Dec. 8, 1970 MASAMICHI SATO ET AL 3,546,545

METHOD OF CHARGING A PHOTOCONDUCTIVE INSULATING LAYER

Filed Sept. 24, 1968

2 Sheets-Sheet 1

FIG. 1

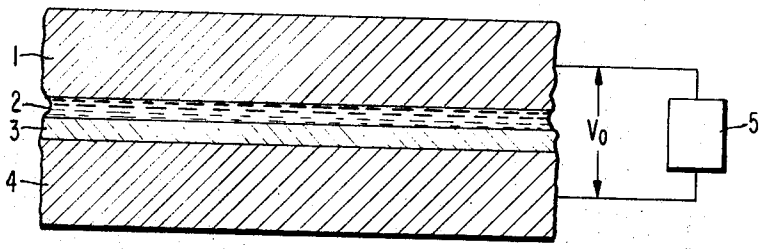


FIG. 2

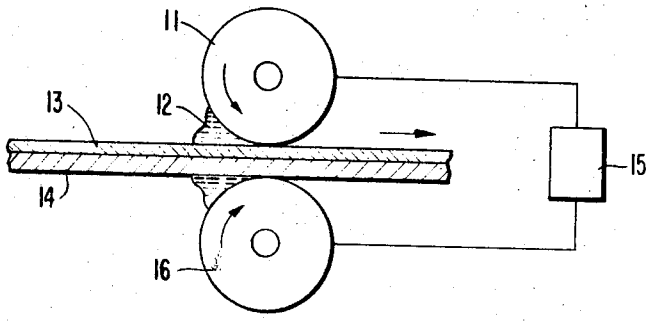


FIG. 3

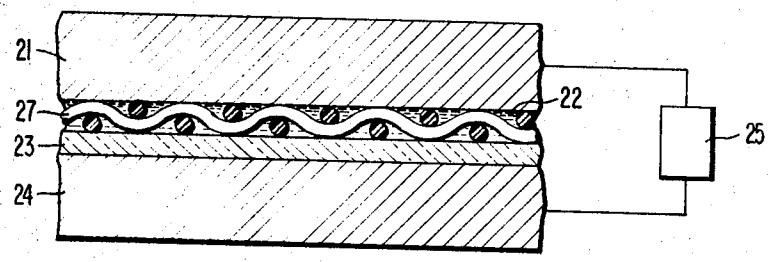
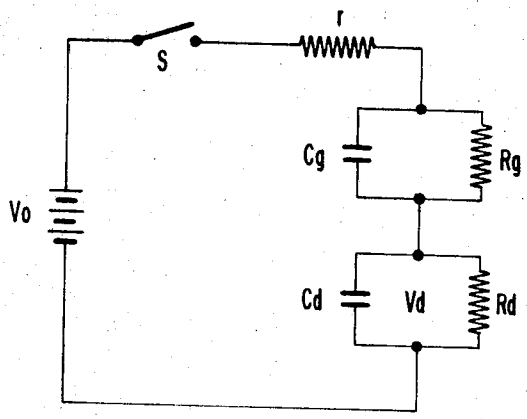


