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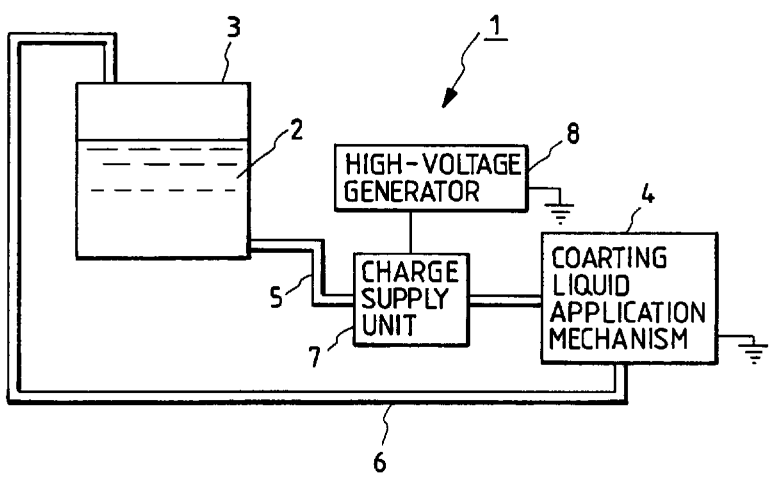
(54) **An electrophotographic photoreceptor manufacturing method**

(57) An electrophotographic photoreceptor manufacturing method by applying at least one layer selected from an under coat layer, a photosensitive layer, and a top coat layer to a substrate of an electrophotographic photoreceptor of an electronic copier is disclosed, wherein charge, which is caused due to flow or friction of a coating liquid before or in applying coating liquid to an original pipe, is discharged, neutralized, or inversely charged.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

This invention relates to an application method of a coating liquid and more particularly to a method of controlling a charge state at the application time for providing a uniform coating film with no defect.

Hitherto, dip coating application, ring application, blade application (the Japanese Patent Application Nos. Hei 5-346548, Hei 6-101289, and Hei 7-47172), roll application, curtain application, ultrasonic dispersion application, air nozzle application, pressure nozzle application, electrostatic spray application, multinozzle application (the UnExamined Japanese Patent Application Publication Nos. Sho 59-196781 and Hei 3-193161), and the like (the Examined Japanese Patent Application Publication No. Hei 5-67345, the Unexamined Japanese Patent Application Publication No. Sho 50-90404, the Japanese Patent Application Nos. Hei 6-10128 and Hei 7-47172) have been known as methods of uniformly applying paint, a coating agent, a photo masking agent, or a functional coating film formation material, etc., of a charge generation layer, a charge transfer layer, etc., of a photosensitive drum for an electronic copier. Among them, the application method actively considering static electricity is only the electrostatic spray application. However, the electrostatic spray application is utilized only in the application for the cars, and is not utilized in manufacturing an electrophotographic photoreceptor.

However, in every application method, a coating liquid is supplied and circulated and contact, friction, flow, etc., occurs accompanying the application operation. In the actual application process, except when a conductive coating liquid is used, static electricity occurs and its charge largely affects formation of a coating film.

For example, occurrence of static electricity affects a coating liquid flow and leveling performance; for a dispersion coating liquid, the disPersion state is changed.

For the conventional application methods, sufficient consideration is not given to the phenomena, leading to a large cause of a film defect and unevenness of a coating film.

Flow charge of a coating liquid is very unstable and it is not rare that charge magnitude changes and that the polarity is also inverted depending on piping conditions, spout conditions into air, etc.

For example, pigment particles dispersed in a charge generation coating liquid for an electrophotographic photoreceptor normally is charged negatively in zeta potential measurement.

On the other hand, if a charge generation coating liquid is caused to flow through a Teflon or stainless steel pipe, generally it is charged positively as a whole. If the positively charged charge generation coating liquid is dropped on an aluminum and polyester sputtered sheet (alpet sheet) and a thin film is formed, occurrence of ununiformities in density based on a group move of a pigment during air drying is observed. It is considered that ununiformities in density occur because the whole liquid is charged positively, thereby raising mobility of the pigment; change in the attraction amount of a binder polymer is also guessed.

In the blade application method with a nozzle and a blade formed in one piece, if an aluminum face of an aluminum-polyester sputtered sheet is used on the blade surface for conduction, for example, to apply a charge transfer layer coating liquid of a photosensitive drum for an electronic copier, if the blade moves spirally on the drum during the application of the coating liquid, the spiral trace when the blade edge leaves the coated face is not leveled and may remain clearly unlike application of conductive paint. It is guessed that charge causes a coagulation phenomenon to occur. The pigment in the coating film holding fluidity becomes ununiformities in density or generates spiral thin and dense streaks corresponding to the running pitch of the blade.

Further, spout of a liquid from the nozzle is disordered because the liquid is charged, and a uniform spout cannot be executed although a metering pump is-used to spout the liquid.

SUMMARY OF THE INVENTION

The inventor et. al have studied in order to provide a uniform coating film. Resultantly, the inventor et al. have solved the above-mentioned problem of coating ununiforinities by discharging, neutralizing, or inversely charging coating liquid charge.

That is, the invention is characterized by

(1) An electrophotographic photoreceptor manufacturing method comprising the steps of applying at least one layer selected from an under coat layer, a photosensitive layer, and a top coat layer to a substrate of an electrophotographic photoreceptor of an electronic copier and manufacturing an electrophotographic photoreceptor, characterized in that charge produced due to flow or friction of a coating liquid before or when the coating liquid is applied to a substrate is discharged, neutralized, or inversely charged.

Further, in the electrophotographic photoreceptor manufacturing method, the invention is characterized by

(2) An electrophotographic photoreceptor manufacturing method comprising the steps of supplying a coating liquid from a coating liquid storage tank via piping to a coating liquid application mechanism and applying the coating liq-

uid, characterized in that a charge supply unit is disposed in a part of the piping, that charge of the coating liquid supplied from the coating liquid storage tank is removed or inversely charged, and that the resultant coating liquid is supplied to a coating supply mechanism and is applied;

(3) An electrophotographic photoreceptor manufacturing method comprising the steps of providing a smoothing member, abutting the smoothing member elastically against a substrate, and smoothing a coating liquid spouted from a coating liquid spout port by the smoothing member, characterized in that at least the smoothing member contact face to a coating film is formed of a conductive material and is electrically grounded; and

(4) An electrophotographic photoreceptor manufacturing method comprising the steps of supplying a coating liquid showing flow charge from a nozzle and applying to a surface of a substrate, abutting a blade elastically against the substrate surface, and sliding the blade, thereby applying and spreading the coating liquid, characterized in that the nozzle and/or blade, which is electrically insulated from other components, is made conductive and that charge opposite to flow charge is applied.

A substrate described in the specification is an electrically conductive substrate, the substrate coated with an under coated layer, or the substrate coated with a photosensitive layer et al. The substrate is a semi-manufacturing which should be coated in the following procedures.

BRIEF DESCRIPTION OF THE DRAWING

In the accompanying drawings:

Fig. 1 is a block diagram to show a basic configuration of a coating liquid application method of the invention;
Fig. 2 is a longitudinal sectional view to show an example of a charge supply unit;
Fig. 3 is a partially cutaway perspective view to show another example of a charge supply unit;
Fig. 4 is a perspective view of a unit to show an application example of an application method of the invention to applying of a coating liquid to an electrophotographic photosensitive drum;
Fig. 5 is a perspective view to show a coating liquid application blade;
Fig. 6 is a sectional view of a portion of applying a coating liquid to a photosensitive drum;
Fig. 7 is a longitudinal sectional view of a unit for applying the coating liquid application method of the invention to dip coating application;
Fig. 8 is a perspective view to show a coating liquid application system of the invention;
Figs. 9A and 9B are views to show a coating liquid application portion; Fig. 9A is a sectional side view and Fig. 9B is a rear view;
Fig. 10 is a sectional side view to show another example of a coating liquid application portion;
Fig. 11 is a sectional side view to show still another example of a coating liquid application portion;
Figs. 13A and 13B show an embodiment of a blade; Fig. 13A is a perspective view and Fig. 13B is a partially longitudinal sectional view;
Fig. 14 is a perspective view to show another example of a blade; and
Fig. 15 is a perspective view to show an embodiment of applying the invention to an electrophotographic photoreceptor.

[Explanation of Reference Numerals]

1:	Coating liquid application system
2:	Coating liquid
3:	Coating liquid storage tank
4:	Coating liquid application mechanism
5:	Piping
6:	Return pipe
7:	Charge supply unit
8:	High-voltage generator
10:	Tubular body
11:	Electrode
13:	Insulating body
15:	Substrate
17:	Rotation shaft
18:	Gear
19:	Motor
20:	Flange

21: Support plate
22: Guide rod
25: Gear drive motor
27: Moving body
29: Nozzle
30: Smoothing member
30a: Coating liquid contact face
38: Coating liquid spout port
40: Piano wire
41: Support member
48: Application system
47: High-voltage generator
46: High resistor

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the invention, we will discuss an electrophotographic photoreceptor manufacturing method comprising the steps of supplying a coating liquid from a coating liquid storage tank via piping to a coating liquid application mechanism and applying the coating liquid, characterized in that a charge supply unit is disposed in a part of the piping, that charge of the coating liquid supplied from the coating liquid storage tank is removed or inversely charged, and that the resultant coating liquid is supplied to a coating supply mechanism and is applied.

