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Tamai et al.

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[54] **ELECTROPHOTOGRAPHIC APPARATUS**

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[52] **U.S. Cl.** ..... **355/13,** 83/169, 117/37 LE, 355/3 R

[51] **Int. Cl.** **G03g 15/00**

[58] **Field of Search** ..... 355/3 R, 13, 10; 117/17.5, 117/37 LE; 83/22, 169

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[57] **ABSTRACT**

In electrophotographic apparatus containing means to cut an electrophotographic sheet, charging means, exposure means, and developing means, a liquid with a high electric resistivity and a low dielectric constant which is mesable with the developer liquid is applied to the paper prior to cutting, whereby scattering of chips produced during the cutting is greatly reduced. In a process for development where the paper is sequently transported to the above means, the improvement comprising applying a liquid as defined prior to cutting to form a thin layer on the paper.

9 Claims, 4 Drawing Figures

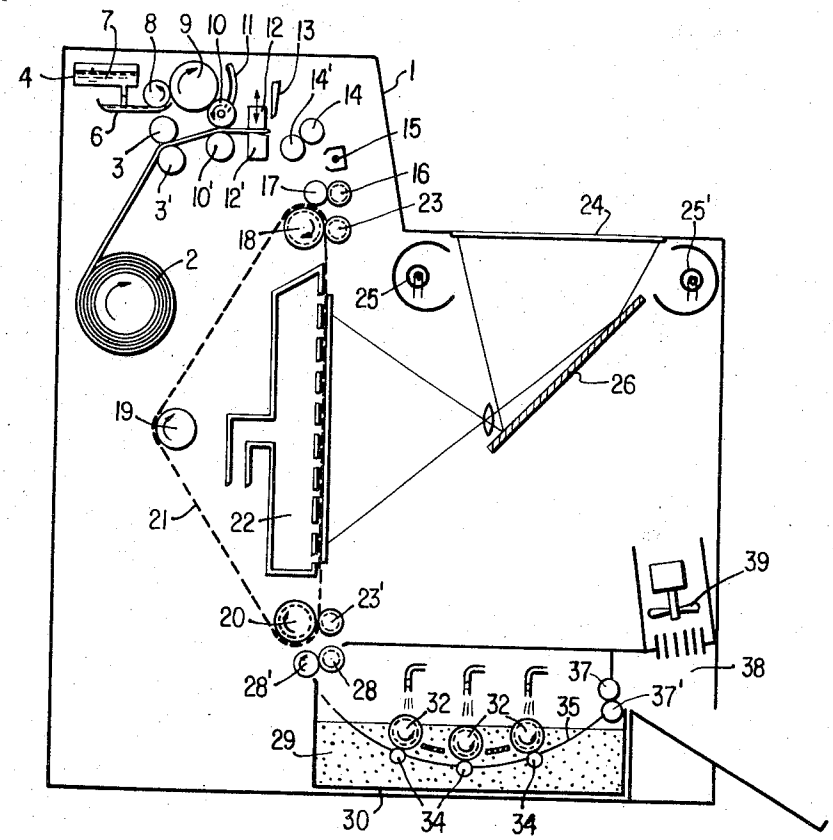

FIG. 1

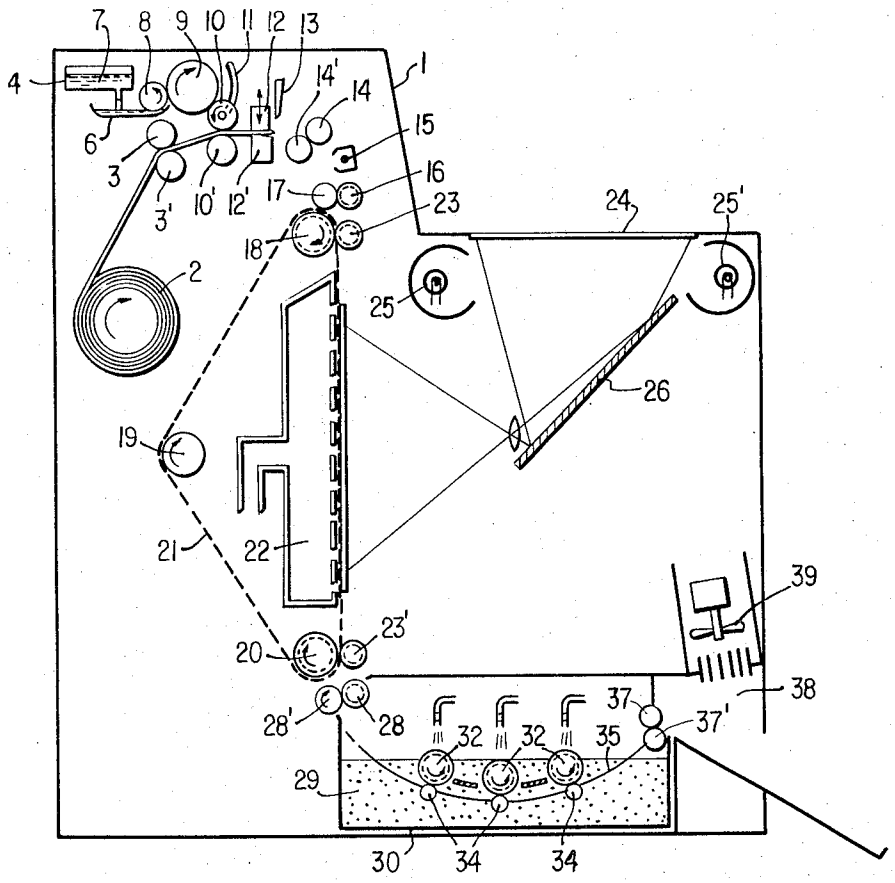
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FIG. 2

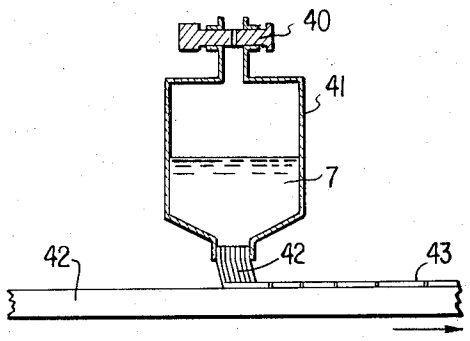


FIG. 3

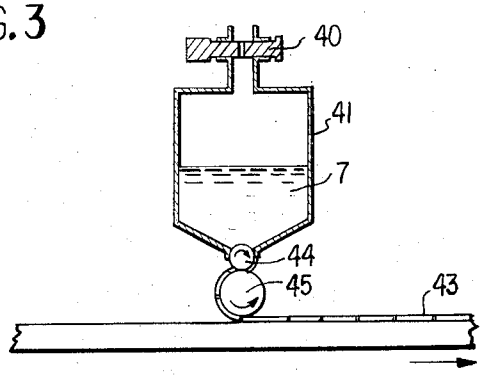
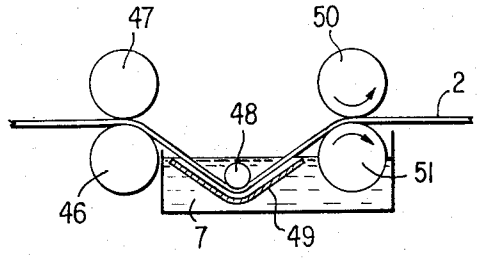


FIG. 4



ELECTROPHOTOGRAPHIC APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an electrophotographic apparatus, and particularly to an electrophotographic duplicaing apparatus which is excellent in the reproduction of continuous-tone images.

2. Description of the Prior Art

Methods, in which an electrostatic latent image on an electric insulating layer or a photoconductive insulating layer is developed by a liquid developer containing electroscopic particles (hereinafter called a toner) so as to obtain visible images are well known. This method has many advantages compared to the dry developing process, such as the cascade developing process, and the like. For example, it is possible with liquid developing to develop an electrostatic image having a weak potential, Further, a developing electrode is easy to use, and a solid latent image plane can be uniformly developed.

However, these advantages can turn to disadvantages in certain instances. For instance, when sufficient development has been effected to obtain a satisfactory image density, undesirable background density of fog often occurs. Further, in order to charge the surface of photosensitive layer a corona discharge is commonly used. However, in this case the phenomenon often occurs that the surface of the photosensitive layer suffers insulation destruction in a spot-like manner due to overcharge, and the charge is lost. Since liquid development makes very small defects easily detectable, portions that have lost their charge appear after development in the form of pin-holes.

