the electric line of force from sub discharging electrode goes onto the surface adjacent the side part of the electrophotographic material as well as the side surface of the electrophotographic material wound roll-like. As a result, positive corona ion on the surface adjacent the side part of the electrophotographic material prevents uniform charging by main charge apparatus **40**. In order to avoid these drawbacks, it is preferable to connect a material provided with only a conductive layer on the substrate and without having the photoconductive insulating layer thereon to the trailing portion of the electrophotographic material and get a large curled thickness even if the electrophotographic material wound around core **45** remains but for a little time.

The other method is to apply an electric source to electrode **42** not electrode **41**, for the curled thickness of take-up roll **44** increases in contrast with the decrease of thickness of supplying roll **43**.

The charging method of this invention is described hereinabove, and the following description is a case combining the charging method in accordance with the present invention with a developing method. FIG. 8 is a schematic cross-sectional view especially showing the developing part.

80 is a developing liquid vessel, **81** developing liquid and **82** a pump to draw up developing liquid. **83** is developing head and **84** is flat reticulate or screen-like developing electrode provided thereon. **85** and **86** are a pair of squeeze rollers, and **87** image exposing apparatus. In this apparatus, a needle-like sub discharging electrode **41** is disposed toward side surface of supplying roll **43** of electrophotographic material and charges the electrophotographic material together with main charging apparatus **40** opposing the photoconductive layer surface. Then, the charged surface is image-exposed by image exposing apparatus **87** and a latent image is formed. Then electrophotographic material is developed using the developing electrode on the developing area.

Developing liquid drawn up by means of pump **82** is applied through developing electrode **84** onto the latent image surface, falls down from the edge of the surface of electrophotographic material and is again circulated in the vessel **80**. Deposited developing liquid on the electrophotographic material is removed by a pair of squeeze rollers **85** and **86**.

FIG. 9 is a schematic view showing an electrophotographic material with a developing electrode being simultaneously charged and developed in according with the present invention. The process of image exposure is omitted. **90** is a devoloping electrode corresponding to developing electrode **84** in FIG. 8. **91** is a toner provided with positive charge. In FIG. 8, the toner is suspended in the insulating liquid, however, the liquid is omitted in FIG. 9. **92** is a negative latent image. The electrophotographic material **1** is supposed to be charged negatively. **93** is uniform negative charge and **94** is its opposite charge. Developing electrode **90** is earthed with conductor **95**.

The following description refers to the developing construction in FIG. 9. Toner **91** providing positive charge is attracted to negative latent image **92**. When the toner deposits on the latent image and the charge of the latent image is a little neutralized, charge **96** is neutralized in its amount. If not neutralized, as a result of toner not being deposited on the latent image, such phenomena happens as the reduction of developing speed, low density of image and aggrevation of edge effect. Suppose the charging current which flows from negative corona discharging electrode **50** to electrophotographic material is i−, and current which flows from the positive sub discharging electrode to the electrophotographic material is i+, the above difficulties can be solved by neutralizing the opposite charge **96** of the latent image under the condition of i−>i+. When i−>i+, relatively free electron **97** for yielding opposite charge **94** occurs and neutralizes opposite charge **96**. Current it is a developing current and flows toward electrophotographic material **1** from developing electrode **90**. The formula (i−=i+ + it) results. When i− is mucht larger than i+, it causes fog, for toner deposits even on a place having no charge. Accordingly, term the range of i−>i+ is to be limited in a range where opposite chage **96** of latent image is neutralized.

FIG. 9 shows so-called positive development (charge of the latent image has counter polarity to toner charge). The following explanation refers to reversal development (charge of the latent image has the same polarity as toner charge).

FIG. 10 is a model of reversal development corresponding to FIG. 9. **100** is toner providing negative charge. Under condition of i+=i−, toner is a little deposited on the outside of a marginal portion where charge of the latent image exists. However, under condition of i+>i−, free electrons **101** in conductive layer **3** transfer to neutralize positive corona ion of i+. Consequently, a conductive layer **3**, which is excess of positive charge, attract negative toner to latent image surface. In this case, when i+ is too large than i−, toner deposits even on a place bearing latent image and causes fog, and the condition of i+>i− must be restricted. In the case of FIG. 10 developing current it flows to developing electrode from electrophotographic material and i+=i− + it results.