A coating liquid application system 1 according to the invention has a coating liquid storage tank 3 for storing a coating liquid 2 and a coating liquid application mechanism 4 for applying the coating liquid 2, and the coating liquid storage tank 3 and the coating liquid application mechanism 4 are connected by piping 5 for supplying the coating liquid 2 from the coating liquid storage tank 3 to the coating liquid application mechanism 4, as shown in Fig. 1. (In Fig. 1, a pump is canceled.)

A structure wherein the coating liquid is circulated through a return pipe 6 from the coating liquid application mechanism 4 can be adopted as required.

The coating liquid storage tank 3 is provided to store a coating liquid having adjusted components or add a necessary component for adjusting the composition of the liquid, and is selected in size and structure in response to the purpose of the coating liquid storage tank 3.

The coating liquid application mechanism 4 is provided to uniformly apply the coating liquid 2 to a substrate to be coated and may be an application mechanism of any type of dip coating application, ring application, blade application, roll application, curtain application, ultrasonic dispersion application, air nozzle application, pressure nozzle application, etc.

In the invention, a charge supply unit 7 is disposed in a part of the piping 5 for supplying a coating liquid 2 from the coating liquid storage tank 3 to the coating liquid application mechanism 4, a charge is given to the coating liquid 2 supplied from the coating liquid storage tank 3 to the coating liquid application mechanism 4, and the charge of the coating liquid 2 is erased or inversely charged.

The charge supply unit 7 can be disposed at any desired position of the piping 5 for supplying the coating liquid 2 from the coating liquid storage tank 3 to the coating liquid application mechanism 4; preferably, it is positioned near the coating liquid application mechanism 4. Therefore, it is possible to dispose the charge supply unit 7 at any position between the ends of the piping 5, preferably, it is positioned near the coating liquid application mechanism 4.

The charge supply unit 7 is insulated from the coating liquid storage tank 3, the piping 5, the coating liquid application mechanism 4, etc., and is connected to a high-voltage generator 8 for generating a DC voltage; a high voltage is applied from the high-voltage generator 8 to the charge supply unit 7.

The structure of the charge supply unit 7 is not limited if it gives a charge to the coating liquid. An example of the structure is given in Fig. 2.

In Fig. 2, the charge supply unit 7 takes a double pipe structure and has a tubular body 10 for forming a flow passage of the coating liquid 2 and an electrode 11 so as to surround the tubular body 10 in a spacing outside the tubular body 10. The tubular body 10 and the electrode 11 are formed in one piece via an insulator 12 and the outside of the electrode 11 is covered with the insulator 13 for protection.

Preferably, the tubular body 10 is made of a material having excellent resistance to corrosion, such as stainless steel. However, the material is not limited to it.

The electrode 11 may be made of any material if the material has electric conductivity; generally, copper, aluminum, or the like is used.

The spacing between the tubular body 10 and the electrode 11 is selected in response to the purpose; generally, it is 1 to 20 mm and preferably about 2 to 10 mm. The space may be an air layer or be filled with insulating oil.

The tubular body 10 is connected at both ends to the piping 5, the coating liquid storage tank 3, or the coating liquid application mechanism 4 via insulator pipes 14, 14 containing insulator pipe and the electrode 11 is connected to the high-voltage generator 8 for applying a high voltage to the electrode 11. Other electrodes of the high-voltage generator 8 are grounded.

If the coating liquid 2 is circulated in the tubular body 10 of the charge supply unit 7 and a high voltage is applied to the electrode 11, a charge is induced in the tubular body 10 and is given to the coating liquid 2 circulated in the tubular body 10 and the charge of the coating liquid 2 is erased or the coating liquid 2 is charged to an opposite potential.

The polarity and voltage of the potential to be applied is selected based on the type and the application system of the coating liquid to be used. Generally, they can be empirically selected by observing the coating state. Generally, they are about ± (50 V to 20 kV).

One charge supply unit 7 may be provided or several charge supply units 7 may be provided in series. Two or more tubular bodies can also be provided in series, as shown in Fig. 3.

The application method of the invention can be used preferably for applying electrophotographic photoreceptor requiring high uniformity of coating film.

An application example of the invention will be discussed in detail by taking application of a coating liquid to a cylindrical or columnar substance as an example.

Fig. 4 shows manufacturing by blade application of an electrophotographic photoreceptor to a substrate surface as an example of the application system for executing the application method of the invention. Fig. 7 shows manufacturing of a photoreceptor by dip coating application.

A coating liquid application mechanism 4 of a coating liquid application system 1 shown in Fig. 4 comprises a drive mechanism for horizontally supporting and rotating a cylindrical or columnar substrate (substance to be coated) 15 and a coating liquid supply mechanism moving in the axial direction of the substrate 15 for supplying a coating liquid to the surface of the substrate 15.

The substrate 15 is not limited; a glass tube, an aluminum cut tube, an aluminum die tube, a resin tube, a paper tube, etc., or a pipe provided by executing ground application or ground treatment to any of the tubes, etc., is used for a substrate of an electrophotographic photoreceptor.

The drive mechanism comprises support plates with a bearing 16 and 16 placed vertically left and right in a predetermined spacing, rotation shafts 17 and 17 placed horizontally via bearings disposed in the upper parts of the support plates, a timing pulley 18 being fixed to one of the rotation shafts, a pulley drive motor 19, and a timing belt 9 for transferring rotation of the motor 19 to the pulley 18.

The cylindrical substrate 15 is rotated by using flanges 20 and 20 each formed at the center with a fit hole of the rotation shaft 17 and previously mounted on both ends of the substrate 15. That is, after the flange 20 is mounted on both ends of the substrate 15, the substrate 15 is placed between the rotation shafts 17 and 17 with an internal expanding collect chuck, one rotation shaft is made to go ahead, the rotation shafts 17 and 17 are fitted into the center holes of the flanges 20 and 20, and the pulley drive motor 19 is driven for rotating the substrate 15. The flanges 20 and 20 are mounted so that the center of axle of the substrate determined concentrically by the center holes of the flanges matches.

The coating liquid supply mechanism comprises support plates 21 and 21 placed vertically left and right in a predetermined spacing, two guide rods 22 and 22 placed between the support plates, a pulley 24 which is provided at an end part of a ball screw 23 placed between the guide rods 22 and 22 between the support plates 21 and 21 with one end thereof projecting from the support plate 21, a pulley drive motor 25, a timing belt 26 for transferring rotation of the motor 25 to the pulley 24, a moving body 27 placed between the support plates 21 and 21 through fit holes of the guide rods 22 made at the left and right of the moving body and a bearing part of the ball screw 23 disposed at the center of the fit holes for fitting the ball screw 23, flexible piping 5 fixed at one end to the moving body 27 and having a nozzle part 29 at the tip (in Fig. 4, a blade is not shown) placed toward the surface of the substrate 15 horizontally placed, a coating liquid storage tank 3 placed on the other end of the piping 5, a metering pump 28 placed in a midpoint of the piping 5, a charge supply unit 7, and a high-voltage generator 8.

A coating liquid 2 supplied from the coating liquid supply mechanism is spouted through an opening of the nozzle 29 in the coating liquid supply mechanism. As shown in Figs. 5 and 6, the coating liquid is spouted to the front of the blade 30 and is leveled by the blade at the same time as it is spouted, forming a uniform film thickness and leaving the blade.

The coating liquid supply pipe can also be provided with a header 31 to which a flexible nozzle 29 is directly attached, or a tube made of a short rigid body is attached to the header and a flexible nozzle can also be attached to the tube. The opening of the nozzle may be positioned just above the center of axle of the cylindrical or columnar substrate 15.

Fig. 7 shows application of the invention to a dip coating application system.

A dip coating tank 32 functioning as a coating liquid application mechanism 4 has a coating liquid introduction port 33 at the bottom and an overflow liquid reception gutter 34 in the upper outer margin, the liquid reception gutter 34 having an overflow liquid discharge port 35 at the bottom.

A return pipe 6 from the dip coating tank 34 is connected to one chamber 3a of two chambers into which a coating liquid storage tank 3 and a flowing-in coating liquid 2 is sucked to a pump 36 from the other chamber 3b. A charge supply unit 7 is disposed in a part of spouting side piping 5 of the pump 36 for supplying the coating liquid 2 to the dip coating tank 32.

A substrate 15 is dipped in and pulled out from the dip coating tank 32 by a separately provided elevator.

An application method according to the invention using the system shown in Fig. 4 is executed as follows:

With the substrate 15 horizontally supported and rotated by the drive mechanism, a coating liquid 2 supplied through the piping 5 from the coating liquid storage tank 3 is supplied through the charge supply unit 7 to the surface of the substrate 15 spirally or like a ring. At the same time as the supplied coating liquid 2 is applied onto the substrate 15, the coating liquid 2 is chafed by the contact portion between the blade 30 functioning as a smoothing member and the substrate 15 and is spread and smoothed. Particularly, if the rotation speed, the liquid viscosity, the coating liquid supply amount, and the like are adjusted appropriately, the smoothed liquid is hardened by normal fixing means and a uniform film is formed. The fixing means may be air drying for a coating liquid of solvent evaporation type, heating suitable to the resin for a coating liquid using a hardening type resin, irradiation with ultraviolet rays, etc.

Application according to the invention using the dip coating application system in Fig. 7 is executed as follows: A coating liquid is poured into the dip coating tank 32 and the coating liquid storage tank 3 and is circulated by the pump 36 via the piping 5 and the return pipe 6.

