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[54] **CORONA DISCHARGE DEVICE FOR REMOVING DIELECTRIC LIQUID**


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[30] **Foreign Application Priority Data**

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[51] **Int. Cl.** .......................................... **H05b 7/18**

[58] **Field of Search** .................... 219/216, 383, 384, 219/348, 349; 34/1



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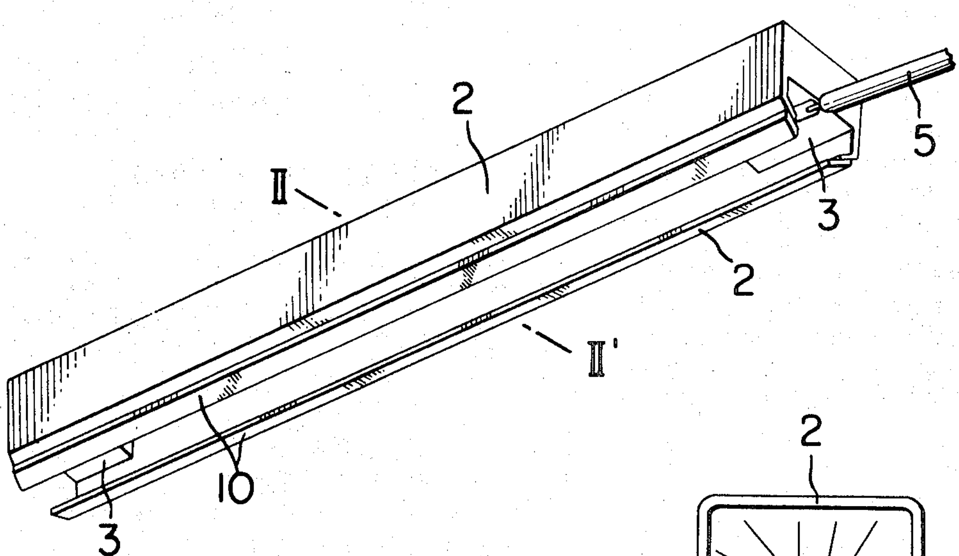
[57] **ABSTRACT**

A device for removing dielectric liquid from a holder member for a photosensitive medium or the like used in an electrophotographic copying machine includes a corona discharging electrode, a shield member substantially surrounding the corona discharging electrode in electrically isolated relationship therewith and having at least a discharge opening, corona discharge converging means provided adjacent to the discharge opening of the shield member, and a power source from which a voltage is applied to the corona discharge electrode.


**11 Claims, 7 Drawing Figures**



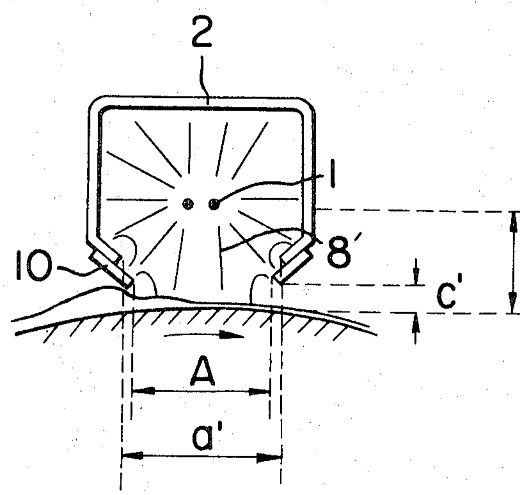
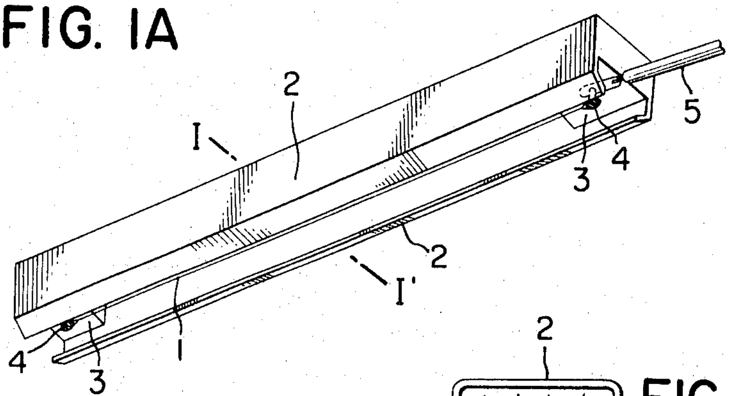