There is a case when the electrophotographic material is driven intermittently. For instance, in this case the electrophotographic material is image-exposed while it is stationary. The main charge apparatus preferably not works between the electrophotographic material which is stationary. However, sub dis-charging electrode does work, for development is continued. Positive developing can be accomplished by the following means in the apparatus shown in FIG. 8. That is, corona discharge is derived by applying negative voltage on the sub discharging electrode without applying voltage on the corona discharging electrode of the main charging apparatus. On reversal development, corona discharge is derived by applying positive voltage on the sub discharging electrode without applying voltage on main charge apparatus. Accordingly, in the case of positive development, positive voltage is applied on the sub discharging electrode during charging and negative voltage is applied during development.

As an electrophotographic material, the following materials are applicable to the present invention. As highly insulating substrate **4**, there are films of polyethyleneterephthalate, polyethylene, polypropylene, polyvinyl chloride, triacetyl cellulose, and paper laminated with polyethylene, polystyrene or polypropylene. As a conductive layer **3**, there are film by vacuum evaporation with aluminum or other metal, film plated with copper, silver, or other metal, iodide copper film, film coated with conductive paint (mixing resin with silver particle, or conductive powder) film coated with conductive high molecular material (e.g. fourth class ammonium polymer; Calgon Conductive Polymer 261; trade name of Calgon Co. in U.S., and Dow Chemical ECR-34; trade name of Dow Chemical Co. in U.S.).

Paper treated with conductive polymer (for instance Calgon Conductive Polymer 261, Dow Chemical ECR-34) has a characteristic sufficient for the present invention because the electric resistance is 10^8–10^9 in its traverse direction even when the length between the main charging apparatus and the sub charging electrode is several ten meters.

As photoconductive insulating layer **2**, coating of mixture of photoconductive particle (zinc oxide, sulfide cadmium selenium, etc.) and insulating resin (polystyrene, silicone, cellulose steel, phenol formaldehyde, polyvinyl chloride, etc.) or organic photoconductive coating film (e.g. polyvinyl carbazole) is used. Any combination of these materials may be used for electrophotographic material.

EXAMPLE 1

A continuous conductive layer was formed on an elongated polyethylene terephthalate film of 100μ in thickness and 250 mm. in width by activating by ultraviolet irradiation and vacuum evaporating. Secondly, coated thereon mixture of photoconductive zinc oxide particle 100 parts by weight, styrene alkyd resin (made by Japan Leihihold: trade name Styresol 4400) 14 parts by weight and polyisocianate compound (made by Japan Polyurethane; trade name Coronate L) 6 parts by weight so as to be about 7μ in thickness after drying.

Said elongated electrophotographic material was developed by the apparatus as shown in FIG. 8. In main charging apparatus **40**, the wire-like corona discharge electrode was a stainless steel wire of 0.1 mm., distance from the electrode to shield case was 15 mm. and distance between the corona discharge electrode and electrophotographic material was 15 mm. Applied —7 kv. to the corona discharge electrode. As the core **45** of supplying roll **43** was employed a core made of polyvinyl chloride in 50 mm. diameter. The outside diameter of a supplying roll **43** was 150 mm. As a sub discharge electrode **41** used was a sewing needle in 50 mm. length, which was set on an axis of supplying roll and the distance from side surface of the roll was 50 mm. The electrode was applied +9 kv.

For exposure xenon flash lamp was employed, whose output was 125 w. sec. and duration time was 80μ sec. Original was a transparent positive image of 60 mm. x 60 mm. An electrophotographic material was driven at definite speed of 40 mm. sec. A developing apparatus had a pump of capacity 15 l./min., and a reticulate development electrode of 2000 mesh stainless steel reticulation and of 230 mm. long and wide. The distance between the development electrode and the electrophotographic material surface was 2 mm. Developing liquid was prepared as follows:

	Parts by weight
Carbon black (nipeal #100: trademark of Nittetsu Chemical Co.)	10
Safflower oiled modified alkyd resin (oil length 65%) (Super Beckosol J-537: trademark of Japan Leihihold Co.)	300
Oleic acid	50
Isoper H (Esso Standard Oil Co., petroleum solvent)	90

These were blended in a ball mill for 50 hours and the obtained high density solution was dispersed into Isoper H of 30 times volume to give a developing liquid. Toner provides positive charge.

The squeeze rollers were stainless rollers in 15 mm. diameter and coated with rubber 5 mm. thick. The drying apparatus was provided with Nichrome wire heater in 500 watts and a fan. The shield case was earthed. By this apparatus, the electrophotographic material was charged to the surface potential of about —180 volts, and moreover an image obtained except edge effect and in high optical density.

EXAMPLE 2

A reversal development was executed in the use of the same electrophotographic material and apparatus as Example 1. To the corona wire of main charging apparatus was applied—6.5 kv., to the sub charging electrode **41** and **42** +8.5 kv. The shield case was earthed.

Developing liquid is prepared as follows.