At this time, a liquid overflowing from the dip coating tank 32 enters one chamber 3a of the coating liquid storage tank 3 and the liquid overflowing the chamber 3a enters the other chamber 3b and increases the coating liquid until the liquid level in the chamber 3b reaches almost the middle of the tank. The charge supply unit 7 is disposed in a part of the piping 5 and a voltage is applied by the high-voltage generator 8.

Next, the substrate 15 vertically chucked is immersed in the dip coating tank 32 and pulled out therefrom, thereby applying the coating liquid 2 to the substrate 15.

Next, in the invention, we will discuss in detail an electrophotographic photoreceptor manufacturing method of comprising the steps of providing a smoothing member at a tip of a nozzle of a coating liquid supply pipe, abutting the smoothing member elastically against a substrate, and smoothing a coating liquid spouted from a coating liquid spout port by the smoothing member, characterized in that at least the smoothing member contact face to a coating film is formed of a conductive material and is electrically grounded.

The invention will be discussed in detail by taking application of a coating liquid to a cylindrical or columnar substrate as an example.

Fig. 8 is an illustration of use for a manufacturing method of an electrophotographic photoreceptor as an example of an application system for executing the application method of the invention. (Parts identical with or similar to those previously described with reference to Fig. 4 are denoted by the same reference numerals in Fig. 8.)

An application system shown in Fig. 8 comprises a drive mechanism for horizontally supporting and rotating a cylindrical or columnar substrate and a coating liquid supply mechanism moving in the axial direction of the substrate for supplying a coating liquid to the surface of the substrate.

A coating liquid supplied from the coating liquid supply mechanism is spouted through a spout port of a nozzle 29 in the coating liquid supply mechanism.

A smoothing member 30 sliding on a coated film for smoothing the coated film surface is attached to the tip of the nozzle 29.

As shown in Figs. 9A and 9B, the smoothing member 30 has the contact face to a coating liquid 30a on the front and a small hole 37 made at the center piercing the front and rear faces, and the nozzle 29 is inserted into the small hole 37 from the rear face, forming a coating liquid spout port 38 in the contact face to the coating liquid 30a on the front.

The small hole 37 is made at the center of the smoothing member 30, but the position of the small hole need not strictly be at the center and may be selected in response to the purpose. The small hole has a wide tolerance particularly for the vertical position and can be made at any position conforming to the conditions.

The smoothing member 30 is abutted elastically against a substrate 15 by an elastic force. Therefore, the nozzle 29 must not restrain motion of the smoothing member 30; it is desirable to form the nozzle 29 of a soft flexible material such as soft polyethylene or silicone rubber or of a rigid material and couple by a flexible tubular body.

The material of the smoothing member 30 is not limited if it has resistance to a coating liquid; an elastic material having flexibility is suitable and a sheet of rubber, plastic, or metal such as copper, aluminum, phosphoric bronze, or stainless steel can be used. It is particularly desirable to make a structure having rubber elasticity with a recess produced upon reception of a local press pressure.

Such a structure can be made of a soft material such as ethylene-propylene rubber, fluorine family rubber, Teflon rubber, silicone rubber, ethylene-vinyl acetate copolymer, or soft vinyl chloride.

A material having comparatively rigidity such as low-density polyethylene, ethylene-vinyl acetate is used to form closed-cell foam, thereby making an elastic structure.

When a material having high hardness such as phosphoric bronze or polyester is used for the smoothing member contact face to the coating liquid 30, preferably the rigid material is thinned and is backed with an elastic substance.

The shape of the smoothing member 30 may be a flat rectangular parallelopiped as shown in Fig. 9; in addition, a thick pipe, a round bar, etc., can also be applied. The blades are abutted elastically against the substrate. A force, an elastic modulus, and a shape may be selected so that the force of the smoothing member 30 pressing the substrate face becomes 1 to 40 gf/full contact face and preferably 5 to 20 gf/full contact face.

A method of elastically abutting the smoothing member 30 against the substrate 15 can be accomplished by forming the smoothing member 30 of a material having proper elasticity; the smoothing member 30 can be supported by an elastic material of a piano wire 40, etc., thereby giving proper elasticity to the smoothing member 30.

It is desired that the spout port 38 of the nozzle 29 for spouting a coating liquid is formed with a small hole 37 1 to 10 mm above the contact place between the substrate 15 and the smoothing member 30 and that the nozzle end comes almost on the blade surface.

When the smoothing member 30 is formed of a nonconductive material, at least the smoothing member contact face to the coating liquid 30a is made conductive.

To make the smoothing member 30 conductive, when a nonconductive synthetic resin or synthetic rubber is used, conductive powder of carbon, metal powder, etc., can be kneaded to make the entire material conductive. The smoothing member 30 is formed as a nonconductive member, then the contact face to the coating liquid 30a and a ground channel can also be formed of a conductive material on the surface to make the surface conductive.

Metal sputtered, application of hardening type conductive paint, a laminate or weave of a conductive sheet or film, or the like can be adopted as the method of making the surface conductive.

The inner diameter of the nozzle 29 is selected according to the liquid viscosity and the spout flowing quantity; preferably, the nozzle has 0.3 to 5 mm∅.

As a preferred example of the smoothing member 30, foamed polyethylene (foamed ratio about 25) is machined to a flat rectangular parallelopiped, as shown in Fig. 9, to which aluminum-sputtered polyethylene terephthalate 75 μm thick is attached, whereby the smoothing member 30 can be formed.

The aluminum sputtered face is the contact side with a coating liquid and the aluminum-sputtered polyethylene terephthalate is extended more than the necessary area and is used for grounding.

As shown in Figs. 9A and 9B, two piano wires 40 and 40 are embedded in a foamed polyethylene block to provide spring action as a whole and at the same time, can also be used as members for supporting the foamed polyethylene block on a support member 41.

Fig. 10 shows an example of a blade using conductive foamed polyethylene (resistance value 150 kΩcm), in which case the blade can be grounded via a piano wire 40.

As shown in Fig. 11, a nozzle 29 can also be attached to the smoothing member contact face to a coating liquid 30a.

In the coating liquid supply mechanism shown in the figure 8, a moving body 27 comprises only one coating liquid supply pipe 5, but can also comprise a plurality of coating liquid supply pipes in a predetermined spacing and can also comprise one coating liquid supply pipe of a branch structure of the tip with a common metering pump 28.

The coating liquid supply pipe can also be provided with a header 31 to which a flexible nozzle 29 is directly attached, or a tube made of a rigid body is attached to the header and a flexible nozzle 29 can also be attached to the tube. The spout port of the nozzle 29 may be positioned just above the center of axle of a cylindrical or columnar substrate 15.

An application method according to the invention is executed as follows:

With the substrate 15 horizontally supported and rotated by the drive mechanism, a coating liquid is supplied by the coating liquid supply unit to the surface of the substrate 15 spirally or like a ring. At the same time as the supplied coating liquid is applied onto the substrate 15, the coating liquid is chafed by the contact portion of the smoothing member 30 with the substrate and is spread and smoothed. Particularly, if the rotation speed, the liquid viscosity, the coating liquid supply amount, and the like are adjusted appropriately, the smoothed liquid is hardened by normal fixing means and a uniform film is formed. The fixing means may be air drying for a coating liquid of solvent evaporation type, heating suitable to the resin for a coating liquid using a hardening type resin, irradiation with ultraviolet rays, etc.

For a substrate like a flat plate, the substrate 15 and the smoothing member 30 move relatively; preferably the smoothing member 30 is inclined in a direction in which the substrate 15 comes off the smoothing member 30, and is brought into contact with the substrate 15.

Next, in the invention, we will discuss in detail an electrophotographic photoreceptor manufacturing method of comprising the steps of supplying a coating liquid showing flow charge from a nozzle and applying to a surface of a substrate, abutting a blade elastically against the substrate surface, and sliding the blade, thereby applying and spreading the coating liquid, characterized in that the nozzle and/or blade is made conductive and that charge opposite to flow charge is applied.

Used as a blade for the method is basically a similar blade to that used for the above-described blade grounding method.

Figs. 13 and 14 show examples of blades used for the method.

Nozzle and blade materials, a method of elastically abutting the blade against a substrate, and a method of making the blade and the blade surface conductive are the same as those used in the above-described blade grounding method.

It is desirable to make the elastic body of a blade 30 conductive; when it is hard to make the elastic body conductive, a conductive body of a polyethylene sheet, etc., can also be laminated on or wound around the insulating elastic body surface for coating.

As shown in Fig. 13B, nonconductive foamed polyethylene 30c is laminated on an aluminum sheet 30b of 1 to 2 mm in thickness and the surface is covered with a conductive polyethylene sheet 30d, forming a coating liquid contact face 30a.

Foamed polyethylene (foamed ratio about 25) is machined to a flat rectangular parallelopiped, as shown in Fig. 13A, to which aluminum-sputtered polyethylene terephthalate 75 μm thick is attached, whereby the blade 30 can also be formed. The aluminum evaporation face is the contact side with a coating liquid and the aluminum-sputtered polyethylene terephthalate is extended more than necessary in a case of a blade and can be used to apply a voltage.

The shape of the blade 30 may be a flat rectangular parallelopiped as shown in Fig. 13; in addition, a thick pipe, a round bar, etc., can also be applied as shown in Fig. 14.