FIG. 1A



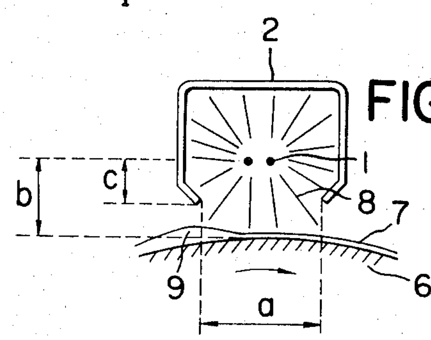
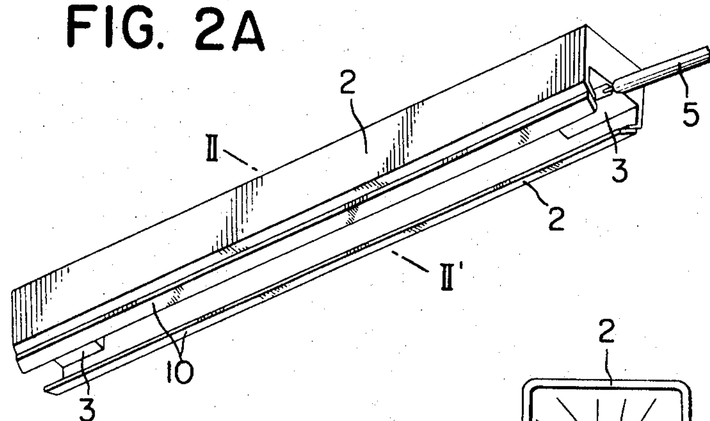




FIG. 1B

FIG. 2A



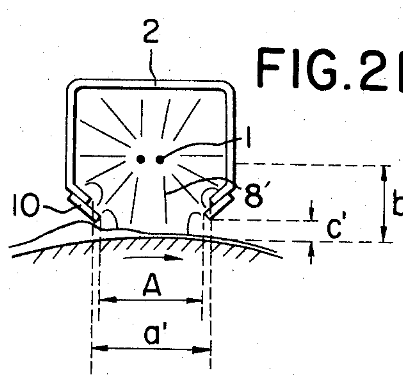




FIG. 2B

FIG. 3

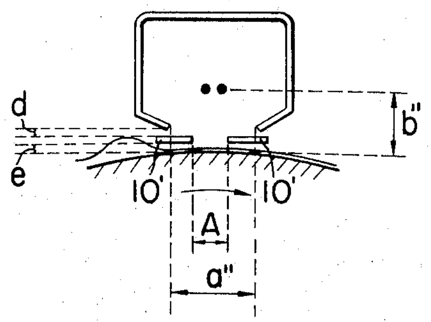



FIG. 4

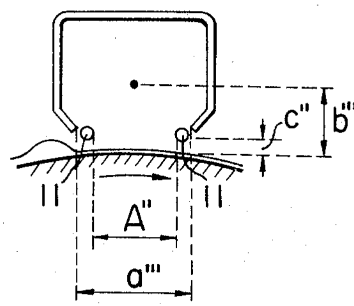
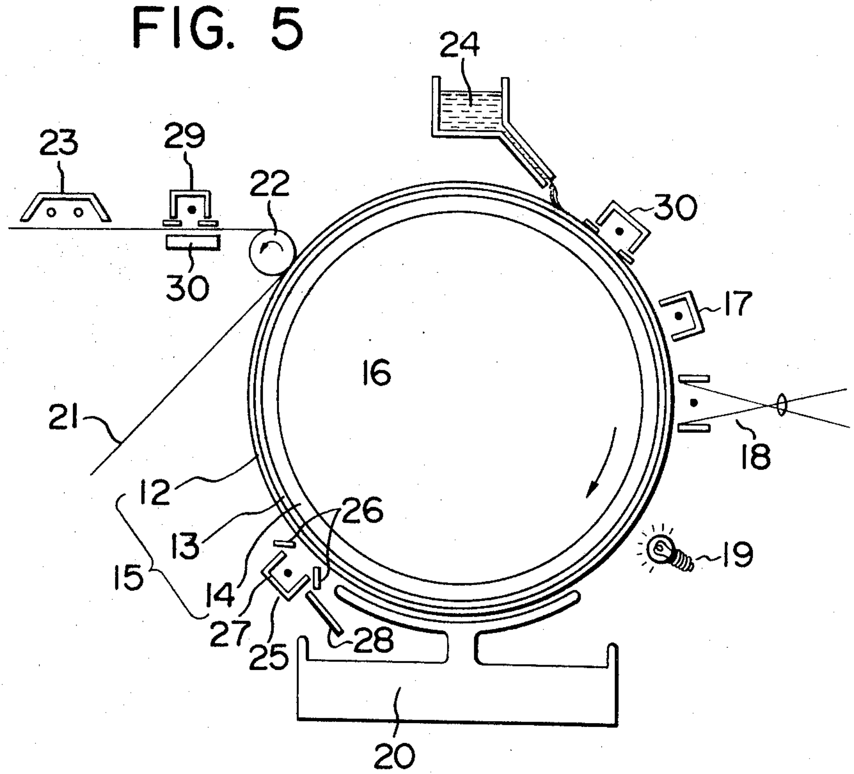