FIG. 4



INVENTORS
MASAMICHI SATO
SATORU HONJO

BY Eugene, Rothwell, Mion, Zinn & Macpeak
ATTORNEYS

Dec. 8, 1970 MASAMICHI SATO ET AL 3,546,545

METHOD OF CHARGING A PHOTOCONDUCTIVE INSULATING LAYER

Filed Sept. 24, 1968 2 Sheets-Sheet 2

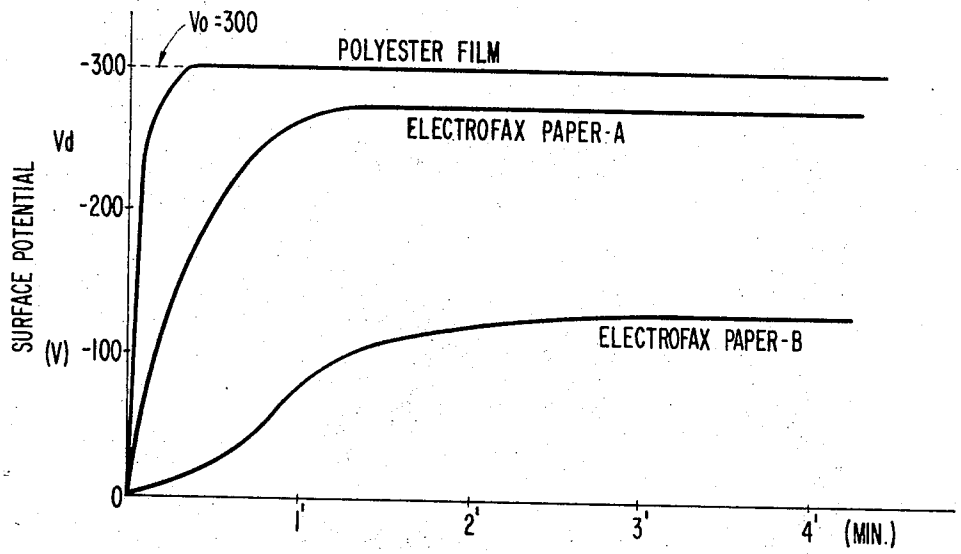


FIG. 5

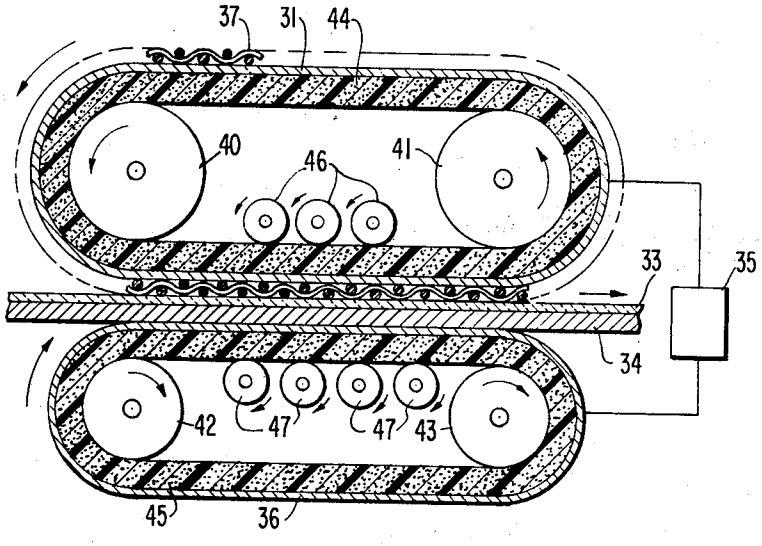


FIG. 6

INVENTORS
MASAMICHI SATO
SATORU HONJO

BY
Leighton, Rothwell, Mion, Zinn & Macpeak
ATTORNEYS

United States Patent Office 3,546,545
Patented Dec. 8, 1970

3,546,545

METHOD OF CHARGING A PHOTOCONDUCTIVE INSULATING LAYER

Masamichi Sato and Satoru Honjo, Asaka-shi, Japan, assignors to Fuji Photo Film Co., Ltd., Ashigara-Kami-gun, Kanagawa, Japan

Filed Sept. 24, 1968, Ser. No. 762,069
Claims priority, application Japan, Sept. 28, 1967, 42/62,530
Int. Cl. G03g 13/02
U.S. Cl. 317—262 6 Claims

ABSTRACT OF THE DISCLOSURE

An improvement in the method of charging photoconductive insulating layers which includes placing a mesh screen between an electrode and the insulating layer so that insulating liquid is in contact with the layer and the electrode. An electrical potential is placed between the electrode and on the backing of the insulating layer to charge the layer.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to the method for the application of an electrostatic charge to the surface of an insulating or photoconductive insulating layer.

Description of the prior art

Generally, charging the surface of an insulating layer in the field of xerography has been carried out by means of ion charging utilizing a corona generating electrode. Ion charging, though it results in uniform and reproducible charging across the surface, requires expensive and relatively clumsy equipment and, conventionally, use of exceptionally high voltages. Furthermore, the gaseous ions generated by ion charging are harmful to the human body.

Another means of charging, known as frictional charging, has been found to be difficult to operate and generally results in uneven or irregular charging across the surface as well as non-reproducible charging.