A blade 30 shown in Fig. 14 is provided (by winding or laminating) a conductive polyethylene sheet 44 around or on the surface of thick cylindrical foamed polyethylene 43 and making the contact portion of the foamed polyethylene 43 with a coating liquid conductive. A part of the sheet is lengthened for connection to a high resistor 46.

A somewhat smaller hole than the outer diameter of a nozzle 29 made of a polyethylene tube is made in the foamed polyethylene sheet 44 and the nozzle 29 is provided at the tip with a small flange 29b to prevent the nozzle from being detached through the hole 38 and allow a coating liquid to drop on the outer surface of the sheet 44. An insulating coupling 45 is placed between the nozzle 29 and piping 5.

In the invention, the shape of the nozzle 29 is not limited. Therefore, the nozzle 29 may be not only a spout member like a slender tube, but also a slit-like spout member having an elongated spout port.

The inner diameter of the nozzle 29 is selected according to the liquid viscosity and the spout flowing quantity; preferably, the nozzle has 0.3 to 5 mm$\varnothing$.

In the invention, either or both of the nozzle 29 and the blade 30 are connected via the high resistor 46 to a high-voltage generator 47 and a voltage opposite to flow charge of a coating liquid is applied.

Therefore, when a voltage is applied to the nozzle 29, the nozzle 29 is formed using metal or the above-described conductive resin, etc.

A material having volume specific resistance 10^4 k$\Omega \cdot$cm or less, preferably 30 k$\Omega \cdot$m or less, more preferably 10 k$\Omega \cdot$cm or less can be used as conductive materials of the nozzle 29 and the blade 30 or 30a.

The polarity and voltage of the potential to be applied is selected based on the type and the application system of the coating liquid to be used. Generally, they can be empirically selected by observing the coating state. Generally, they are about $\pm$ (50 V to 20 kV).

Either or both of the nozzle 29 and the blade 30 to which a voltage is applied are insulated from other components of the system.

Fig. 15 shows manufacturing by blade application of an electrophotographic photosensitive material to a substrate surface as an example of the application system for executing the application method of the invention. (Parts identical with or similar to those previously described with reference to Fig. 4 or 8 are denoted by the same reference numerals in Fig. 15.)

The coating liquid application mechanism shown in Fig. 15 comprises a high-voltage generator and a high resistor connected to the portion of the blade in Fig. 8.

[Examples]

The invention will be discussed in more detail with reference to examples, but is not limited to the following examples unless the spirit of the invention is exceeded:

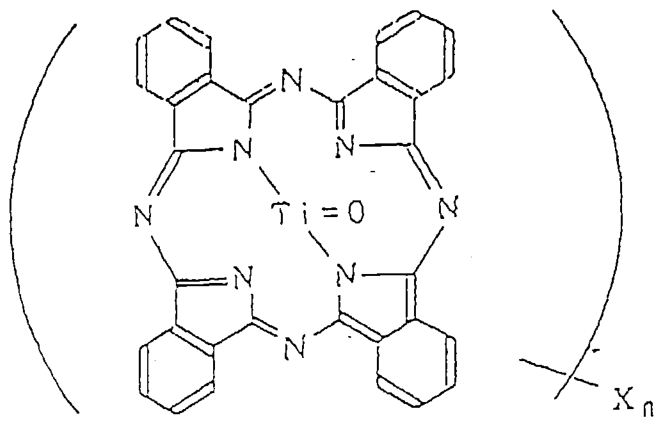
(Example 1)

The system in Fig. 4 is used as a coating liquid application system, a charge supply unit takes the structure shown in Fig. 2, and an application blade takes the structure shown in Fig. 5.

An aluminum cut tube (30.0 mm in outer diameter, 28.5 mm in faucet part inner diameter, and 260 mm long) is used as a substrate. A flange is attached to the aluminum substrate and an internal expanding collet chuck of a substrate rotation mechanism is inserted into a flange hole. A gear motor of the substrate rotation mechanism is driven for rotating the aluminum cut tube at 200 rpm. The smoothing member (blade) is made 50 mm long and 25 mm wide and a polyethylene tube with a flange is made to pierce an upper portion slightly from the center of the smoothing member. The blade touches the aluminum cut tube at a position of about 45° and comes in contact with a coating liquid spout port at a position of about 60°.

A coating liquid introduction pipe uses a SUS pipe 2 mm in inner diameter and 3 mm in outer diameter and is coupled with the charge supply unit by a Teflon joint. The SUS pipe is covered with a copper pipe for use as an electrode. A gap 4 mm is provided. Furthermore, the whole is shielded by an epoxy pipe. After a coating liquid is caused to flow, a potential of -4 kV is applied from a high-voltage generator.

[General formula (A)]



wherein X denotes a halogen atom and n represents a numeral from 0 to 1.

The following is used as the coating liquid:

200 parts by weight of n-propanol are added to 10 parts by weight of oxytitanium phthalocyanine shown in the following formula (A) and they are crushed and dispersed for 10 hours by a sand grind mill, then mixed with a 10% methanol solution of 5 pats by weight of polyvinyl butyral (denka butyral #-6000C manufactured by Denki Kagaku Kougyou (kabu)) to produce an electrophotographic photosensitive charge generation layer dispersion liquid, which will be hereinafter referred to as "dispersion liquid A." A gear pump is operated so as to form wet film thickness 10 µm by using the dispersion liquid A. The smoothing member is moved axially so that one revolution of the aluminum cut tube becomes a 0.6-mm pitch. It is recognized that after air drying, the coating film shows a uniform color tone and has an even film thickness. Spiral streaks made by blade chafe traces are not found.

(Control example 1)

Coating liquid is applied under the same conditions as in Example 1 except that applied voltage to electrode is set to 0 (zero). After air drying, ununiformities in density are found throughout the length and on the entire circumference and spiral streaks are also found.

(Example 2)

The system in Fig. 7 is used as a coating liquid application system and a charge supply unit having the structure shown in Fig. 3 is used. The system is filled with the same coating liquid as in Example 1. The coating liquid is circulated in the amount of 1.5 liters/min relative to dip coating tank capacity of 1 liter and storage tank capacity of 1.5 liters, and the charge supply unit uses five pipes each 3 mm diameter x 300 mm in length.

Applied voltage to the charge supply unit is -4 kV.

A workpiece is pulled out at the speed 300 mm/min and a uniform film having dry film thickness 0.57 µm can be provided.

(Control example 2)

Coating liquid is applied under the same conditions as in Example 2 except that applied voltage to charge supply unit is set to 0 (zero).

The workpiece pulling-out speed to provide dry film thickness 0.57 µm is 200 mm/min and ununiformities in density are found in some films.

(Example 3)

The smoothing member shown in Fig. 9 is used. As a coating liquid supply mechanism, a coating liquid supply pipe 5 is joined to the spout side of a metering pump 28 and the opposite end of the pipe is coupled to a header 31. A flexible nozzle 54 is attached directly to the header.

A flange is attached to an aluminum substrate (30.0 mm in outer diameter, 28.5 mm in faucet part inner diameter, and 260 mm long), and an internal expanding collet chuck of a substrate rotation mechanism is inserted into a flange hole. A gear motor of the substrate rotation mechanism is driven for rotating the aluminum cut tube at 200 rpm. Foamed polyethylene 100 mm long, 15 mm wide, and 10 mm thick is used as the smoothing member 30. It is covered with alpet 75 µm (aluminum-sputtered polyester sheet) with the aluminum sputtering face as the outer face, is fixed with a cord, and is grounded through the alpet extended upward from the foamed polyethylene. A polyethylene pipe 0.6 mm in inner diameter as a flexible nozzle 29 is inserted into a small through hole at a 40 mm position from the tip of the smoothing member 30 so the a spout port 38 comes on the front.

A header 31 is set so that when the header is moved down, the spout port side of the smoothing member 30 comes in contact with the aluminum cut tube at a position of about 60° from the horizontal.

Dispersion liquid A is used and a gear pump is operated so as to form wet film thickness 20 µm. The smoothing member is moved axially so that one revolution of the aluminum substrate becomes a 0.6-mm pitch. After air drying, the coating film shows a uniform color tone and has an even film thickness like the sample provided by dip coating application.

(Example 4)

The smoothing member shown in Fig. 10 is used.

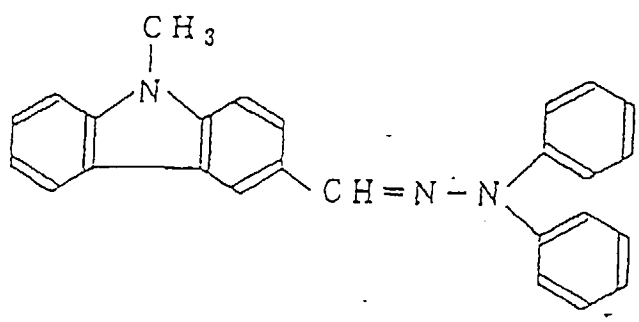
The same aluminum tube 15 as Example 3 is held and rotated in a similar manner to that in Example 3.

Two piano wires each 0.6 mm∅ are inserted almost to the tip of conductive foamed polyethylene 15 mm wide, 100 mm long, and 10 mm thick, which is fixed to the nozzle base with the piano wires sandwiched between metal plates and is grounded.

A polyethylene tube 1.0 mm in inner diameter is made to pierce a 40 mm position from the lower end of the conductive foamed polyethylene, and the opening of the polyethylene tube is positioned on the surface of the conductive foamed polyethylene.

