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(54) Drum photoconductor.

(57) A drum photoconductor for use in a electrophotographic laser printer is disclosed. The photoconductor comprises a hollow inner aluminum core whose cylindrical outer surface is prepared to provide a nonspecular reflecting surface of controlled roughness. A thin barrier/adhesive layer is placed on the prepared core surface by a dip coating process. The barrier/adhesive layer comprises an epoxy resin, or a phenoxy resin that crosslinks in the presence of heat, such layers being insoluble in amine solvents. An OHSQ charge generation layer is dip coated onto the heat cured barrier/adhesive layer using of a coating ink that contains amine solvents. Dip coating of the charge generation layer includes the use of air flow control means to control the manner in which the amine solvents leave the coating ink as the drum is withdrawn from the bulk supply of coating ink. A DEH charge transport layer is dip coated onto the heat cured charge generation layer.

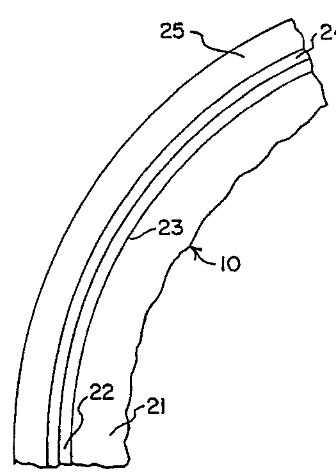

FIG. 2.

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DRUM PHOTOCONDUCTOR

Field of the Invention

This invention relates to the field of cylindrical photosensitive drums for use in an electrophotographic reproduction device, and particularly to layered photoconductor drums for use in a xerographic printer having a scanning laser imaging station.

Background of the Invention

As is well known to those of skill in the art, in an electrophotographic or xerographic reproduction device an electrostatic latent image is formed on a moving photoconductor or photoreceptor drum that repeatedly cycles through the reproduction process as the photoconductor drum is reused.

A well know type of photoconductor is a layered photoconductor having a metallic ground plane member on which a barrier/adhesive layer is coated, followed in order by a charge generation layer (CGL) and a charge transport layer (CTL). When such a photoconductor is made in a drum configuration, the ground plane member may comprise a circular cylinder metallic core.

United States Patent 4,123,270 is of interest in that it teaches a method of making a electrophotographic imaging member, including drums, of the layered type. In addition this patent teaches the advantages of solution coating (i.e. nonpigment coating) the CGL, with or without a binder material, by the use of an amine solvent, or a solvent mixture that contains an amine. The generating molecule of the CGL are of the monoazo, disazo, or deriva tives of squaric acid type, these generating materials being soluble in organic primary amines.

The first process step of well known reproduction devices of the electrophotographic type can be considered to be the full-surface charging of the photoconductor drum to a uniform and usually quite high DC voltage, as the drum rotates past a charging station such as a charge corona. The charged drum surface is then moved through an imaging station.

In a copier, the imaging station usually comprises an optical system that operates to reflect light off of an original document to be copied. As a result of the discharging effect of the reflected light received from the document's white or lightly colored background area, the drum retains a charge only in the area that corresponds to the document's darker or less reflective image area. This latent image is then toned, i.e. cover with toner, as the drum passes through a developing station. Since toner is applied to the charged latent image in a copier, the process is called a charged area development (CAD) process.

In a printer, the imaging station usually comprises a printhead that is driven by binary print data that is supplied by a computer of some type. Scanning laser printheads and LED array printheads are two well known imaging stations. Printers usually operate to discharge the drum in the pattern of the image to be printed, i.e. the printhead usually writes the image to be printed, and as a result the latent image comprises discharge areas of the drum. However, printers can also be configured to write the background, in which case the latent image comprises a charged drum area. In any event, this latent image is then toned, i.e. cover with toner, as the drum passes through a developing station. When toner is ap plied to the discharged latent image in a printer, the process is called a discharged area development (DAD) process. When toner is applied to the charged latent image in a printer, the process is again called a DAD process.

As will be apparent, the present invention finds utility in either a printer or a copier, and in either a CAD or a DAD process.

The drum photoconductor of the invention includes a metallic core, for example, a hollow, aluminum, circular cylinder, extruded, tube-like member. In accordance with a feature of the invention, the metallic surface of this core is processed so as to present a non-specular reflective surface to the imaging light source, for example to the scanning laser imaging station of a printer.

The usual next step of either a copier or a printer process is to transfer a major portion of the toner image that is carried by the drum, at a position that is down stream of the developer station, to transfer material, preferably to dielectric transfer material such as paper.

Sheet transfer material is supplied to a transfer station where the paper moves in actual contact, or in close proximity to, the drum, so as to in effect cover the drum and its toner image. As one side of the paper is in this close proximity to the drum, the other side of the paper is subjected to the action of a toner transfer station. Two well known transfer stations are roll transfer and corona transfer. In either event, an electrical charge is applied to said other side of the paper, so as to attract toner from the drum to said one side of the paper.

Thereafter, the paper is separated from the drum and is transported to a fusing station whereat the toner is fused to said one side of the paper. The drum is usually discharged and cleaned of residual toner, in preparation for reuse in the reproduction process.

The present invention relates to a method of making an electrophotographic drum photoconductor having a low molecular weight, crosslinked, barrier layer located between an aluminum conductive core member and a charge generating layer, and to a drum photoconductor made in accordance with this method.

United States Patent 3,819,369 relates to the different reproduction technology of frost imaging, and teaches a frost imaging member having a blocking layer located between a photoconductive layer and a high positive reduction potential conductive layer, this blocking layer comprising a high molecular weight phenoxy or epoxy resin. United States Patent 4,579,801 describes the use of thermosetting epoxy as a subbing layer between a substrate layer and a photoconductive layer.

United States Patent 4,485,161 teaches an electrophotographic element having a barrier layer located between an electrically conductive layer and a photoconductive layer, the barrier layer comprising a crosslinked monomer.

The various layers of the photoconductor of the invention are applied by means of dip coating processes. United States Patent 4,563,408 describes a photoconductive imaging member whose manufacturing process may include dip coating.

Summary of the Invention

The invention provides an improved drum photoconductor and method of making the same. A preferred embodiment of a drum photoconductor in accordance with the invention is used in a discharged area development (DAD) electrophotographic laser printer.

The drum photoconductor of the invention includes an inner aluminum core whose cylindrical outer surface is prepared to be nonspecular, for example by means of diamond turning. In order to minimize the production of black toner dots (i.e. dot defects) in an area of the photoconductor's surface that in fact comprises the white background of a black toner image being printed by the printer, this diamond turning step is followed by mild mechanical abrasion of the aluminum core. In this way the nonspecular surface is preserved, and yet the surface roughness is slightly reduced, to thereby eliminate the occurrence of dot defects during subsequent use of the drum photoconductor in a reproduction device.