FIG. 5



## CORONA DISCHARGE DEVICE FOR REMOVING DIELECTRIC LIQUID

### BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a device for removing dielectric liquid which utilizes corona discharge to remove excess dielectric liquid which may be present on a photosensitive medium or sheet or a transfer medium during the copying process in various types of electrophotography. More particularly, the dielectric liquid to be removed by the device of the present invention may include excess liquid developer which may be present on a photosensitive medium after an electrostatic latent image formed on the surface thereof is liquid-developed but before the developed image is transferred to a transfer medium or which may be present on such transfer medium after the image transfer is done, or cleaning liquid which may be residual on the surface of the photosensitive medium after the developing liquid remaining on the image-transferred photosensitive medium is washed with the cleaning liquid. The device of the present invention for removing dielectric liquid may also be applicable to remove excess developing liquid which may be present on the surface of a photosensitive sheet after an electrostatic latent image formed thereon is liquid-developed but before it is fixed.

2. Description of the Prior Art

In the electrophotographic copying machines of the wet and transfer type, it is generally the practice to develop an electrostatic latent image on the surface of a photosensitive medium with the aid of liquid developer, transfer the developed image onto a transfer medium and fix the transferred image. After the image transfer process, the photosensitive medium has residual developer thereon washed away with cleaning liquid at a cleaning device to make the photosensitive medium ready for reuse. In such conventional electrophotographic processes, the transferred image on the transfer medium has suffered from fogs or blurs formed in its areas corresponding to the light areas of the original image, thus resulting in a very poor definition and hence ugliness of the final copy image. Such adverse effect may be attributable to excess developing liquid which usually may contain at least toner and carrier and which may be residual on the surface of the photosensitive medium after the electrostatic latent image thereon has been developed, and to the fact that some of the toner particles contained in such developing liquid tend to be suspended in the other areas of the photosensitive surface than the image-bearing area thereof and remain fixed to such areas. Also, in the electrophotography of the transfer type, the aforesaid adverse effect may be attributed to the fact that the suspended toner particles tend to be transferred and fixed to the non-image-bearing portion of the transfer medium during the image transfer process or to the fact that the toner particles once attracted to the image-bearing portion are caused to flow with carrier from the image-bearing portion to the non-image-bearing portion due to the pressure applied during the image transfer operation. In addition, the amount of developing liquid transferred from the photosensitive medium to the transfer medium may contain a substantial amount of excess carrier, which would generate a great deal of carrier gas when the transfer medium is heated at a dryer, such gas being very harmful hygienically.

For these reasons, the prior art has provided squeeze rollers or like means disposed with respect to the photosensitive medium so that the excess developing liquid on the photosensitive medium may be squeezed out after the development process. The use of such squeeze rollers, however, has necessarily disturbed the formed image in the same way as experienced during the aforesaid image transfer process, and this also holds true with the case where similar squeeze rollers are used to remove the excess developing liquid remaining on the transfer medium. In order to collect the cleaning liquid once used to wash the residual developer away from the surface of the photosensitive medium after the image transfer, use has heretofore been made of a blade, roller or other means disposed in contact with the surface of the photosensitive medium, but this system has been apt to injure the photosensitive medium and accordingly reduce its service life.