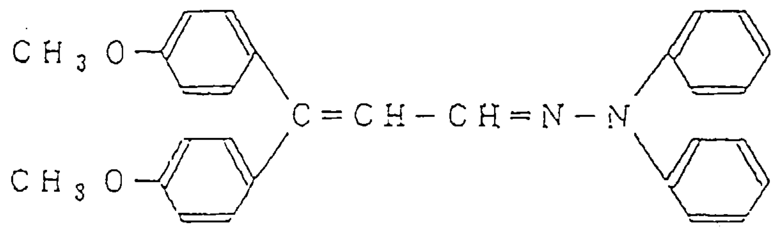
On the other hand, 56 parts by weight of a hydrazone compound shown in the following formula (1),

[Formula (1)]



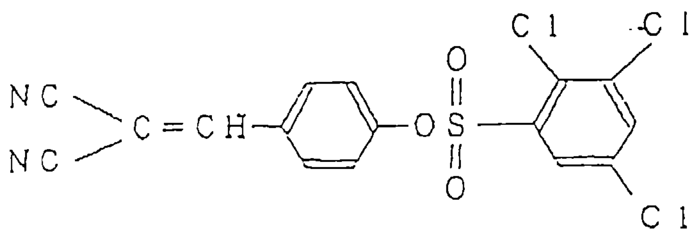
14 parts by weight of a hydrazone compound shown in the following formula (2),

[Formula (2)]



1.5 parts by weight of a cyano compound shown in the following formula (3),

[Formula (3)]



and 100 parts by weight of a polycarbonate resin (Mitsubishi Kagaku (kabu) Nobarex 7030A) are dissolved in a mix solvent of 500 parts by weight of 1,4-dioxane and 500 parts by weight of tetrahydronfuran to produce a coating liquid for an electrophotographic photosensitive charge transport layer.

This coating liquid is spouted from the polyethylene pipe so as to form wet film thickness 100 µm. The polyethylene pipe is moved in the aluminum tube axial direction so that one revolution becomes a 1.0-mm pitch. The number of revolutions of the aluminum tube is 300 rpm. After application and drying in the air, the sample is dried at 125°C for 30 minutes and coating film surface roughness is observed. The result is Rmax = 0.3 µm. The film thickness ranges from 19.7 µm. to 20.3 µm.

Application of the coating liquid to the sample is repeated several times; if at the idle time the polyethylene pipe is dipped in the used solvent for a short time and then is held in solvent vapor, clogging or dirt scarcely occurs.

(Control example 3)

Coating liquid is applied under the same conditions as in Example 3 except that no alpet is attached to foamed polyethylene block.

The liquid level leaving the blade is smooth and the color is also even, but the pigment gradually moves by the time the coating film is fixed, and ununiformities in density occur.

(Control example 4)

Coating liquid is applied under the same conditions as in Example 4 except that nonconductive foamed polyethylene is used.

Surface roughness after drying is Rmax = 1.0 µm, and a spiral move trace of the foamed polyethylene is clearly recognized.

(Example 5)

The system in Fig. 15 is used as a coating liquid application system and an application blade 30 takes the structure shown in Fig. 14.

An aluminum substrate (30.0 mm in outer diameter, 28.5 mm in faucet part inner diameter, and 260 mm long) is used as a substrate 15. A flange 20 is attached to the aluminum substrate and an internal expanding collet chuck of a substrate rotation mechanism is inserted into a flange hole. A gear motor 19 of the substrate rotation mechanism is driven for rotating the aluminum cut tube 15 at 300 rpm. Foamed polyethylene tube 43 used for the blade 30 is made 50 mm long, 20 mm in outer diameter, and 10 mm in inner diameter and is covered with a conductive polyethylene sheet 90 µm thick, and the top and bottom are fastened with a cord for fixing to the foamed polyethylene tube.

A conductive polyethylene tube with a flange as a nozzle 29 is made to pierce an upper portion slightly from the center. The blade 30 touches the aluminum cut tube at a Position of about 45° and comes in contact with a coating liquid spout port at a position of about 60°.

Piping 5 uses a SUS pipe 2 mm in inner diameter and 3 mm in outer diameter and is coupled with the conductive nozzle 29 by an insulating Teflon joint. The nozzle 29 and the conductive polyethylene sheet 44 are joined by a crocodile clip branching at a midpoint and coupled to a high resistor 46.

When dispersion liquid A is used as the coating liquid, applied voltage is -400 V.

Dispersion liquid A is used as the coating liquid and a gear pump is operated so as to form wet film thickness 10 µm. The blade 30 is moved axially so that one revolution of the aluminum substrate becomes a 1.2-mm pitch. It is recognized that after air drying, the coating film shows a uniform color tone and has an even film thickness. Spiral streaks made by blade chafe traces are not found.

(Example 6)

Coating liquid is applied under the same conditions as in Example 5 except that only a nozzle 29 of a conductive polyethylene tube is joined to a power unit, that a conductive polyethylene sheet 44 is grounded, that a voltage of -600 V is applied. After air drying, the coating film is the same as that in Example 5.

(Control example 5)

Coating liquid is applied under the same conditions as in Example 5 except that applied voltage to electrode is set to 0 (zero). After air drying, ununiformities in density are found throughout the length and on the entire circumference and spiral streaks are also found.

(Example 7)

Coating liquid is applied under the same conditions as in Example 5 except that only a conductive polyethylene sheet for forming a blade contact face to a coating liquid 30a is joined to a power supply, that a conductive polyethylene tube for forming a nozzle 29 is grounded, that a voltage of -550 V is applied.

After application and air drying, spiral traces or ununiformities in density are not found on the film.

Claims

1. An electrophotographic photoreceptor manufacturing method by applying at least one layer selected from an under coat layer, a photosensitive layer, and a top coat layer to a substrate of an electrophotographic photoreceptor of an electronic copier, wherein

   charge, which is caused due to flow or friction of a coating liquid before or in applying coating liquid to a substrate, is discharged, neutralized, or inversely charged.

2. The electrophotographic photoreceptor manufacturing method of Claim 1, wherein

   a coating liquid is supplied from a coating liquid storage tank via piping to a coating liquid application mechanism, and wherein
   a charge supply unit is disposed in a part of the piping, charge of the coating liquid supplied from said coating liquid storage tank being removed or inversely charged, so that the coating liquid is supplied to a coating supply mechanism so as to be applied.

3. The electrophotographic photoreceptor manufacturing method of Claim 1, wherein

a smoothing member is elastically abutted against a substrate, and

a coating liquid spouted from a coating liquid spout port is smoothed by said smoothing member, and wherein at least the smoothing member contact face to a coating film is formed of a conductive material, and is electrically grounded.

4. The electrophotographic photoreceptor manufacturing method of Claim 1, wherein

a coating liquid showing flow charge is supplied from a nozzle to apply to a surface of a substrate,
a blade is elastically abutted against the substrate surface, said blade being slided so as to apply and spread the coating liquid, and wherein
said nozzle and/or blade, which is electrically insulated from other components thereof, is made conductive, so that charge opposite to flow charge is applied.

5. The electrophotographic photoreceptor manufacturing method of Claim 1, wherein

a small hole pierces front and rear faces at a center of a smoothing member,
a nozzle of a coating liquid supply pipe is communicated to the small hole,
a coating liquid spout port is formed on the front of said smoothing member, and
a lower part of the coating liquid spout port of said smoothing member is elastically abutted against a substrate.

6. The electrophotographic photoreceptor manufacturing method of Claim 1, wherein

a nozzle is provided on a contact face between a smoothing member and the substrate along said smoothing member, and
a nozzle opening is placed before a position at which said smoothing member abuts the substrate.

7. The electrophotographic photoreceptor manufacturing method of Claim 1, wherein

a smoothing member is made of an elastic material so as to give elasticity to said smoothing member.

8. The electrophotographic photoreceptor manufacturing method of Claim 1, wherein

a smoothing member is supported on an elastic material so as to give elasticity to said smoothing member.

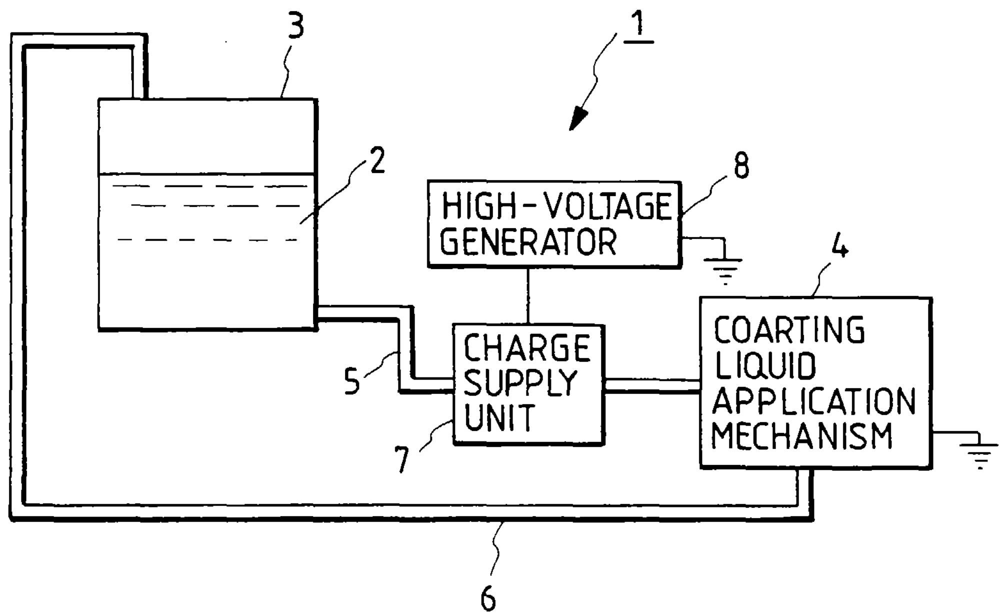
9. The electrophotographic photoreceptor manufacturing method of Claim 1, wherein

a smoothing member is made of foam of a conductive resin.