The aluminum core is then cleaned, as by the use of a vapor degreasing technique.

A thin barrier/adhesive layer, in the range of 0.05 micro meters thick, is then placed on the prepared surface of the aluminum core by means of a dip coating step, followed by a heat curing step. The barrier/adhesive layer comprises a resin that is insoluble in amine type solvents. Preferable, the barrier/adhesive layer comprises a crosslinked aliphatic epoxy resin, a crosslinked aromatic epoxy resin, or a phenoxy resin that crosslinks in the presence of heat.

A charge generation layer is then dip coated onto the cured barrier/adhesive layer by the use of a coating ink that includes a charge generation molecule, for example OHSQ, a resin, for example a toluene sulfonamide resin, and a solvent system containing amines. In this dip coating process, the drum is first lowered into a tank of coating ink, as the drum axis extends vertically. As the drum is subsequently withdrawn from this dip tank, using a controlled rate of vertical movement, air flow means operates to ensure controlled flow of the amine vapors solvent away from the surface of the drum at a location immediately above the dip tank. In a preferred embodiment of the invention, the air flow means comprises a drying ring having internal air flow flow means that produce laminar flow as the amine vapors leave the coating ink, while the drum continuously moves vertically upward out of the dip tank. The charge generation layer is then heat cured.

An object of the invention is to control the solvent vapors that leave the wet surface of a dip coated drum, as the drum is withdrawn from a bulk supply of coating ink. With uncontrolled solvent vapor flow, the coated layer may not have the required molecular structure for proper functioning in a xerographic reproduction device. Drying/curing is completed by the use of an oven, at an elevated temperature.

A charge transport layer is then dip coated onto the cured charge generation layer, for example by using a coating ink having a transport molecule such as DEH, a yellow dye, a polyester resin, a polycarbonate resin, and a solvent system. The charge transport layer is then heat cured.

An object of the invention is to provide a drum photoconductor for use in a electrophotographic laser printer. The drum photoconductor comprises an aluminum core whose cylindrical outer surface is prepared to provide a nonspecular reflecting surface of controlled roughness, such that a thin barrier layer may be incorporated into the drum photoconductor without the production of dot defects during use of the drum photoconductor in the printer.

A further object of the invention is to provide such a nonspecular surface by means of diamond turning, followed by mild mechanical abrasion, such that a thin barrier/adhesive layer may then be placed on the nonspecular surface by means of a dip coating process.

As a feature of the invention, the barrier/adhesive layer comprises a crosslinked aliphatic epoxy resin, a crosslinked aromatic epoxy resin, or a phenoxy resin that crosslinks in the presence of heat, such layers being insoluble in amine solvents that are used to subsequently coat a charge generation layer onto the barrier/adhesive layer.

An charge generation layer is then dip coated onto the barrier/adhesive layer by the use of a coating ink that contains amine solvents. As a feature of the invention, dip coating of the charge generation layer includes the use of a drying ring type air flow means to control the manner in which the amine solvent vapors leave the coating ink as the drum is withdrawn from the bulk supply of coating ink. As a further feature of the invention, the charge generation layer coating ink includes OHSQ and a toluene sulfonamide resin.

A charge transport layer is then dip coated onto the charge generation layer. As a feature of the invention the charge transport coating ink includes DEH, a polyester resin and a polycarbonate resin.

These and other objects and advantages of the invention will be apparent to those of skill in the art upon reference to the following detailed description, wherein reference is made to the drawing.

Brief Description of the Drawing

FIG. 1 is a simplified showing of a DAD printer having a drum photoconductor in a accordance with the present invention,

FIG. 2 is an enlarged view of the drum photoconductor of FIG. 1, showing the layered construction thereof,

FIG. 3 shows the aluminum core of the drum photoconductor, and showing a plastic plug that is used therewith during manufacture of the drum photoconductor,

FIG. 4 illustrates how, in the dip coating process of the invention, the general relationship between the percent solids within the coating ink, and the rate of withdrawal from the bulk supply of coating ink, can be varied, as may be desired, in order to produce the same general coating thickness,

FIG. 5 shows a dip coating station in accordance with the invention, and

FIGS. 6 and 7 show in simplified form the diamond turning, followed by the mild surface abrasion, respectively, of the aluminum core of the drum photoconductor.

Detailed Description of the Invention

As stated previously, the invention finds utility in both CAD and DAD reproduction devices. In its preferred form, the drum photoconductor of the invention finds utility in the DAD laser printer shown in FIG. 1.

The printer of FIG. 1 is a DAD reproduction device in which the drum photoconductor is of a small process size in relation to the process size of the sheets of transfer material. A small desk top printer is an example of such a device. The spirit and scope of the invention is not to be limited, however, to such a small process size drum photoconductor.

In this printer, sheets of 22 x 28 cm (8.5 x 11 inches) or 22 x 36 cm (8.5 x 14 inches) paper move through the reproduction process with a short 22 cm (8.5 inches) edge as a leading edge, and with the two longer sheet edges extend in a direction that is parallel to the process direction. Thus the process size of a sheet of transfer material is either 28 cm (11 inches) or 36 cm (14 inches).

In the reproduction device of FIG. 1 drum photoconductor 10 rotates CW about its horizontal axis 11 at a substantially constant speed during reproduction cycles. An exemplary surface or process speed of drum 10 is about 5,2 cm (2 inches) per second. By way of example, drum 10 may have an axial length of about 25,6 cm (10 inches), and a circumferential length of about 13,2 cm (5 inches). Thus, a little over two revolutions of drum 10 are required for the processing of one sheet of 28 cm (11 inches) long paper.

In sequence, and as is well known by those of skill in the art, the outer photosensitive surface of drum 10 is first charged to a relatively high DC voltage, for example -800 volts, as incremental areas of the drum surface move through or past a charging station that is defined by charge corona 12. The charged photoconductor surface next passes through an imaging station 13. In this preferred embodiment, but without limitation thereto, imaging station 13 comprises a scanning laser means 14 of the well known type. Scanning laser means 14 receives binary data to be printed by way of print data line or bus 15.

As a result of the operation of imaging station 13, an electrostatic latent image resides on photoconductor drum 10 downstream of imaging station 13. As is well known, scanning laser 14 operates to discharge, or write, drum areas that correspond to the image being printed. Thus, this latent image comprises discharged drum areas. This electrostatic image then passes through or adjacent to developer station 16 whereat toner is applied to the latent image. As stated, since this preferred embodiment is a DAD device, the discharged areas are toned.

A feature of the invention provides an aluminum core for drum 10 that has been processed to present a nonspecular reflecting surface to scanning laser 14.