In the case of a photosensitive sheet, the use of squeeze rollers for removing the excess developer from the surface thereof after an electrostatic latent image formed thereon is developed has likewise imparted disturbance to the formed image, and whenever a heat drying process is effected without being preceded by a squeezing process, the carrier contained in the developer on the photosensitive sheet will produce gases which are hygienically very harmful.

### SUMMARY OF THE INVENTION

It is therefore a principal object of the present invention to provide an improved device for removing dielectric liquid used in an electrophotographic copying apparatus which can remove excess dielectric liquid remaining on a photosensitive medium without injuring the latter.

It is another object of the present invention to provide an improved device of the described type which can cause an electrostatic latent image formed on the photosensitive medium to be developed and fixed thereon and simultaneously can remove the carrier liquid with toner particles suspended therein.

It is still another object of the present invention to provide an improved device of the described type in which corona discharge is applied to the dielectric liquid remaining excessively on the surface of the photosensitive medium to remove such liquid therefrom.

It is yet another object of the present invention to provide an improved device of the descirbed type in which the corona discharge applied to the excess dielectric liquid remaining on the surface of the photosensitive medium need not be raised in potential to efficiently remove such liquid from said surface.

It is yet still another object of the present invention to provide an improved device of the described type in which either dielectric members or electrically conductive members electrically isolated from any other member are provided adjacent to the discharge opening of a corona discharger for applying a corona discharge to the excess dielectric liquid remaining on the surface of the photosensitive medium, whereby the width of the corona discharge is narrowed so as to intensify the corona discharge and accordingly enhance the removal effect of the dielectric liquid.

The device for removing dielectric liquid according to the present invention will be outlined hereunder.

The device of the present invention is applicable in electrophotographic copying machines and intended to remove dielectric liquid from a holder member by applying a corona discharge of any desired polarity to the holder member from one or the other surface thereof, which holder member may include a photosensitive medium or sheet from which a liquid-developed image is to be transferred to other medium and which carries excess developing liquid still left thereon after the liquid development process, a photosensitive medium from which an image is to be transferred to other medium and which carries cleaning liquid still left thereon after washed with the cleaning liquid, and a transfer medium which has received a liquid-developed image and carries excess developing liquid still left thereon. Thus, a layer of such residual dielectric liquid is electrically charged progressively from one surface thereof toward the other, to thereby create a concave recess or self-squeezing effect in the liquid surface. As the result, the residual liquid may almost completely gather together into a bulged body for ready removal. Particularly, the corona discharge applied to the developing or the cleaning liquid residual on the surface of a photosensitive medium causes the surface to be also electrically charged, with a resultant strong electric field produced at the end of the charged surface area to further increase the self-squeezing tendency of the liquid and enhance its removal effect. The body of dielectric liquid self-squeezed in this way may then be removed as by suction or other removal means.

Reference will now be made to the polarity of the corona discharge as applied to the dielectric liquid overlying the holder member for the removal thereof. Where the subject of the application of corona discharge is a developing liquid once used to develop an electrostatic latent image formed on the surface of a photosensitive medium, the polarity of the corona discharge may preferably be the same as the polarity of the toner contained in such liquid. The reason is that the corona discharge of the same polarity as that of the developing toner forces the toner particles against the surface of the photosensitive medium while squeezing the toner particles without disturbing the image on the photosensitive medium. However, where the toner particles are intensely or strongly attracted to the electrostatic latent image on the photosensitive surface, the polarity of the corona discharge applied to the liquid for the removal thereof may be opposite to the polarity of the developing toner, with a good result and without any disturbance imparted to the image. Thus, either polarity may be available for a good removal effect, although this depends more or less upon the situation. Where it is desired, as usual, to squeeze and remove dielectric liquid such as cleaning liquid or the like, the polarity of the corona discharge to be applied to such liquid may be freely selected.

While the corona discharge has hitherto been described as that of DC voltage, an AC voltage has empirically been found usable to obtain a sufficient removal effect.