On the other hand, electrophotographic photosensitive paper is provided with a photoconductive insulating layer on a support (usually paper) which has been subjected to an electroconductive treatment. In order to reproduce continuoustone images by electrophotography this electroconductive treatment is very important. Usually, the electroconductive treatment is effected by applying or impregnating a moisture-absorbent quaternary ammonium compound or vinylbenzene sulfonate onto the surface of paper. At the same time, moisture-absorbent inorganic compund, such as an alumina gel stabilized with a mineral acid, or a silica gel, may be used in conjunction with the above materials.

When an electrophotographic photosensitive paper having a support which has been subjected to such an electroconductive treatment is wound in the form of a roll and fed to duplicating apparatus, it is necessary to cut the photosensitive paper into sheet having a predetermined length at the time of suplication. Usually, cutting is effected by means of a cutter in the apparatus. When this apparatus is used daily, numerous cuttings must be effected and fine chips are produced. This mass of fine chips can flow in the air stream in the duplicating apparatus, and is thereby widely spread in the apparatus. Such paper chips contain moisture-absorbent, electroconductive materials and if such materials attach to metallic portion within the duplicator, they tend to produce rust.

Such paper chips attach themselves to electric circuits and tend to damage the insulating property thereof. Particularly, when they attach to the metallic

needles or metallic wires of a corona discharge electrode, non-uniform charging occurs. When such paper chips attach to an optical syste, the contrast of image is decreased. Thus, the chips of the electroconductive material to be treated can have a harmful effect when they are dispersed, and they result in shortening the life of the duplicator.

SUMMARY OF THE INVENTION

The present invention relates to an electrophotographic apparatus in which the above-mentioned defects have been ameliorated.

The object of the present invention is to provide a duplicating apparatus which produces duplicates without fog or non-uniformity of charge, and one of the principal object of the present invention is to provide electrophotographic apparatus which does hardly produces any cut chips at all.

The present invention relates to an electrophotographic apparatus wherein the parts for contacting at least the surface of the photosensitive layer of a web-like photosensitive paper with a liquid of high electric insulation, cutting parts for cutting this photosensitive paper into sheets of predetermined length, parts for charging the photosensitive layer by subjecting the surface of photosensitive layer of the photosensitive paper to a corona discharge, parts for image-exposing to a charged surface of photosensitive layer, parts for developing and parts for contacting the liquid developer containing toner with the surface of the photosensitive layer which has been image-exposed are disposed in a certain enumerated order along the conveying path of the photosensitive paper.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a longitudinal sectional view of one embodiment of electrophotographic apparatus in accordance with the present invention.

FIGS. 2 to 4 are longitudinal sectional views showing several embodiments of mechanisms for applying an insulating liquid to the surface of an electrophotographic material.

DETAILED DESCRIPTION OF THE INVENTION

The present invention will now be described in detail with reference to certain embodiments thereof.

Referring now to FIG. 1 this is a sectional view of electrophotographic apparatus according to the present invention. In FIG. 1 numeral 1 represents a case in which the mechanisms of the apparatus are contained. 2 is the web-like photosensitive paper wound in the form of a roll, the photosensitive paper being wound with its photosensitive surface facing outward. The photosensitive paper 2 is withdrawn by means of rollers 3, 3', and transported to insulating liquid contacting mean (hereinafter called the preceeding bath).

While the photosensitive paper may be directly contacted with the insulating liquid, but it is preferred to first pass the insulating liquid onto the surface of rollers or onto a porous material body, and then apply the insulating liquid to the surface of the photosensitive paper. 4 is a vessel for storing the insulating liquid, which is passed to a container 6. The insulating liquid 7 has high electric resistance and is a liquid of low dielectric constant. For example, a solvent of the hydrocarbon series which is relatively non-volatile, i,e., kerosene, decalin, etc., solvents of the isoparaffin series (for ex-