10. The electrophotographic photoreceptor manufacturing method of Claim 1, wherein

a smoothing member is made of a synthetic polymeric material with a metal layer laminated on the contact face to a coating liquid.

FIG. 1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HIGH-VOLTAGE GENERATOR
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CHARGE SUPPLY UNIT
COARTING LIQUID APPLICATION MECHANISM
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FIG. 2

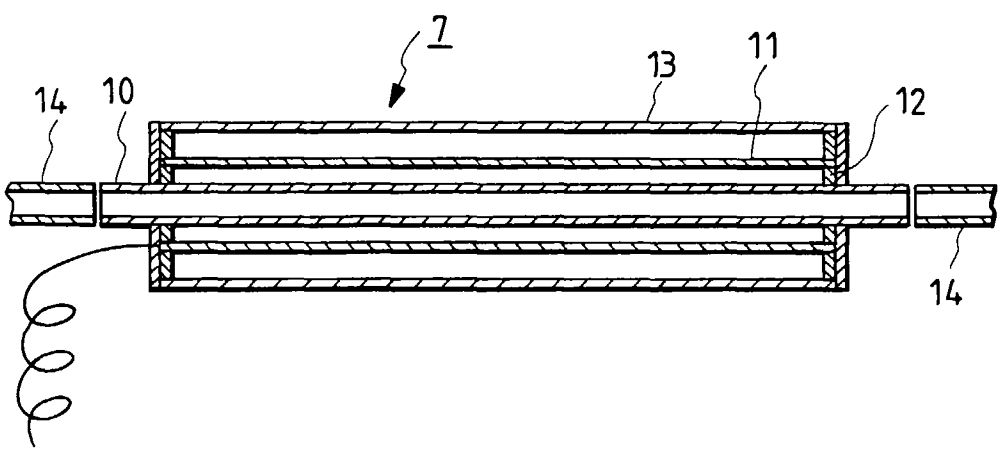
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FIG. 3

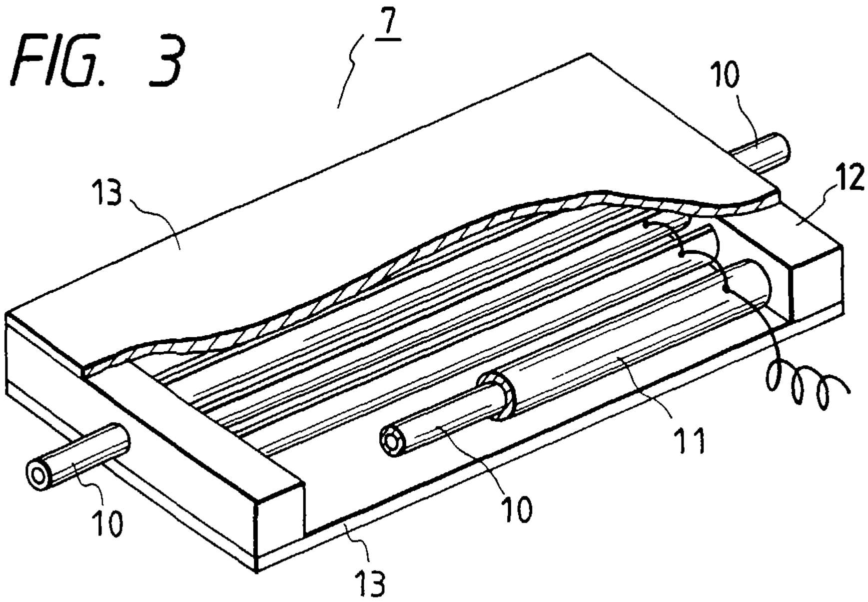

FIG. 5

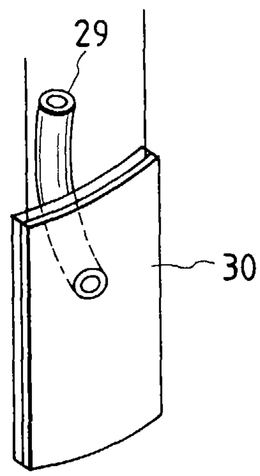

FIG. 6

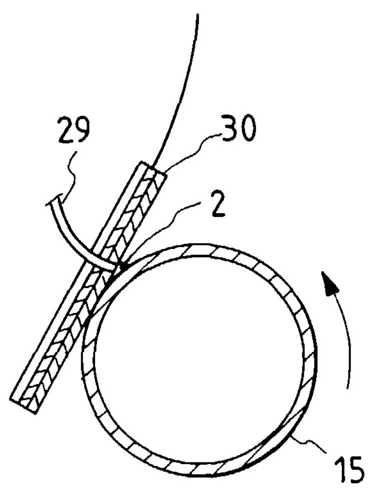

FIG. 4

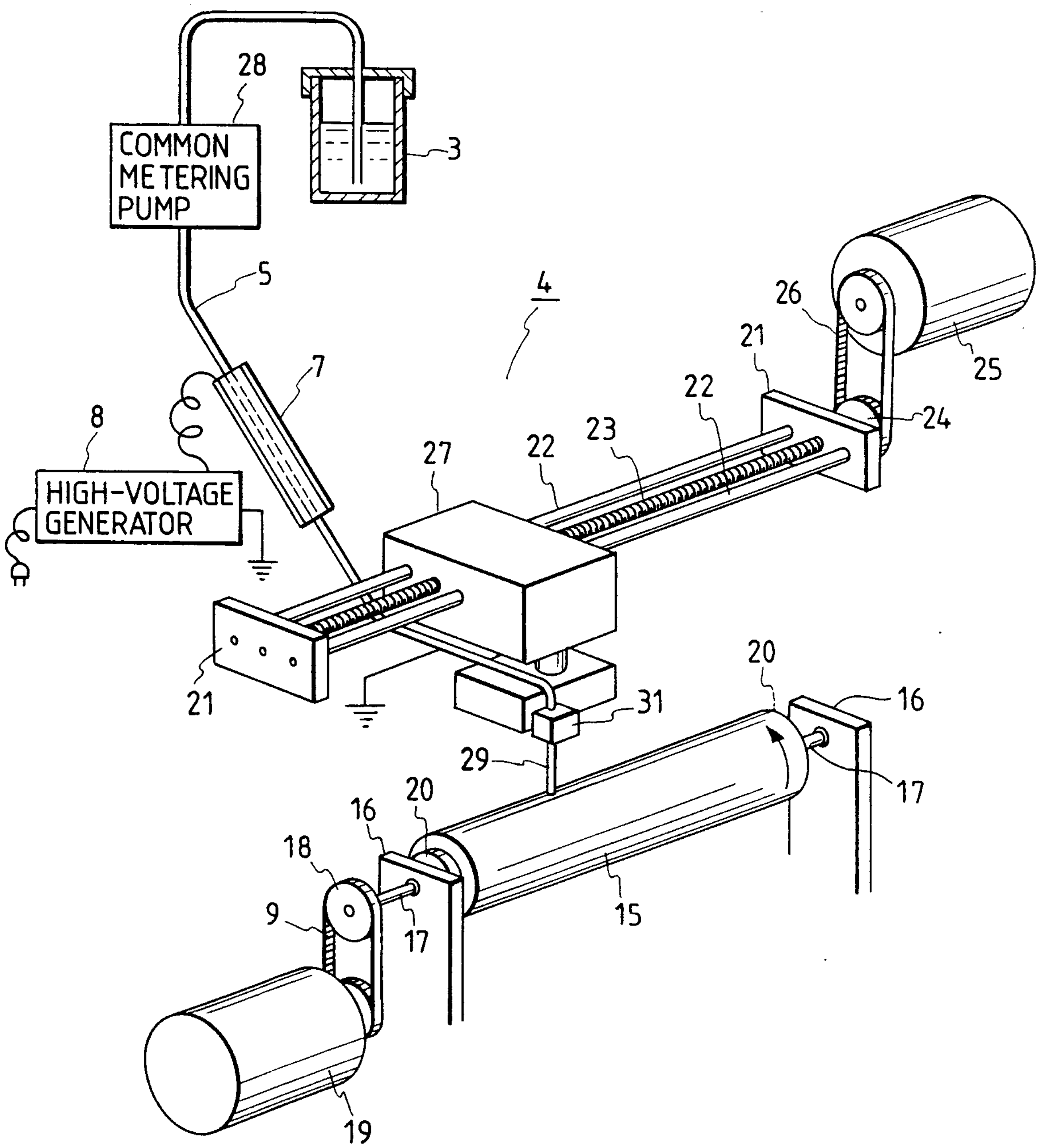
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FIG. 7