As the now toned image on the surface of drum 10 moves toward transfer station 17, a sheet of paper is fed from sheet supply and feeding means 18, for example at the same speed of about 5,2 cm (2 inches) per second, i.e. the same speed as the process speed of drum 10. The details of construction and arrangement of sheet supply/feeding means 18 may take many forms, as is well known to those skilled in the art. In addition, it is within the invention to control the beginning of laser scan as a function of the feeding of a sheet from means 18, or alternatively to control means 18 as a function of the progress of the laser scanning process.

Sheets that move through or into the reproduction process at about 5,2 cm (2 inches) per second follow a generally straight path having a first portion 19 that is upstream of transfer station 17, and a second portion 20 that is down stream of transfer station 17.

When consecutive reproductions or printed sheets are being produced, sheets are sequentially fed from means 18 with about a 2,56 cm (1 inch) spacing between the trailing 22 cm (8.5 inches) edge of a one sheet and the leading 22 cm (8.5 inches) edge of the next sheet.

In this preferred embodiment, transfer station 17 comprises a transfer corona 30 and an erase or quench lamp 31. Transfer corona 30 operates to provide a charge on the bottom side of a sheet of transfer material as the sheet moves through transfer station 17 at a speed of about 5,2 cm (2 inches) per second. As a result, a major portion of the photoconductor's toner image transfers to the upper surface of this sheet.

After toner is transferred to the top surface of a sheet of transfer material, the sheet enters the portion 20 of the sheet's process path. In this portion of the path the toner image is fused to the surface of the sheet, for example by operation of fuser station 33. The finished sheet is then deposited in an exit means.

The surface of drum photoconductor 10 then moves to a cleaning station, in preparation for recycling through the reproduction process.

FIG. 2 shows a portion of drum photoconductor 10 enlarged relative the showing of FIG. 1. In this figure reference numeral 21 identifies an hollow, circular cylinder, aluminum core that constitutes the well known ground plane member of such a layered electrophotographic photoconductor. In practice, this core is formed from an extruded aluminum tube having closely controlled eccentricity. For example, the radial thickness of core member 21 may be about 1,3 mm (0.05 inch). During operation of drum photoconductor 10 in the printer of FIG. 1, core member 21 is conventionally connected to ground potential.

As a feature of the invention, the external cylindrical surface 23 of core member 21 is processed to present a nonspecular reflecting surface to scanning laser 14. For example, surface 23 is diamond turned, and is thereafter subjected to a mild abrasion process. This topographic preparation of surface 23 provides a nonspecular reflecting surface to the imaging station of an electrophotographic reproduction device, and also minimizes dot image defects that are sometimes caused when irregularities in surface 23 cause undesirable discharge of an area of the drum that should remain charged. After this surface preparation process step, core member 21 is cleaned.

A continuous barrier layer 22 (i.e. a layer having no discontinuities) is dip coated onto the external cylindrical surface 23 of core member 21. As described above, in accordance with a feature of the invention the topography of surface 23 is prepared prior to the coating of barrier layer 22.

Barrier layer 22 is very thin, by way of example, barrier layer 22 may be about 0.05 micro meters thick.

Barrier layer 22 comprises an electrical insulator or barrier which functions in a well known manner to prevent the leakage of the highly charged -800 volt DC background area on the surface of CTL 25 to ground plane member 21, to provided a more suitable surface for the coating of CGL 24, and/or to provided a smoothing effect relative any ridges, points or bumps that may unexpectedly remain on the surface 23 of core member 21 after the topography of surface 23 is prepared in accordance with the invention, thus additionally minimizing dot image defects in the drum photoconductor. In addition, layer 22 functions as an adhesive layer between core member 21 and CGL 24. Since layer 22 is very thin, electrical functioning of the photoconductor in the electrophotographic process of FIG. 1 is not disturbed by the presence of this insulating layer.

As a feature of the invention, barrier layer 22 comprises a crosslinked resin that is not soluble in the solvent(s) that is subsequently used to coat CGL 24. Preferably, layer 22 is coated from a coating ink containing an aliphatic epoxy and a crosslinking agent, or from a coating ink containing an aromatic epoxy and a crosslinking agent, or from a coating ink containing a phenoxy that crosslinks after coating by the application of heat.

After barrier layer 22 has cured to its crosslinked form, a continuous CGL 24 is dip coated thereon. CGL 24 is also a very thin layer, in the range of about about 0.25 micro meters thick.

As a feature of the invention, CGL 24 is coated from a solution that includes a resin, for example a toluene sulfonamide resin, a hydroxysquarylium charge generation molecule, and an amine solvent system. As a further feature of the invention, as CGL 24 is dip coated onto barrier layer 22, evaporation of the amine solvent from the wet coating is concomitantly controlled by the use of an air flow means, in order to preserve the electrical properties of CGL 24, for example by the use of a drying ring air flow means.

After CGL 24 has cured, a continuous CTL 25 is coated thereon by the use of a dip coating process. CTL 25 is a relatively thick layer, being in the range of about 22.50 micro meter thick. In a preferred embodiment of the invention, CTL 254 is coated from a dispersion that includes a polycarbonate resin, a polyester resin, a DEH transport molecule, and a solvent.

FIG. 3 shows the aluminum core 21 of drum photoconductor 10, one end 42 of core 21 being spaced a short distance from a plastic plug 35 that is useful during both the dip coating and the handling of drum 10, as the drum is manufactured in accordance with the invention.

Without limitation thereto, core member 21 is of an exemplary overall length 36 of about 25 cm (9.84 inches), has an inner diameter 37 of about 3,9 cm (1.52 inches) and has an outer diameter 38 of about 4 cm (1.57 inches). Dimension 39, which is of an exemplary length of 26 cm (9.29 inches) and which is centered within dimension 36, defines the surface of the drum that is electrically operational in the electrophotographic process of FIG. 1. This cylindrical surface 39 is prepared to be generally nonspecular to the scanning laser imaging station 14 of FIG. 1, and to accept a very thin barrier layer 22 without the production of dot defects, all in accordance with a feature of the invention.

The surface roughness or surface preparation of the major central portion 39 of core member 21 in accordance with the invention must produce two important photoconductor characteristics. First, the surface 39 of core 21 must be nonspecular to the imaging station of the reproduction device in which the photoconductor is used. In this way, the imaging station, for example the scanning laser beam of a xerographic printer, will not appreciably reflect from core member 21. Thus, image interference patterns are avoided.