ample, Isoper H, Isoper G, manufactured by the Esso Standard Oil Co.,) and the like, are typically used. Oil-soluble resins, vegetable oils or silicone oil and the like may be mixed with the above-mentioned solvents, if desired. When a comparatively volatile solvent such as cyclohexane, n-heptane, n-octane, isooctane, gasoline or the like is used, it is prefered to add to them vegetable oil, silicon oil etc., as well as a solvent having high boiling point. The addition of these materials is preferred a for controlling the volatility of the insulating liquid. When the surface of the photosensitive paper has been dried before it is brought into contact with the liquid developer, the effect of the insulating liquid is decreased. It is further preferred that the solvent be miscible with the liquid developer. The insulating liquid must not dissolve or strongly swell the photosensitive paper **2.** From the results of experiments, it has been found that the liquid should an electric resistivity have more than 10^{12} Ω cm and a dielectric constant less than 3.5. The insulating liquid **7** is scooped up by means of a roller **8,** passed onto a roller **9,** then onto a roller **10.**

The insulating liquid **7** is applied to the photosensitive paper **2** on the photosensitive surface while the paper passes between rollers **10** and **10'.** The thickness of the liquid film applied to the photosensitive surface is preferably selected to be in the range of from 0.1 μ to 800 μ, most preferably from 0.3 μ to 300 μ. If the thickness is too small, background density or fog increases, and if it is too large the interior of the apparatus tends to be contaminated with liquid **7.**

As for rollers **8, 9** and **10,** rollers made of metal or of an insulting material may be used. The may be porous or of a rigid solid material. Roller **10** is of the type such that when the apparatus is not in operation it moves upwardly along guide groove **11** away from roller **10.**

To put the apparatus into operation, the electric power is turned on and liquid **7** is fed from the roller **8** to the roller **9** and then to the peripheral surface of the roller **10.** It is preferred that after this condition is reached the roller **10** approaches the photosensitive paper **2.** It has been found that when insulating liquid **7** was applied to the surface of the photosensitive layer the background density decreased remarkably.

The photosensitive paper is then passed to the cutting part. The holding plate **12** for holding the photosensitive paper is movable upwards and downwards, and after photosensitive paper of a predetermined length has passed by the cutting part, it holds the photosensitive paper, cooperating with a holding plate **12',** while cutter blade **13** moves downwards and cuts the photosensitive paper into sheets of the desired length. When the apparatus is out of operation, the roller **10** moves upwards and holding plate **12** moves downwards and holds the photosensitive paper.

Since the surface of the photosensitive paper has applied thereto liquid **7,** the movement of the cutter blade **13** is always smooth. Further, chips of paper are not scattered upon cutting, and also because the cutting of the photosensitive paper is effected while it is moistened with liquid **7,** no rust occurs on the blade **13.** Since no chips is produced, dust is not produced within the apparatus, and the interior thereof is always clean. Any fine chips which might be produced are transported into the liquid developer under the action of the liquid **7.** Accordingly, the occurence of "rust" of the metallic part due to the chips which contain substances for electroconductive treatment, is not observed.

The photosensitive paper is then passed by means of rollers **14** and **14'** towards a charging zone. **15** is a well known corona discharging device. When the surface of the photosensitive paper moistened by the liquid **7** is exposed to the corona discharge, corona ions penetrate the liquid film and electrostatically charge the surface of the photosensitive layer. The inventors of the present invention have found that, if any insulating liquid film exists on the surface of the photosensitive layer the surface is charged to a 10 to 40 percent higher potential, as compared to the case where the liquid film is not present.

Further, the inventors of the present invention have found that when such a surface was charged in the presence of the liquid film to the same potential as in the case where the liquid film did not exist, the number of pin-holes decreased.

The charged photosensitive paper is then passed to an image exposing zone by rollers **16** and **17.** The roller **16** is a roller provided with a flange which holds only the end portion of the photosensitive paper. The image exposing zone is one side of an endless belt **21.** The endless belt **21** is of a permeable material or has a number of holes, and is actuated by rollers **18, 19** and **20.** At the back side of the endless belt **21** in the image exposing zone there is an air evactuating chamber **22,** which adheres the photosensitive layer onto the endless belt through a front slit, and conveys it to the exposure position. Rollers **23** and **23'** are guide rollers which hold only the side end portions of the sheet-like photosensitive paper. When the liquid **7** is applied to both surfaces of the photosensitive paper, it is prefered that the endless belt and the air with drawing device be made of an oil-resistant material, and have filters which adsorb liquid droplets.