	Parts by weight
Carbon black (the same as in Example 1)	10
Vinyl chloride-vinyl acetate copolymer (Dekavinyl 1000 GS: tradename of Denki Kagagu Kogyo K.K.)	200
Linseed oil	50
Acetone	80

These were blended in a ball mill for 40 hours and dispersed into the solution of the mixture of linseed oil 100 ml. and kerosene 1 l. to give a diluted solution of 30 times in capacity providing supersonic wave energy. The output of the energy was 150 watts and frequency was 29 kHz. Thus obtained toner in this developing liquid was charged in negative. The original was a transparent negative in 60 mm. x 60 mm. The exposing apparatus was the same as Example 1. Driving speed of electrophotographic material was 100 mm./sec. An excellent image was obtained.

What is claimed is:

1. An electrophotographic method for charging the surface of an elongated electrophotographic member wound upon at one roll, at least the surface of said roll being electrically insulating, said member including a photoconductive insulating layer disposed on an ungrounded conductive substrate interposed between said photoconductive insulating layer and an electrically insulating substrate by simultaneously respectively applying high charging voltages of opposite polarities to a main corona discharge electrode disposed adjacent to the upper surface of said elongated member and a sub-discharge corona discharge electrode disposed adjacent the side of said roll.

2. An electrophotographic method as claimed in claim **1** wherein the charged surface is image-exposed and is developed using a development electrode.

3. A method as in claim **1** where said roll is mounted on an electrically insulating core and said sub-discharge corona discharge electrode is disposed at the end of said core.

4. A method as in claim **1** where said main discharge electrode extends substantially entirely across the width of said elongated electrophotographic member.

5. A method as in claim **1** where said one roll is a supply roll and said elongated material is taken up on a take-up roll and further charging a further sub-discharge corona discharge electrode disposed adjacent the side of said take-up roll.

6. A method as in claim **5** where as the voltage on the corona discharge electrode adjacent the take-up roll is increased the voltage on the corona discharge electrode adjacent the supply roll is decreased.

7. A method as in claim **2** where said elongated electrophotographic member is continuously moved, the polarity of said charging voltages being opposite an simultaneously present during said uniform charging.

8. A method as in claim **7** where said developing is normal developing and the absolute value of the voltage applied to said main corona discharge electrode is greater than the absolute value of the voltage applied to said sub-discharge corona electrode by an amount sufficient to effect substantial neutralization of the charge of opposite polarity induced in said conductive substrate opposite the latent image such that toner is attracted substantially only to the charged areas of the latent image.

9. A method as in claim **7** where the absolute value of the voltage applied to said sub-discharge corona discharge electrode is greater than the absolute value of the voltage

applied to said main corona discharge electrode by an amount sufficient to produce in said conductive substrate charge of a polarity opposite to that of the latent image such that toner is attracted substantially only to the non-charged areas of the latent image.

10. A method as in claim **2** where said elongated electrophotographic member is intermittently moved, the latter member being stopped during said image exposing and developing, the polarity of said charging voltages being simultaneously present and opposite during said uniform charging of the electrophotographic member and the polarity of the voltage applied to said sub-discharge electrode being changed to that of said main corona discharge electrode during said developing while said main corona discharge electrode is rendered inoperative.

11. A method as in claim **10** where said developing is normal developing and the polarity of the voltage applied to said sub-discharge corona discharge electrode during said developing is the same as that of the latent image.

12. A method as in claim **10** where said developing is reverse developing and the polarity of the voltage applied to said sub-discharge corona discharge electrode during said developing is opposite to that of the latent image.

13. A method as in claim **1** where the resistance of said electrically conductive layer is no greater than 10^9 ohms in its transverse direction.

14. A method as in claim **13** where said resistance is between 10^8–10^9 ohms.

15. A method as in claim **1** where said sub-discharge electrode is pointed in configuration and directed toward said roll.

References Cited

UNITED STATES PATENTS

3,041,167	6/1962	Blakney et al.	96—1.4
2,790,082	4/1957	Gundlach	96—1 C
3,543,022	11/1970	Lennon	96—1 C
3,675,011	7/1972	Silverberg	250—49.5 ZC
3,444,369	5/1969	Malinaric	250—49.5 ZC
3,519,420	7/1970	Goffe	96—1 R
3,412,242	11/1968	Giaimo	250—49.5 ZC
2,965,481	12/1960	Gundlach	96—1 R

ROLAND E. MARTIN JR., Primary Examiner

U.S. Cl. X.R.

96—1 R, 1 LY; 317—262 A, 267 AE; 250—49.5 ZC; 117—37 LE