The requirement that surface portion 39 be nonspecular requires an amount of surface roughness. However, in accordance with a second requirement of the invention, this surface roughness must not produce high localized electrical fields that tend to discharge small areas on the surface of drum 10, so as to produce dot defects in the reproduced images and/or background. This later characteristic of surface portion 39 is especially impor tant when the barrier layer 22 of the drum photoconductor 10 is a very thin layer, as it is in the preferred embodiment of the invention.

In an exemplary embodiment of the invention, but without specific limitation thereto within the broader spirit and scope of the invention, the surface roughness (Ra) of portion 39 of core member 21 was about 0.15 micro meters (6 micro inches). The peak-to-valley height (Ry) of this rough surface did not exceed about 1.25 micro meters (50 micro inches), and the mean spacing between peaks at the mean line of surface roughness (Sm) did not exceed about 0.1 mm (0.004 inch).

Prior to, and after, each of the three coatings 22, 24 and 25 are placed on aluminum core member 21, core member 21 is handled, either manually or robotically, by means of a cylindrically shaped, solid, plastic plug 35. Thus, possibly contaminating physical contact with the outer surface of core member 21 is avoided.

As will be explained with reference to FIG. 5, plug 35 is in place on the bottom vertical end 42 of core member 21 during the dip coating of each of the three layers 22,24,25 of drum photoconductor 10. In this way the lower end 42 of core member 21 is closed or sealed. As a result, coating ink is not wasted by unnecessarily coating the interior cylindrical surface of core member 21. Since the cylindrical coating tank 51 of FIG. 5, to be described, is only somewhat larger in diameter than is drum photoconductor 10, only a small quantity of coating ink need be placed in tank 51 in order to effectively coat the vertical length of the drum. This feature of the invention results in an appreciable cost savings.

As will be explained in relation to FIG. 5, the other end 43 of core member 21 is held by an expanding mandrel, not shown, that inserts into the interior of core member end 43, and then expands to frictionally hold the core member for vertical movement during dip coating.

Plug 35 includes an cylindrical portion 40 that frictionally fits within the inner diameter 37 of the end 42 of the core member. Once plug 35 is so mounted to be a portion of the end 42 of core member 21, the plug may be handled by means of a manual or a robotic tool, not shown, that releasable cooperates with an annular groove 41 that is formed in plug 35. In this way, core member 21 can be transported between the dip coating station of FIG. 5 and a curing oven, for example.

In a preferred embodiment, a curing oven support fixture, not shown, for core member 21 included a pair of closely spaced, upward extending, metal pins over which core member 21 was inserted, as plug 35 and core end 42 were oriented be at the vertical upper end of the core member.

These two pins closely fit the inner diameter of core member 21 and function to support the core member during heat curing. Preferably, plug 35 is removed during the heat cure cycle, and plug 35 is reinserted into the upper end 42 of core member 21 after cooling of the core member.

In a robotic embodiment of the invention, plug 35 did not include annular recess 41, but rather was formed in the shape of a smooth plug. A robotic device included an expanding mandrel to engage the inner cylindrical surface of core end 43. This robotic device included a movable rod that extended down through the center of core member 21. This rod was used to push the smooth plug 35 from core end 42, prior to placing the core member into the curing oven. Subsequently, after heat curing of a coating on core member 21, the robotic device reengaged the core member, and then pushed the core member down onto another such plug 35, prior to the coating of another layer onto the core member.

After the drum photoconductor 10 has been manufactured in accordance with the invention, the two open ends 42 and 43 of cylindrical core member 21 are closed, as by the use of an annular plastic or metal drive gear support means and an idler bearing support means, not shown. These two means allow drum 10 to be mounted within the reproduction device of FIG. 1, and allow a rotational, force to be coupled to drum 10, as is well known by those of skill in the art. In addition, when a metal or electrically conductive drive and/or bearing means are used, these means may be used to provide electrical contact to the ground plane member, i.e. to core member 21, of drum photoconductor 10. As will be appreciated, the dip coating of drum photoconductor 10 leaves an annular band of core member 21 uncoated adjacent its end 43. Brush means or similar electrical contact means may also be used to provide electrical contact to core member 21 by way of this uncoated band.

In a preferred embodiment of the invention, and for the coating thickness and core withdrawal rates specified, barrier layer 22, CGL 24 and CTL 25 were dip coated from coating inks of the following compositions.

The coating ink from which barrier layer 22 was dip coated comprised about 0.4 wt. % epoxy resin, the brand Epon 1001, about 0.1 wt. % polyamide, the brand Versamid 150, and about 99.5 wt. % tetrahydorfuran (THF) solvent.

In this barrier layer formulation, the polyamide constituent comprises a crosslinker for the epoxy constituent. Crosslinking of the epoxy occurs during the heat curing cycle for the barrier layer. In accordance with a feature of the invention, the resulting barrier layer is insoluble in the highly active amine solvent system that is used to subsequently dip coat the the CGL onto the crosslinked barrier layer. Cross linked aliphatic epoxy and crosslinked aromatic epoxy are both usable in accordance with this feature of the invention. As an alternative to the use of a crosslinked epoxy, a phenoxy resin that crosslinks in the absence of a crosslinking constituent, during the heat cure cycle for the barrier layer, is suggested.

This feature of the invention allows a very thin barrier layer 22 to operate in the well known manner as an integral part of the finished drum photoconductor 10, and yet barrier layer 22 does not dissolve during the subsequent dip coating of CGL 24, in which dip coating process crosslinked barrier layer 22 is subjected to the presence of the highly active CGL solvent system.

The coating ink from which CGL 24 was dip coated comprised about 1.2 wt. hydroxysquarylium (OHSQ) charge generation molecule, about 4.8 wt. % toluene sulfonamide resin, the brand Ketjenflex, about 7.5 wt. % of pyrrolidine amine solvent, about 9.4 wt. % of morpholine amine solvent, and about 77.1 wt. % THF.

The coating ink from which CTL 25 was dip coated comprised about 76.7 wt. % THF, about 0.2 wt. % the brand Savinyl Yellow yellow dye, about 1.2 wt. % polyester resin, the brand PE-200, about 12.6 wt. % polycarbonate resin, the brand MPG 3408, about 9.3 wt. % of the 1,1-diphenylhydrazone of diethylaminobenzaldahyde (DEH) transport molecule, and a trace amount of a polydimethyl siloxane silicone fluid, the brand DC-200.

As will be appreciated, the above formulations will yield a specific percent of solids within the coating ink.

Within the scope and spirit of the invention, the percent solids within the barrier layer, the CGL, and the CTL coating inks can be changed as is desired. In general, it will be found that as the percent solids within a given coating ink increase, the withdrawal rate of the drum cylinder from that coating bath must be decreased in order to yield the same coating thickness. This relationship is shown in FIG. 4. While this figure shows an exemplary straight line function for the percent-solids/rate-of-withdrawal relationship, this usually will not be a straight line function, and will vary with the constituents chosen for the coating inks.