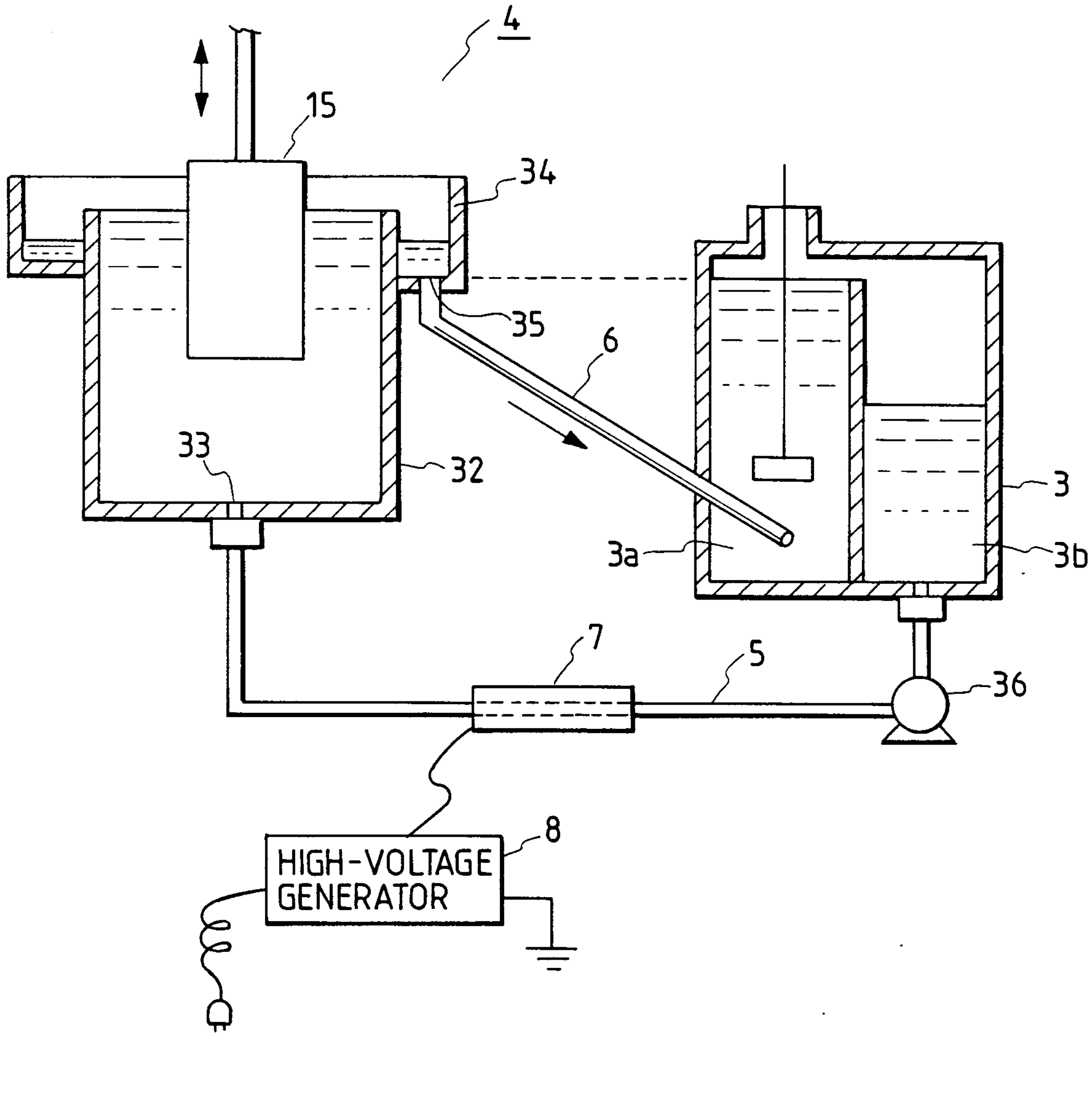

FIG. 8

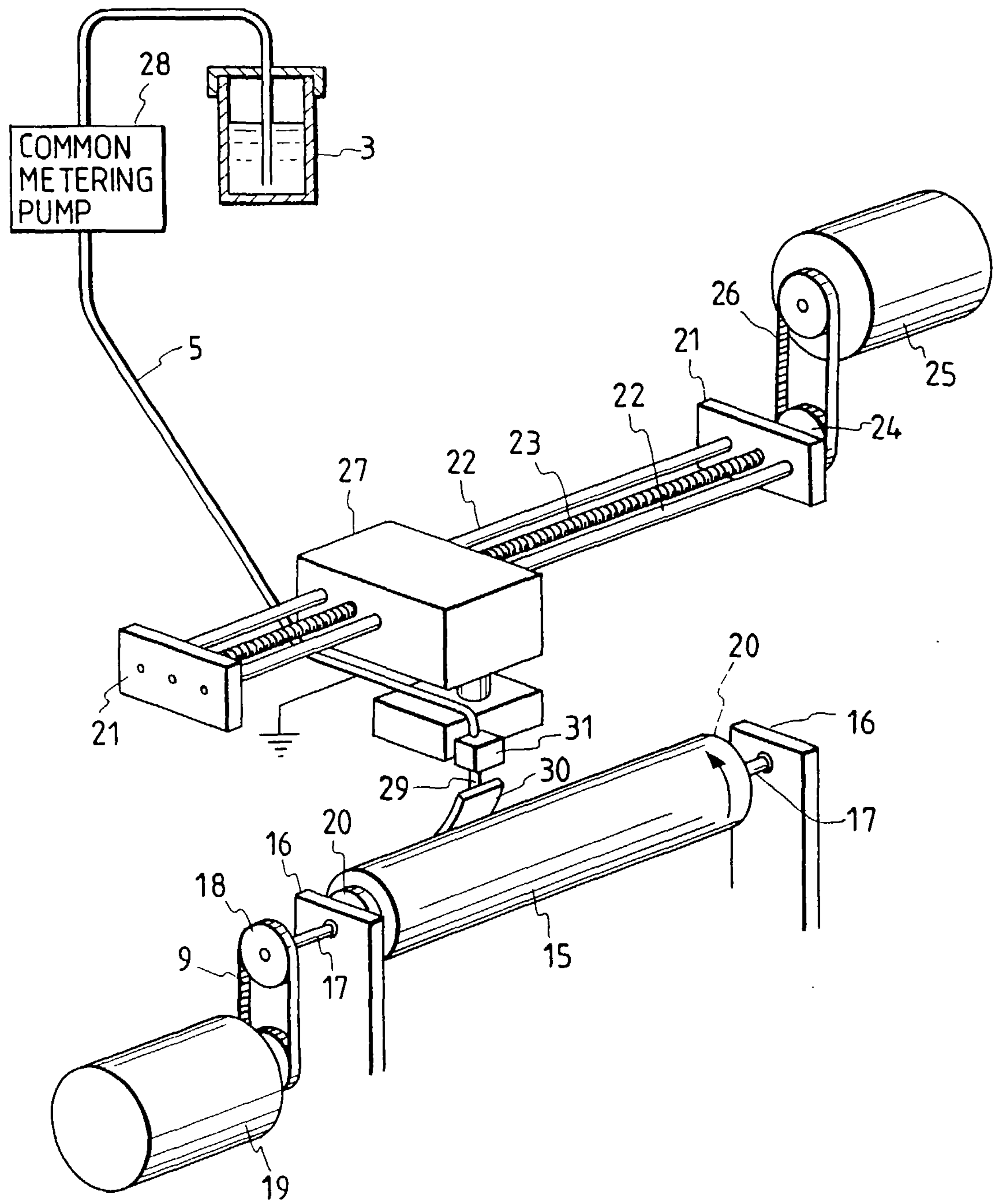
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FIG. 9A