Another means of charging, based on a direct charge, is also known. In the method described in U.S. Pat. No. 2,987,660, the insulating layer provided on an electrically conductive backing is brought into contact with a conductive or electrolytic liquid, whereby an electric potential is created between the conductive backing and the liquid. Satisfactory reproducibility may be obtained by charging the insulating layer to nearly the same potential as that of the conductive liquid with a low voltage supply but this is not suitable when charging a photoconductive insulating layer, since direct contact of a conductive liquid with the layer will sometimes deteriorate the electrophotographic properties of the layer. Furthermore, if a droplet of the conductive liquid remains on the layer after charging the charge on the droplet will instantaneously dissipate to the ground through the layer and leave an uneven charge distribution on the surface. Experiments have proved that electrophotographic coatings comprising amorphous selenium or ZnO/resin mixtures, and exhibiting a strongly hydrophobic property are apt to hold small droplets of the aqueous electrolyte solutions after charging by this method.

Still another means is described in U.S. Pat. No. 2,904,431, which, as shown schematically in FIG. 1, comprises coating the surface of an insulating layer **3** on a conductive backing **4** with a thin film of insulating liquid **2**, placing electrode **1** close to said insulating layer and in surface contact with the thin liquid film and establishing

an electric potential between the electrode and the backing. The potential to be applied is preferably from 100 to 200 volts and the thickness of the liquid film is about 0.5 to 75 microns. This method, however, has a defect in that the charge induced on the insulating layer critically depends on the thickness of the liquid film which may vary due to the presence of irregularities on either the layer or the electrode. It is also very difficult to obtain uniform spacing between the layer and the electrode over the whole surface. In FIG. 2 there is shown an arrangement to carry out the above described method. In this figure, a flexible electrophotographic recording member comprising a conductive backing **14** (when the member is "Electro-fax" paper the backing is made of specially treated conductive paper) and a photoconductive insulating layer **13** is inserted between a pair of rotating conductive rolls **11** and **16**. An insulating liquid **12** is supplied between the recording member and the two rolls so as to form an extremely thin liquid film therebetween and an electric potential is applied between these two rolls by means of a voltage supply **15** causing the recording member to be charged during the passage between the rolls. Our experiments employing this arrangement showed that the resulting charge on the member is always uneven, and that minute dust particles adhering to the rolls are the major cause for such an undesirable result.

Accordingly, the object of the present invention is to provide an improved method of charging an insulating layer, free from any of the above mentioned shortcomings.

SUMMARY OF THE INVENTION

The present invention is characterized by a flexible, insulating, thin sheet mesh screen being placed between a charging electrode and an insulating layer to be charged and the free space between these being filled with an insulating liquid so that uniform electric contact between the electrode and the insulating layer will occur. The screen is constructed so that the insulating liquid can penetrate in a direction perpendicular to the electrode. The screen serves mainly to create uniform spacing between the electrode and the layer.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1 and 2 schematically represent conventional charging methods. FIG. 3 is a cross-sectional view of a charging arrangment of the present invention. FIG. 4 shows the equivalent circuits of FIG. 1, FIG. 3, and FIG. 2, and FIG. 5 shows the charging characteristics of the surface using insulating layers charged by the method of the present invention. FIG. 6 shows a cross-sectional view of an apparatus that may be employed in the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

The present invention will now be explained more in detail with reference to the accompanying drawings. As shown in FIG. 3, a sheet mesh screen **27** made of an insulating wire of fiber, such as nylon for example, is placed between an electrode **21** and a photoconductive insulating layer **23**, which is provided on a conductive backing **24**. The free space between these is filed with an insulating liquid **22** and an electric potential applied between the electrode and the conductive backing by direct current voltage supply **25**. Since the composite is tightly pressed during the application of potential, the spacing between the two electrodes is substantially determined by the thickness of the screen, and at the same time uniform contact is easily realized throughout the whole contact area by virtue of the insulating liquid.

FIG. 4 represents an electric circuit equivalent to the arrangements shown in FIG. 1, FIG. 2, and FIG. 3. S designates a switch r the whole lead resistance including

a protective resistance, R_g and C_g, the resistance and capacity of the insulating liquid film, R_d and C_d the resistance and capacity of the insulating layer to be charged, and V_o the voltage source.

In this equivalent circuit, the surface potential U_d of the photoconductive insulating layer is given by the following equation:

$$U_d = \frac{R_d}{R_g + R_d} V_o \left[1 - \exp\left(- \frac{R_g + R_d}{R_g R_d (C_g + C_d) t} \right) \right]$$

where t is the time after the circuit is closed. In the equation r was neglected since $r \ll R_g$, and $r \ll R_d$. In FIG. 5 are shown charging characteristics of three different insulating layers: (a) a polyester film having a thickness of 75 microns, (b) highly insulating Electro-fax paper A, and (c) relatively low insulating Electro-fax paper B. These curves were obtained by employing an arrangement similar to that shown in FIG. 3, using kerosene as the insulating liquid, a nylon screen having a thickness of 56 microns as the insulating screen, and a 300 volt voltage source. A rapid increase in charge is observed with the highly insulating polyester film since $R_g \ll R_d$, while the two Electro-fax sheets exhibit a slower rise as well as saturated surface potential values lower than V_o.