After each of the layers 22,24,25 of drum 10 are dip coated, and prior to the dip coating of the next layer, the drum is placed in an oven for curing. Exemplary cure cycles for these layers are about 30 minutes at about 100 degrees centigrade for both barrier layer 22 and CGL 24, and about 60 minutes at about 100 degrees centigrade for CTL 25.

FIG. 5 shows a preferred dip coating station in accordance with the invention. While this coating station is configured to coat only one core member 21 at a time, it is to be understood that the dip coating means shown in FIG. 5 can be duplicated a number of times, to thereby simultaneously coated a number of core members. In this figure, core member 21 is shown as it is in the process of moving upward out of metal, cylindrical, dip tank 51, see arrow 50. For purposes of simplicity, the expanding mandrel and associated robotic means that supports the end 43 of core member 21, and the plug 35 of FIG. 3 that seals the end 42 of the core member, are not shown. The rate of this upward movement 50 is related to the thickness of the coating that is desired, and to the percent solids that are present in the bulk supply of coating ink 52, as was explained relative to FIG. 4.

It will be recognized that core member 21 will be covered by a prior cured coating or coatings on the occasion of the dip coating of CGL 24 and CTL 25. However, for convenience, these dip coating operations are referred to only as the dip coating of a core member 21.

The inner diameter of dip tank 51 is about 5,2 cm (2 inches), as compared to the about 4 cm (1.57 inch) outer diameter of core member 21. Thus, core member 21 closely fits within dip tank 51. As a result, only a small quantity of barrier layer, CGL or CTL coating ink 52 need be placed in tank 51. Since core member 21 is closed or sealed at its end 42, this small quantity of coating ink 52 will rapidly rise within tank 51 as core member 21 moves down into tank 51, and as the core member reaches the lower end of its range of downward movement. In this manner, all but the extreme upper, ring shaped, portion of end 43 of the core member is subjected to the supply of coating ink. In accordance with the invention, substantially no residence time is provided with substantially the full length of core member immersed in coating ink 52. That is, upward movement 50 begins substantially immediately after core member 21 reaches the lower limit of its downward movement.

As can be appreciated, as core member 21 is withdrawn from dip tank 51, the level of the coating ink within tank 51 drops as core member 21 moves upward. In the preferred embodiment of the invention, the rate at which the coating ink level moves down relative to upward moving core member 21 is about 120 cm (4 feet) per minute when dip coating barrier layer 22, about 60 cm (2 feet) per minute when dip coating CGL 24, and about 43 cm (1.4 feet) per minute when dip coating CTL 25.

FIG. 5 also shows a drying ring that is preferable used to coat CGL 24. More specifically, dip tank 51 is enclosed and sealed within a larger metallic, circular cylinder, tank 53 whose bottom end 54 is closed or sealed. One or more conduits 55 are provided at the bottom portion of tank 53, and this conduit is connected to a source of negative pressure, i.e. to a vacuum source.

Dip tank 51 is generally centrally located within tank 53 by means of an annular, donut shaped, support means 56 that includes a plurality of air flow channels 57 that are provided in a symmetrical pattern about the circumference of member 56. As a feature of the invention, air flow means 57 is configured to insure a uniform quantity of downward air flow about the circumference of dip tank 51.

The upper end of tank 53 is closed by an annular, donut shaped, plug member 58 that supports a drying ring means 59 in accordance with the invention. Drying ring means 59 is constructed and arranged to insure that downward directed laminar air flow will surround core member 21 during its withdrawal movement 50.

More specifically, drying ring means 59 includes a metal circular cylinder 60 that is mounted to an annular plug member 58. Cylinder 60 is about 7,7 cm (3 inches) in axial length, and has an inner diameter of about 5,6 cm (2 inches). Thus, a thin cylindrical air space 64 is formed between the inner surface of cylinder 60 and the outer surface of core member 21.

Plug member 58 is formed with an internal, closed, annular cavity 62 that is located adjacent to its upper flat surface 65. Cavity 62 is connected to ambient air by way of one or more conduits 63. As the term is used herein, ambient air may include the use of an inert gas such as nitrogen, the use of nitrogen being preferred in coating locations having high humidity. In accordance with the invention, air flow into cavity 62 from conduit(s) 63 is such that uniform pressure is maintained about the circumference of cavity 62. In a preferred embodiment of the invention, air flow into cavity 62 was maintained to be at the rate of about 780 l/h (25 standard cubic feet per hour). The inner circular wall of cavity 62 is formed by a porous annular ring 66 having uniform porosity about the circumference of the ring, for example a porous polypropylene membrane.

While drying ring means 59 has utility in the coating all three coatings 22,24,25 on core member 21, it has been found to be of great utility when coating the CGL of the present formulation, i.e. when dip coating a formulation having an OHSQ transport molecule in solution in a coating ink 52 that includes an amine solvent system.

We have discovered that such a CGL coating ink requires that the amine solvents leave the wet coating ink, and that they amine vapors do not subsequently impinge upon the wet surface of the upward moving core member 21. In our experience, should such an event occur, the OHSQ molecules of the CGL do not switch to their aggregate state, and as a result, poor electrical effects may subsequently appear in the reproduction device of FIG. 1.

When the drying ring means 59 of the present invention is used, downward laminar flow of the amine solvent vapors occurs within cylindrical space 64, and all portions of the CGL properly switch to the aggregate state. Flow quantity is equalized about the circumference of core member 21, as above mentioned, and this laminar flow is directed parallel to the axis of the core member.

As will be appreciated by those skilled in the art, various surface treatment means may be employed to produce the required nonspecular surface for core member 21, for example the preferred Ra of about 0.15 micro meters, Ry no more than about 1.25 micro meters, and Sm no more than about 0.1 mm, as above mentioned.

We have found that diamond turning, followed by mild mechanical abrasion are preferred surface treatment means. FIGS. 6 and 7 show two such means.

In FIG. 6 core member 21 is mounted on a horizontal axis 91 and is driven at a high speed, for example about 1800 rpm. A diamond cutting tool 92 engages the surface of core member 21, and moves axially thereof at about the speed of 25,6 cm (10 inches) in 3 second. After core member is subjected to the surface treatment action of diamond tool 92, the core member is taken to the fixture shown in FIG. 7. At the FIG. 7 fixture, core member is mounted on horizontal axis 93 and is driven at a lower speed of about 100 rpm. A portion 94 of a fine abrasive synthetic rayon cloth web, for example the brand Microcloth by Buehler Ltd., and about 25,6 cm (10 inches) in width as measured parallel to the axis of core member 21, wraps the bottom portion of core member 21. Cloth portion 94 is held stationary as core member 21 rotates. However, the cloth is incremented from a supply spool 95 to a takeup spool 96 between the treatment of one or more core members 21. In this manner the above defined Ra, Ry and Sm characteristics for the surface of core member 21 are established in accordance with a preferred embodiment of the invention.