The manuscript to be copied is placed on a glass support **24** with the surface to be transferred turned downwards. The manuscript is illuminated by means of light sources **25** and **25'.** The light image is formed, by means of a reflecting mirror **26** and lens **27,** onto the photosensitive layer surface, the flatness of which is maintained by being drawn onto the endless belt. The image exposure light may be a stationary exposure light or a scanning exposure light.

After the termination of image exposure, the photosensitive paper is then conveyed to the developing area of the apparatus. Rollers **28** and **28'** are guide rollers, roller **28** being a roller with a flange disposed in a manner that it holds only the end portion of the photosensitive paper. Liquid developer **29** contained in a vessel **30** is scooped up by means of a pump (not shown in the drawing) and is sprinkled from nozzles **31** onto the upper surface of developping rollers **32** which rotate synchronized with the transportation speed of the photosensitive paper. **33** is a developing electrode disposed so as to not contact the surface of the photosensitive paper. Rollers **34** are guide rollers. Rotary developing rollers **32** are all provided with flanges disposed in a manner that only the end portions contact the photosensitive paper. However, if the photosensitive paper has a finely roughened surface, the surface of the photosensitive paper is allowed to contact the developing rollers **32.** As for developing rollers **32** and developing electrode **33,** it is prefered that their surfaces be electrically conductive, and they be grounded in the posi.-

posi. process. It is not advisable that the surface of the photosensitive paper, rollers **32** and electrode **33** make direct electrical contact. In reversal development (the nega.-posi. process), a biasing voltage is impressed between the roller **32**, the electrode **33**, and the photosensitive paper. **35** is a guide plate which determines the conveying path of the sensitive paper. **36** is a cover which prevents volatilization of the carrier liquid in the liquid developer.

Liquid developer **29** can be any well known developer which contains fine toner particles dispersed in a carrier liquid having high electric resistance. Typical of such developers are those wherein a pigment is dispersed with dispersion stabilizer and electric charge controller in a carrier liquid such as cyclohexane, decalin, kerosene, mineral spirits, gasoline, isoparaffin series solvents, chlorofluorohydrocarbon solvents, and the like.

The inventors of the present invention have found that when an electrostatic latent image is formed on a photosensitive paper having a liquid film of insulating liquid **7** thereon, an image of high optical density is obtained, compared to the case in which the image is formed on a photosensitive paper which has an electrostatic image of the same potential and no liquid film. This is believed to be due to the fact that the latent image is protected from the attack of ionic substances or impurities in the developer, and the life of the latent image is thereby prolonged.

After the termination of the development, photosensitive paper is passed between a pair of squeezing rollers **37** and **37'** and excess developer wetting the surface of the photosensitive paper is removed.

It is effective to obtain better images to wash the photosensitive paper after development with an insulating liquid which does not contain toner when the photosensitive paper is still moistened with developer.

The sheet-like photosensitive paper is then dried by an air stream coming from a fan **39** in drying zone **38.** If an air stream which has been used to cool the light sources **25** and **25'** is utilized, drying is further accelerated.

Although concern would exist about decreasing resolving power due to turbulence of the image due to the presence of liquid when a photosensitive paper having liquid film on its surface is used, from experimental results it has been found that such a defect is not a practical problem. On the contrary, it has been found that the resolving power is increased because of decrease of fog, a rise in image density and unlikelihood of charging uneveness and the like. Further, it has been found that images having less defects are obtained as compared to a process wherein a photosensitive paper is charged and a liquid film is provided after image exposure (for example, a process as disclosed in British Pat. No. 1118812 and United States Pat. No. 3512965). This is due to the difficulty in providing a liquid film uniformly on the surface of a dried photosensitive paper having an electrostatic latent image. It has been found that the provision of liquid film on the surface of the photosensitive paper before charging (as in the present invention) was rather easy, and the latent image was not damaged.

In FIGS. **2** to **4**, examples of other forms of the apparatus in which an insulating liquid is applied onto a photosensitive paper prior to electrostatic charging are shown.