In order that the removal effect of dielectric liquid from the holder member through the application of corona discharge thereto may be further enhanced, it is necessary to apply certain additional means to the ordinary corona discharger. One such additional means may be provided as by raising the voltage to be applied to the corona discharging electrode or by disposing the corona wire adjacent to the holder member. However, such means will of necessity cause an intensified charge of the photosensitive medium which in turn would cause undesirable effects such as spark discharge, destruction of the dielectric layer in the photosensitive medium, etc. It is thus desirable to achieve a successful squeezing effect of dielectric liquid without resorting to a raised discharge potential. The studies caried out on the removal of dielectric liquid from the holder member show that the corona discharge must be abruptly applied to obtain an efficient squeezing effect. In other words, even if application of a corona discharge has increased or intensified the charge potential of the dielectric liquid, the resultant squeezing effect of the liquid will be very weak as long as the charging takes place over a wide range of area. In contact, even a lower discharge potential may result in a greater squeezing effect if the corona discharging takes place abruptly in a narrow range of area. Based on the recognition of these facts, the present invention provides either dielectric members or electrically conductive members electrically isolated from any other member in the vicinity of the discharge opening in the corona discharger, to thereby enable corona discharge to be abruptly effected in a narrow range of area. Thus, the charge from the corona discharging electrode to the holder member, even if its discharge potential is lower, may be much greater in quantity and intensity and may result in a much better removal effect of the dielectric liquid, than in the case where none of said members is provided in the neighborhood of the corona discharge opening.

## BRIEF DESCRIPTION OF THE DRAWINGS:

The invention will be described more particularly with reference to the accompanying drawings, in which;

FIG. 1A is a perspective view of the device for removing dielectric liquid according to an embodiment of the present invention;

FIG. 1B is a cross-sectional view taken along lines 1—1′ of FIG. 1A;

FIG. 2A is a perspective view of an improved embodiment of the device for removing dielectric liquid according to the present invention;

FIG. 2B is a cross-sectional view taken alsong lines II—II′ of FIG. 2A;

FIGS. 3 and 4 are cross-sectional views showing modifications, respectively, of the FIG. 2 embodiment; and

FIG. 5 is a schematic view for illustrating the construction of an electrophotographic copying apparatus to which the device of the present invention has been applied.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. 1A and B, the illustrated device for removing dielectric liquid is substantially the same as the corona discharger which has conventionally been used in an electrophotographic copying apparatus. The device includes a corona discharging electrode 1, a grounded shield member 2 formed with a discharge opening, supporting blocks 3 mounted on the shield member at the opposite ends thereof, and supporting pins 4 provided in the blocks 3 for supporting the corona wire 1 extending therebetween. A high voltage may be applied to the corona wire 1 through a power supply line 5. Referring particularly to FIG. 1B, which is a cross section taken along lines I—I' of FIG. 1A, a holder member for a photosensitive or a transfer medium, designated by numeral 6, may be moved in the direction as indicated by arrow. A layer of dielectric or insulative liquid 7, which may be developing liquid or cleaning liquid, is present over the outer surface of the photosensitive or the transfer medium. The device for removing dielectric liquid is disposed with its discharge opening opposed to the dielectric liquid. When supplied with a high voltage, the corona wire 1 produces lines of electric force, as designated at 8, which are shown to be relatively wide-angled with respect to the holder member. The corona discharge charges the dielectric liquid over the holder member so that the charges of the same polarity produced in the dielectric liquid repulse one another or an electric field is produced by the charges on the holder member, and this seems to produce a result that the liquid self-squeezes to gather as at 9 for removal.

Referring now to FIGS. 2A and B, of which FIG. 2B is a cross section along lines II—II' of FIG. 2A, the parts designated by 1, 2, 3, 4 and 5 are substantially the same as those designated by similar numerals in FIG. 1, except that the shield member 2 is provided with dielectric members 10 attached to the opening edges thereof as by bonding or other means. The dielectric members 10 so attached to the shield member 2 serve to provide a narrower width over which the lines of electric force 8' are produced from the corona discharge electrode 1 onto the holder member, than in the case of FIG. 1. When the same voltage as that applied to the discharger of FIG. 1 was experimentally applied to the corona discharging electrode 1 of FIG. 2 for the purpose of removing the residual dielectric liquid, the result was that the holder member after subjected to such liquid removing operation showed much less of residual liquid than in the case of FIG. 1. This is believed attributable to the fact that corona discharge is abruptly effected within the reduced width to enhance the removal effect. Also, in FIG. 2, the dielectric members 10 may be formed of metal or other electrically conductive material, with substantially the same result attained, provided that these members 10 are sufficiently insulated from the grounded shield member 2 and the like.