While the present invention has been described with reference of preferred embodiments thereof, it will be appreciated that those skilled in the art will, upon learning of the invention, visualize yet other embodiments that are within the spirit and scope of the invention. Thus, the invention is to be limited only by the claims hereof.

Claims

1. A method of making a drum photoconductor for use in an electrophotographic reproduction device, comprising the steps of,
providing a cylindrical aluminum core,
preparing the topography of the cylindrical outer surface of said core to be a nonspecular reflecting surface,
dip coating a thin, fluid, barrier/adhesive layer onto said cylindrical outer surface, said barrier/adhesive layer including a resin that, when cured, is insoluble in amine solvents,
heat curing said barrier/adhesive layer, to form a cured barrier/adhesive layer that is insoluble in amine solvents,
dip coating a fluid charge generation layer onto said cured barrier/adhesive layer using a coating ink that contains amine solvents,
heat curing said charge generation layer, to form a cured charge generation layer,
dip coating a fluid charge transport layer onto said cured charge generation layer, and
heat curing said charge transport layer, to form a cured charge transport layer.

2. The method of claim 1 including the step of providing air flow control means to produce laminar flow of amine solvent vapor that leaves said fluid charge generation layer as said core is withdrawn from a bulk supply of charge generation coating ink.

3. In an electrophotographic printer having a drum photoconductor and a scanning laser imaging station, said drum photoconductor comprising;
a cylindrical aluminum core having a cylindrical outer surface that is nonspecular reflective of said scanning laser imaging station,
a thin barrier/adhesive layer dip coated on said cylindrical outer surface, said barrier/adhesive layer including a resin that is insoluble in amine solvents,
a charge generation layer dip coated on said barrier/adhesive layer using a coating ink that contains amine solvents, and
a charge transport layer dip coated on said cured charge generation layer.

4. The printer of claim 2 or 3 wherein said charge generation layer includes OHSQ charge generation molecules.

5. The printer of claim 4 wherein said charge transport layer includes DEH charge transport molecules.

6. The printer of claim 5 wherein said barrier/adhesive layer includes a cured epoxy resin, or a cured phenoxy resin, such resins when cured being insoluble in amine solvents.

7. A method of making a drum photoconductor for use in an electrophotographic reproduction device, comprising the steps of,
providing a cylindrical, electrically conductive, metal core,

preparing the outer surface of said core to be a nonspecular reflecting surface by providing a surface roughness (Sm) of about 0.15 micro meters,
dip coating and then heat curing a fluid barrier layer onto said cylindrical outer surface, said barrier layer including a resin that, when cured, is insoluble in amine solvents, and said barrier layer being about 0.05 micro meters thick,
dip coating and then heat curing a fluid charge generation layer onto said cured barrier layer using a coating ink that contains amine solvents, said charge generation layer being about 0.20 micro meters thick, and
dip coating and then heat curing a fluid charge transport layer onto said cured charge generation layer, said charge transport layer being about 22.50 micro meters thick.

8. The method of claim 7 wherein the peak to valley height (Ry) of said cylindrical outer surface of said core does not exceed about 1.25 micro meters.

9. The method of claim 8 wherein the mean spacing between peaks at the mean line (Sm) of said cylindrical outer surface of said core does not exceed about 0.1 milli meters.

10. The method of claim 9 including the step of providing air flow control means to produce laminar flow of amine solvent vapor that leaves said fluid charge generation layer as said core is withdrawn from a bulk supply of charge generation coating ink.

11. A method of making a drum photoconductor for use in an electrophotographic printer having a scanning laser imaging station, comprising the steps of,
providing a cylindrical metal core,
preparing the topography of the cylindrical outer surface of said core to have an Sm parameter of about 0.15 micro meters, an Ry parameter that not exceed about 1.25 micro meters, and an Sm parameter that does not exceed about 0.1 milli meters,
coating a barrier layer onto said cylindrical outer surface, said barrier layer being about 0.05 micro meters thick,
coating a charge generation layer onto said cured barrier layer, said charge generation layer being about 0.20 micro meters thick, and
coating a charge transport layer onto said cured charge generation layer, said charge transport layer being about 22.50 micro meters thick.

12. In an electrophotographic printer having a scanning laser imaging station and a drum photoconductor, said drum photoconductor comprising;
a cylindrical metal core having an outer surface having an Sm parameter of about 0.15 micro meters, an Ry parameter that does not exceed about 1.25 micro meters, and an Sm parameter that does not exceed about 0.1 milli meters,
a barrier layer on the outer surface of said core, said barrier layer being about 0.05 micro meters thick,
a charge generation layer on said barrier layer, said charge generation layer, said charge generation layer being about 0.20 micro meters thick, and
a charge transport layer onto said charge generation layer, said charge transport layer being about 22.50 micro meters thick.

13. The printer of claim 10 or 11 wherein said barrier layer includes a resin is selected from the group aliphatic epoxy and a crosslinking agent therefor, aromatic epoxy and a crosslinking agent therefor, or phenoxy.

14. The printer of claim 12 or 13 wherein said charge generation layer includes OHSQ charge generation molecules, and a toluene sulfonamide resin.

15. The printer of claim 14 wherein said charge transport layer includes DEH charge transport molecules, a polyester resin, and a polycarbonate resin.