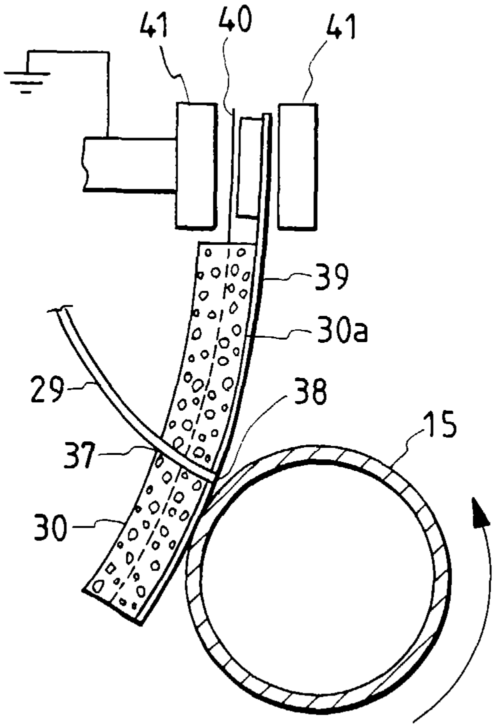


FIG. 9B

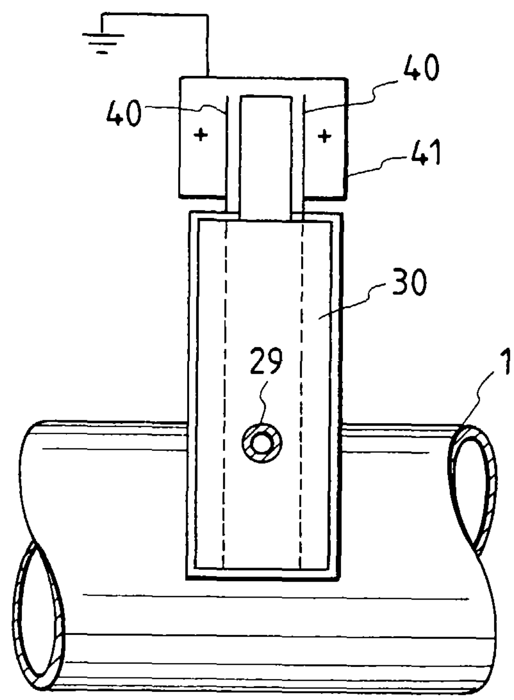


FIG. 10

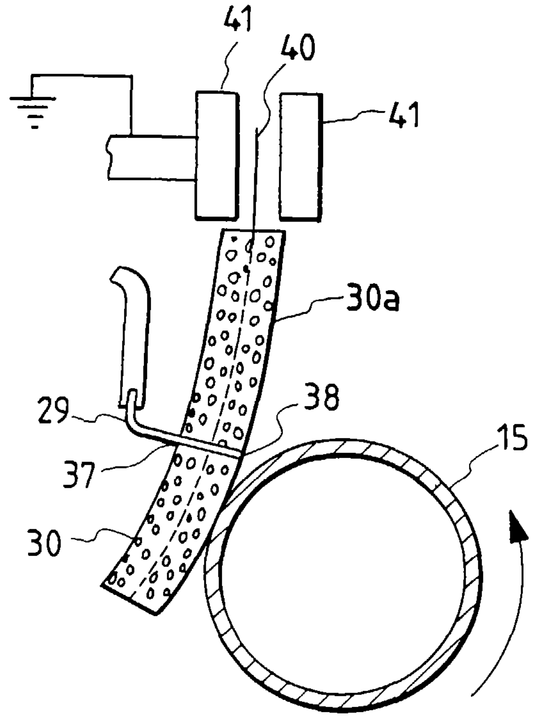


FIG. 11

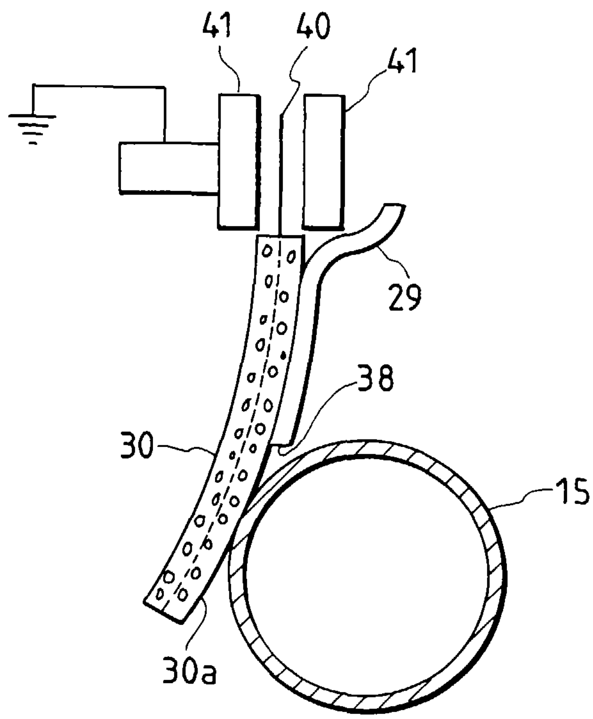


FIG. 13A

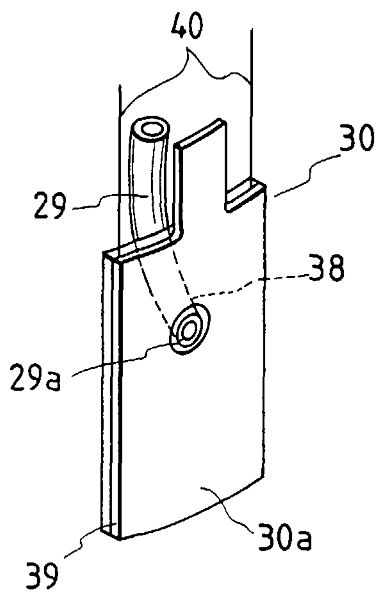


FIG. 13B

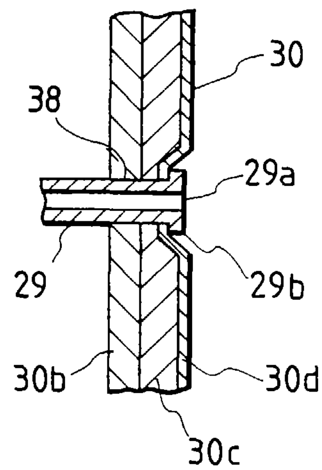


FIG. 14

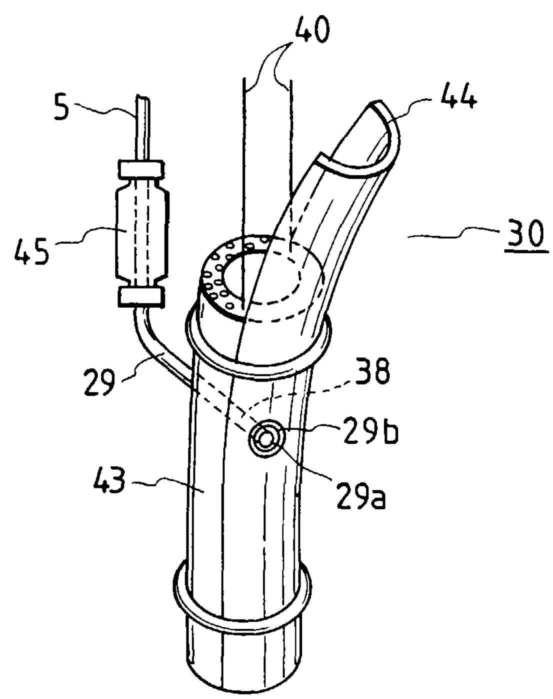
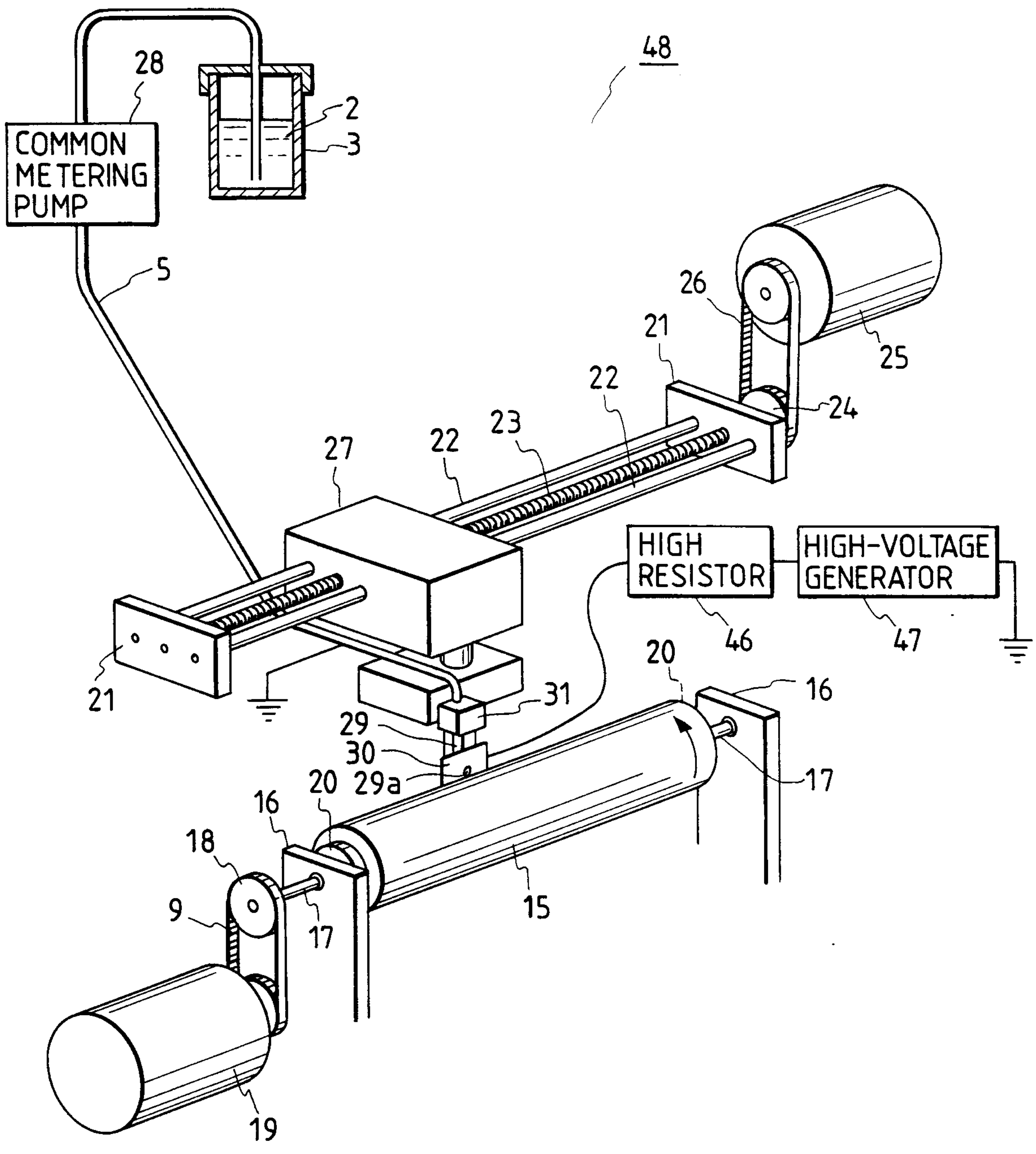


FIG. 15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