FIGS. 3 and 4 show modifications of the FIG. 2 embodiment. In FIG. 3, dielectric members 10' are positioned in spaced apart relationship from the opening edges of the shield member 2 and in parallel relationship with the holder member 6. This arrangement has again been found to provide good removal of the dielectric liquid residual on the holder member.

In FIG. 4, dielectric members of rod-like shape are disposed in parallel relationship with the discharger, as indicated at 11, and this arrangement may attain as good a result as that attained by the previous embodiments. Again in this case, the dielectric members 11 may be formed of metal or other electrically conductive material and electrically isolated from the shield member 2, to thereby obtain the same result.

Referring now to FIG. 5, there is shown an example of the electrophotographic copying apparatus which has incorporated the device of the present invention. With this apparatus, an electrostatic latent image may be formed on the outer surface of a drum 16 in a conventional manner. A dielectric layer 12, a photoconductive layer 13 and an electrically conductive support layer 14, disposed one upon another, constitute a photosensitive medium 15, which is carried on the drum 16. The surface of the photosensitive medium 15 may be uniformly charged by a primary charger 17, subsequently subjected to simultaneous application of image light and secondary charge opposite in polarity to the primary charge or AC corona discharge by a corona-discharge and exposure means 18, and then, if required, subjected to overall exposure at 19 to thereby form an electrostatic latent image on the surface of the photosensitive medium. Such an electrostatic latent image may be developed by a liquid developing device 20, and then the visible image may be transferred onto a transfer medium 21 with the aid of transfer roller 22 and fixed to provide a permanent copy by fixing means. Thereafter, the surface of the photosensitive medium 15 may be washed with cleaning liquid 24 so that it may be reused.

In the copying apparatus described above, the device of the present invention for removing dielectric liquid is designated by numeral 25 and disposed behind the developing device 20 as viewed in the direction of movement of the drum 16, so that the residual developing liquid on the surface of the photosensitive medium may be efficiently removed therefrom in the described manner, without the developed image being disturbed. If the removing device is of the type as shwon in FIG. 1 or 2, the residual liquid will be caused to bulge or build up locally as indicated at 9 in FIG. 1B, and such bulged or built-up liquid would contact the opposed edge of the device and flow into the hollow of the shield member to stain the same.

To avoid this, a clearance may be provided between each corona ion converging member 26 and shield member 27 so that the liquid in contact with the converging members 26 may flow down along these members 26 and thence along a guide 28 for collection into the developer container 20. The formed image on the drum 16 may be fixed either immediately thereafter or after once transferred.

With such an arrangement, both the removal and collection of the dielectric carrier liquid remaining on the photosensitive medium may be achieved with high efficiency and without contaminating the discharger.

Where image transfer takes place without the liquid removal being done after the liquid development process, a device of the present invention may be disposed with respect to the transfer medium, as indicated at 29, to thereby remove the developing liquid from the transfer medium and also facilitate the fixing operation which is to follow. An electrode 30 may be disposed in opposed relationship with the back side of the transfer medium and just below the device 29, and this electrode may be grounded. At the cleaning station subsequent to the transfer process, a device of the present, instead of a blade, may be provided as at 31 for removing cleaning liquid from the surface of the photosensitive medium so as to make it suitable for reuse.

Various forms of the present invention have been described above with reference to FIGS. 1 to 4. Examples of carrying out these embodiments will now be shown below.

In FIG. 1, the width *a* of the discharge opening in the shield member 2 was 20 mm, the distance *b* between the discharging electrode 1 and the surface of the holder member 6 was 12 mm, and the distance *c* between the lower edge of the shield member **6** and the surface of the holder member was 5 mm. A voltage of −6.5 KV was applied to the discharging electrode **1** with the holder member **6** moved at a rate of 16 cm/sec in the direction of arrow and carrying thereon a layer of dielectric liquid (with a resistivity of $10^{13}$ Ω cm) as thick as approximately 100 microns. The result was that only **20** microns of dielectric liquid was left on the surface of the holder member **6.**

Next, in FIG. **2,** the width a' of the discharge opening in the shield member **2** was 20 mm, the width *A* of the opening defined by the dielectric members **10** was 14 mm, the distance *b'* between the discharging electrode and the surface of the holder member was 12 mm, and the distance *c'* between the lower end of the dielectric member and the surface of the holder member was 2 mm. A voltage of −6.5 KV was applied to the discharging electrode **1** with the holder member moved at the same rate and carrying thereon the same layer of dielectric liquid, as in the previous example. As the result, there was left a layer of dielectric liquid as thin as approximately 10 microns on the surface of the holder member.