16. The printer of claim 15 wherein said charge transport layer includes a yellow dye.

17. A drum photoconductor manufactured in accordance with the method of claim 6 or 16.

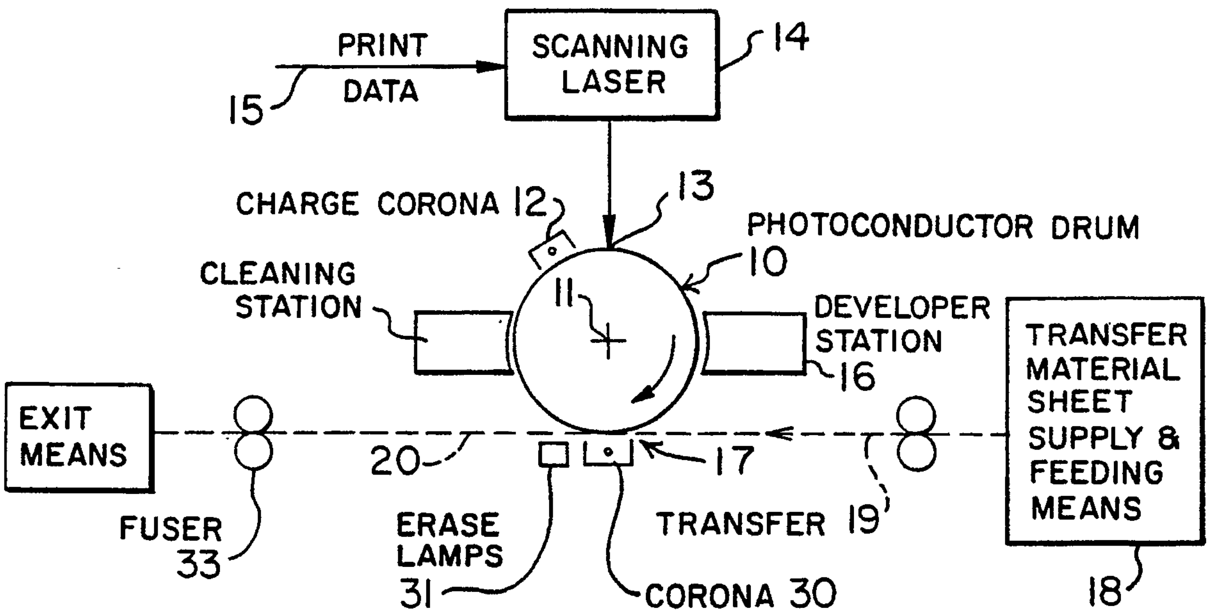


FIG. 1.

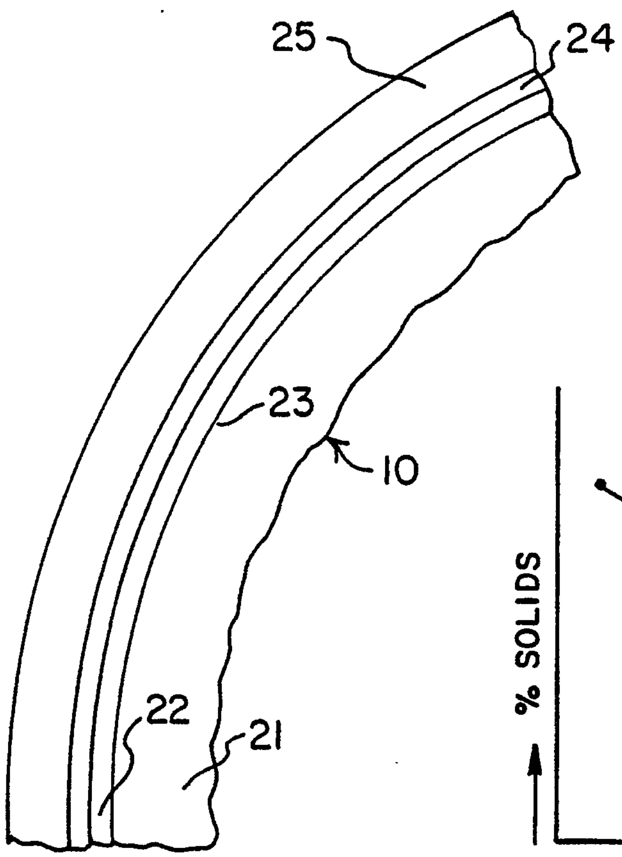


FIG. 2.

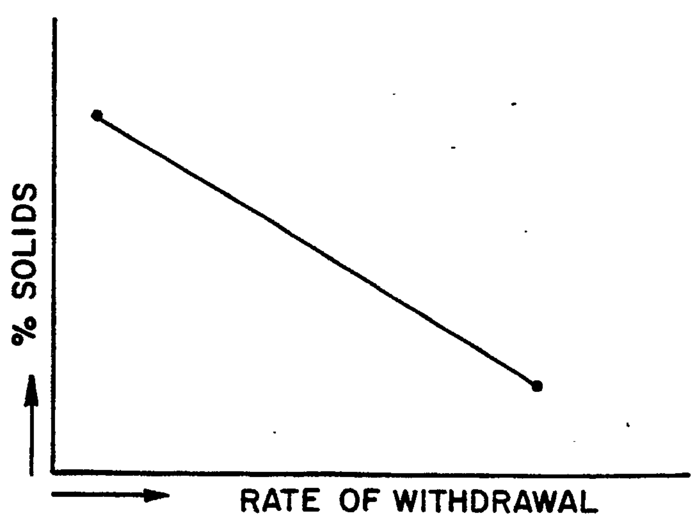
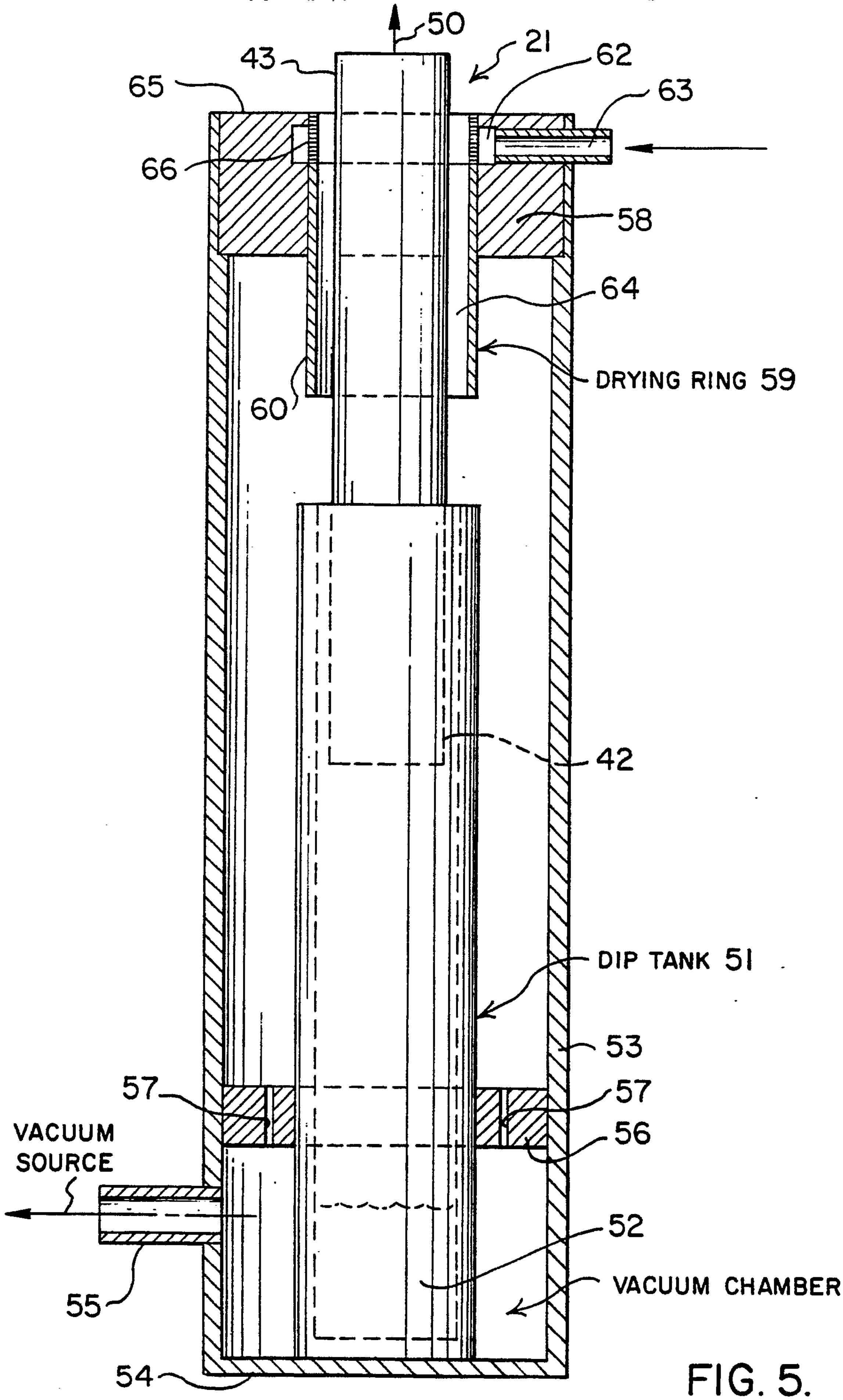