As the curves in FIG. 5 prove, a prolonged charging or a high voltage with a short charging time is necessary to achieve a surface charge of about several hundreds volts, therefore a compact charging unit of reduced size with a relatively low voltage supply is hardly possible based on the arrangement shown in FIG. 2. FIG. 6 shows another embodiment for practicing the present invention which has a high efficiency with a low voltage supply. Two endless, resilient belts **44** and **45**, made of sponge, are driven by rollers **40** and **41** in the direction shown by the arrows. On the outer surface of each belt there is a flexible conductive layer which may be made by chemical plating or by superposing a metalized plastic film on the belt. On the outer side of electrode **31**, there is an insulating sheet mesh screen **37** (for example, a nylon screen). A potential is applied between the electrodes **31** and **36** by voltage supply **35**.

Between the moving insulating screen **37** and the electrode **36**, an electrophotographic member comprising a conductive support **34** and a photoconductive insulating layer **33** is inserted. The member is driven by the rotation of the belts and the insulating mesh screen maintains a uniform spacing between the layer **33** and the electrode **36** during passage. The screen is saturated with an insulating liquid from a reservoir (not shown in the figure). Since the period during which the potential is applied to the insulating layer is much longer than in the arrangement shown in FIG. 2, a high potential is induced on the insulating layer by a single passage of the member through the charging unit.

An insulating screen for use in the present invention must be in such a form that an insulating liquid can penetrate from the electrode **31** to layer **33**. Separate screens, for example woven fabrics, may be superposed and fixed on a metal electrode by a suitable adhesive; or small islands of fine lines regularly distributed and composed of an insulating material may be provided on the electrode by printing or other suitable means.

As will be clearly understood from the above explanations, the present invention can bring about a uniform charge on an insulating layer by utilizing an insulating liquid for an improved electric connection between an electrode and the layer to be charged and an insulating screen which serves for accomplishing a uniform spacing therebetween.

Another advantage of the present charging method appears in the image quality obtained by the subsequent liquid development. In charged layer may be subjected to image exposure by means of projection (contact exposure is not suitable because of the existence of liquid film on the surface of the layer) then to liquid development. When the exposed member is brought into contact with a liquid developer the thin film of the liquid used in charging will partly diffuse in the developer and remain in place during development, thereby preventing a noisy adhesion of toner on the layer by forces other than electrostatic, which result in a marked decrease of background density.

What is claimed is:

1. In a method of charging a photoconductive insulating layer which comprises placing an electrical potential between two electrodes which have spaced therebetween an insulating layer and a layer of highly insulating liquid, the improvement consisting of placing an insulating fiber mesh screen between one of said electrodes and said insulating layer, said screen being permeable to said insulating liquid so that there is direct liquid contact between said electrode and the insulating layer.

2. The improvement of claim **1** wherein the electrical potential applied is about 300 volts and, the thickness of the screen is about 56 microns.

3. The improvement of claim **2** in said screen is a nylon screen.

4. This improvement of claim **1** wherein said insulating layer is a ployester film having a thickness of about 75 microns.

5. The improvement of claim **1** wherein said insulating liquid is kerosene.

6. A device for charging a photoconductive insulating layer consisting essentially of at least a pair of endless belts having a flexible conductive layer on the outer surface thereof, means for applying an electrical charge to said conductive surfaces, and means for moving said belts so that an electrophotographic member is fed therebetween, said member comprising a conductive support and a photoconductive insulating layer, one of said belts having an insulating mesh screen substantially covering said flexible conductive layer, said screen having an insulating liquid within it so that said liquid is in contact with the conductive layer of the belt containing said screen and the insulating layer of said electrophotographic member.

References Cited

UNITED STATES PATENTS

2,904,431	9/1959	Moncrieff-Yeates	317—262X
2,987,660	6/1961	Walkup	317—262
3,398,336	8/1968	Martel et al.	317—262

LEE T. HIX, Primary Examiner