In FIG. **4,** the width *a''* of the discharge opening in the shield member **2** was 20 mm, the width *A''* of the opening defined by the dielectric members **11** having a diameter of 2 mm was 15 mm, the distance *b'''* between the discharging electrode and the holder member was 12 mm, and the distance *c''* between the dielectric members and the holder member was 3 mm. A voltage of +7.0 KV was applied to the discharging electrode with the holder member moved at a rate of 12 cm/sec in the direction of arrow and carrying thereon a layer of dielectric liquid (with a resistivity of $10^3$ Ω cm) as thick as approximately 80 microns. The result was that a layer of dielectric liquid as thin as about 15 microns was left on the durface of the holder member.

While various examples of the invention have been shown above with specific numerical data given together, importance must be attached to these two points; (1) that the distance between the lower end of the corona discharge converging members and the surface of the holder member should be no greater than about 5 mm, and a smaller value for such distance would result in an enhanced removal effect; and (2) that the vertical distances from the corona converging members and from the corona discharging electrode to the surface of the holder member should be no greater than 10 mm, most preferably in the vicinity of 5 mm. The other numerical values shown above are not restrictive but various values in a considerably wide range are also applicable to carry out the present invention.

It will thus be appreciated that the use of the device of the present invention for removing the dielectric liquid staying on the holder member may lead to the advantages which will be mentioned hereunder. There is no possibility of damages or injuries being imparted to the surface of the holder member, especially of the photosensitive medium or sheet. Efficient removal of dielectric liquid may be ensured irrespective of the low voltage applied to the corona discharge wire of the liquid removing device, which in turn leads to the elimination of spark discharge which might otherwise occur on



the surface of the photosensitive medium to destroy the dielectric layer thereof, and further to an economical advantage in the cost of operation. Moreover, the removal of the developing liquid from the surface of the photosensitive medium may be effectively achieved without adversely affecting the toner image which is acting to develop an electrostatic latent image. The last-mentioned effect, in particular, has been enhanced by disposing the corona discharge converging members in proximity to the corona discharge opening, thus ensuring that the developed image after subjected to such a removing process is entirely free of fogs.

We claim:

**1.** A device for removing dielectric liquid from a holder member for a photosensitive medium or the like, comprising, in combination:

a corona discharging electrode;

a shield member, means mounting said shield member adjacent to said electrode, said shield member substantially surrounding said electrode in electrically isolated relationship therewith and having at least a discharge opening;

corona discharge converging means, means mounting said corona discharge converging means adjacent to said discharge opening of said shield number; and

a power source for applying a voltage to said corona discharge electrode.

**2.** A device according to claim **1,** wherein said shield member is formed of electrically conductive material and grounded.

**3.** A device according to claim **2,** wherein said converging means comprises dielectric members attached to said shield member adjacent to said discharge opening thereof.

**4.** A device according to claim **2,** wherein said converging means comprises dielectric members disposed in spaced apart relationship from said shield member and adjacent to said discharge opening thereof.

**5.** A device according to claim **2,** wherein said converging means comprises electrically conductive members attached to said shield member adjacent to said discharge opening thereof

but in electrically isolated relationship from said shield member.

**6.** A device according to claim **2,** wherein said converging means comprises electrically conductive members disposed in spaced apart relationship from said shield member and adjacent to said discharge opening thereof but in electrically isolated relationship from said shield member.

**7.** A device according to claim **1,** wherein said converging means is in the form of plate.

**8.** A device according to claim **1,** wherein said converging means is in the form of rod.

**9.** A device according to claim **1,** wherein said power source is an AC source.

**10.** A device according to claim **1,** wherein said power source is a DC source.

**11.** A device according to claim **1,** wherein said converging means acts to conduct the removed dielectric liquid therethrough.

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