In FIG. **2**, the insulating liquid **7** is contained in a vessel **41** provided with a stop cock **40** in the upper portion thereof. When the apparatus is put into operation, the stop cock **40** is opened. The liquid **7** passes through a porous body **42** (for example, felt) situated at the bottom of the vessel **41**, and is applied to the photosensitive paper **2** which is moving from left to right. The surface of photosensitive paper to which the liquid **7** is applied is naturally the surface of the photosensitive layer side. Thus, a liquid film **43** is formed on the surface of the photosensitive paper. The stop cock **40** is closed when the apparatus is out of operation, and prevents the natural flow of liquid **7.**

In FIG. **3**, the container is provided with two rollers **44** and **45** at its bottom. By the rotation of these rollers, the insulating liquid **7** is conveyed onto the surface of photosensitive paper, and a liquid film **43** is formed.

FIG. **4** shows apparatus in which a liquid film is formed on both sides of the photosensitive paper. The latter is conveyed into the insulating liquid **7** by means of guide rollers **46** and **47.** The photosensitive paper **2**, guided by roller **48** and guide plate **49** then passes between squeezing rollers **50** and **51.** The thickness of the liquid film formed on the front back side of the photosensitive paper is determined by the pressure between the squeezing rollers. In this apparatus the occurence of fog on the back side of photosensitive paper is also prevented.

As has been mentioned above in detail, since the insulating liquid layer is formed before charging in the present invention, a duplication image is obtained in which fog is remarkably reduced, having few pin-holes, and the image density is extraordinarily high, compared to conventional duplicators where the same photosensitive paper and the same liquid developer are used. Further, in this apparatus an insulating liquid is applied onto the surface of a web-like photosensitive paper before it is cut into sheets and chips are not produced at all, and do not scatter. Accordingly, even when the duplication is repeatedly effected many times, the interior of the apparatus remains remarkably clean, and any problem as mentioned above due to cutting chips does not occur. In other words, various problems such as extremely moisture-absorbent cutting chips attaching to metallic ("rust") insulation of electric circuits being damaged, uneveness of charge cutting chips attaching to the optical system reflecting mirror being corroded, etc., are all solved by the apparatus of the present invention.

What is claimed is:

1. An electrophotographic apparatus characterized by means for coating a photosensitive layer surface of a web-like photosensitive electrophotographic paper with a liquid having high electric resistivity and low dielectric constant and miscible with a carrier liquid of an electrophotographic developer, means for cutting said photosensitive paper while said paper is still wet with a layer of said liquid having high electric resistance, said paper being cut into sheets of a determined length, means for effecting corona discharge of the surface of said photosensitive layer of said cut paper so as to charge said photosensitive layer, means for image-exposing the photosensitive layer and means for applying liquid developer containing toner to the surface of said image-exposed photosensitive layer, said aforementioned means being disposed in the order of the above enumeration along the transporting path of said

photosensitive paper, whereby upon cutting of said paper, dust like particles of said paper are not scattered due to the effect of said layer of said liquid having a high electric resistance.

2. The apparatus of claim **1** where said liquid layer as an electric resistivity greater than 10^{12} Ω cm and a dielectric constant less than 3.5.

3. The apparatus of claim **1** where said means for applying the liquid developer applies the developer while said paper is still wet with said liquid having a high electrical resistivity.

4. In apparatus for producing an electrophotographic image, said apparatus comprising means for cutting a photosensitive paper, means for corona discharging the surface of said photosensitive paper, means for image-exposing said charged surface and means for developing said image-exposed surface with a liquid developer containing toner, the improvement comprising means for coating the surface of said photosensitive paper with a liquid having a high electric resistivity, a low dielectric constant and miscible with the liquid developer, said liquid coating means being disposed along the path of said paper and prior to the means for cutting said paper, said cutting means being so positioned with respect to said liquid coating means that the paper is cut while it is still wet with a layer of said liquid having a high electric resistivity so that upon cutting the said paper, dust like particles are not scattered due to the effect of said liquid having a high electric resistance, low dielectric constant and which is miscible with said liquid developer.

5. The improvement of claim **4** wherein the electric resistivity is greater than 10^{12} Ωcm and the dielectric constant is less than 3.5.

6. The improvement of claim **4** wherein said liquid film is coated to a thickness of 0.1 μ to 800 μ.

7. The improvement of claim **6** wherein said thickness is 0.3 μ to 300 μ.

8. The improvement of claim **4** wherein said developer liquid comprises a carrier liquid and toner.

9. The improvement of claim **4** where said developing means develops said surface while it is still wet with said liquid having a high electrical resistivity.

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