FIG. 4.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DRYING RING 59
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DIP TANK 51
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VACUUM
SOURCE
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VACUUM CHAMBER
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FIG. 5.

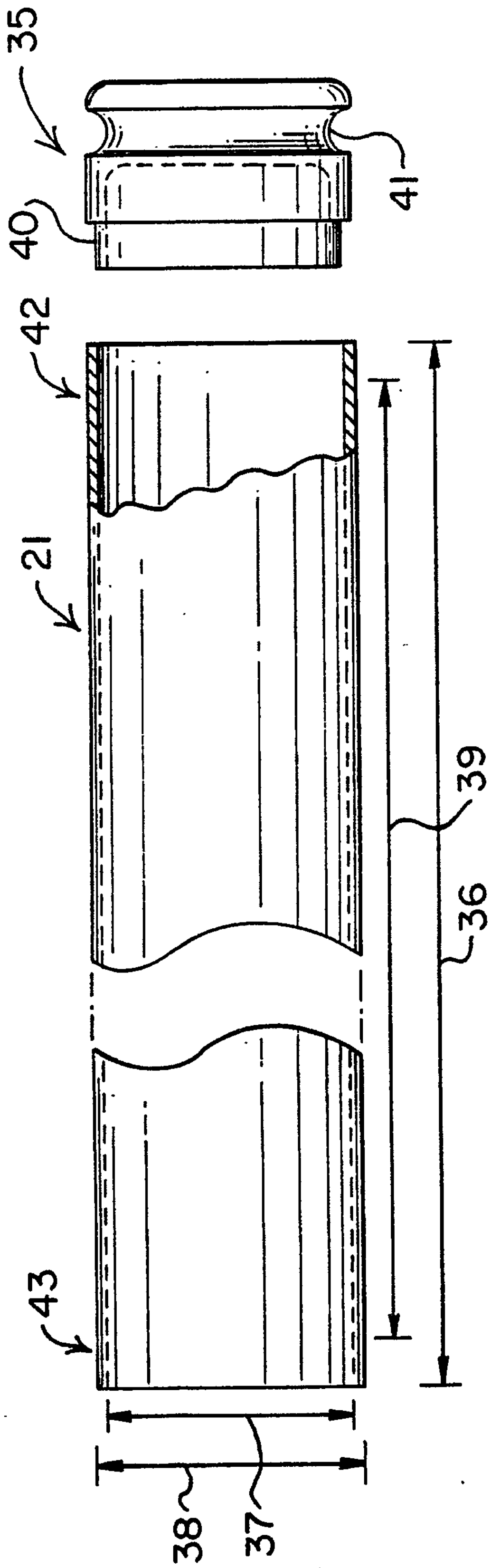

FIG. 3.

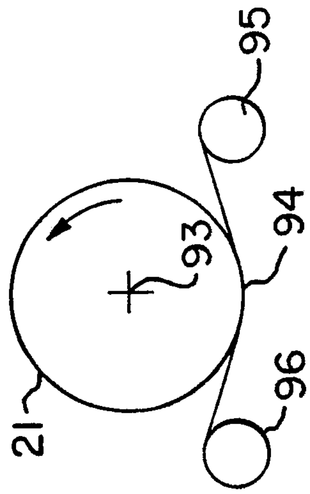

FIG. 7.

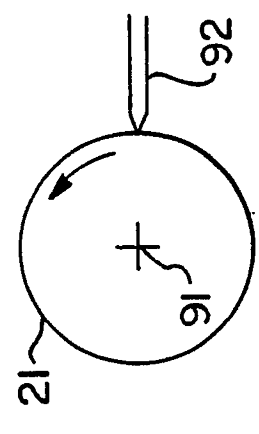

FIG. 6.

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90 48 0106

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y,A	GB-A-2 156 089 (CANON KABUSHIKI KAISHA) * abstract * * page 2, lines 74 - 80 * * page 3, lines 36 - 119 @ page 4, lines 5 - 90 EP 90480106030* * page 6, lines 18 - 89 * claims: 1,2,4-6,15-17 ,22,23,27,32 *	1,3,4,6,7, 11-13,17, 5,14,15	G 03 G 5/05 G 03 G 5/14
D,Y	DE-A-2 635 887 (INTERNATIONAL BUSINESS MACHINES CORPORATION) * page 15, line 17 - page 17, line 3 * * page 21, lines 15 - 22 * claims: 1,4,6,10,11,1 3,20,21 *	1,3,4,6,7, 11-13,17	
A	PATENT ABSTRACTS OF JAPAN vol. 13, no. 32 (P-817)(3380) 25 January 1989, & JP-A-63 229461 (FUJITSU LTD.) 26 September 1988, * the whole document *	1,3,5,7, 11,12,	
A	EP-A-0 213 836 (CANON KABUSHIKI KAISHA) * abstract * * page 4, lines 26 - 59 * * page 5, lines 7 - 30 * * page 6, lines 18 - 71 *	1,3,5,7, 11,12,14, 15	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

G 03 G 5

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	05 December 90	HINDIAS E.

CATEGORY OF CITED DOCUMENTS

X: particularly relevant if taken alone
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