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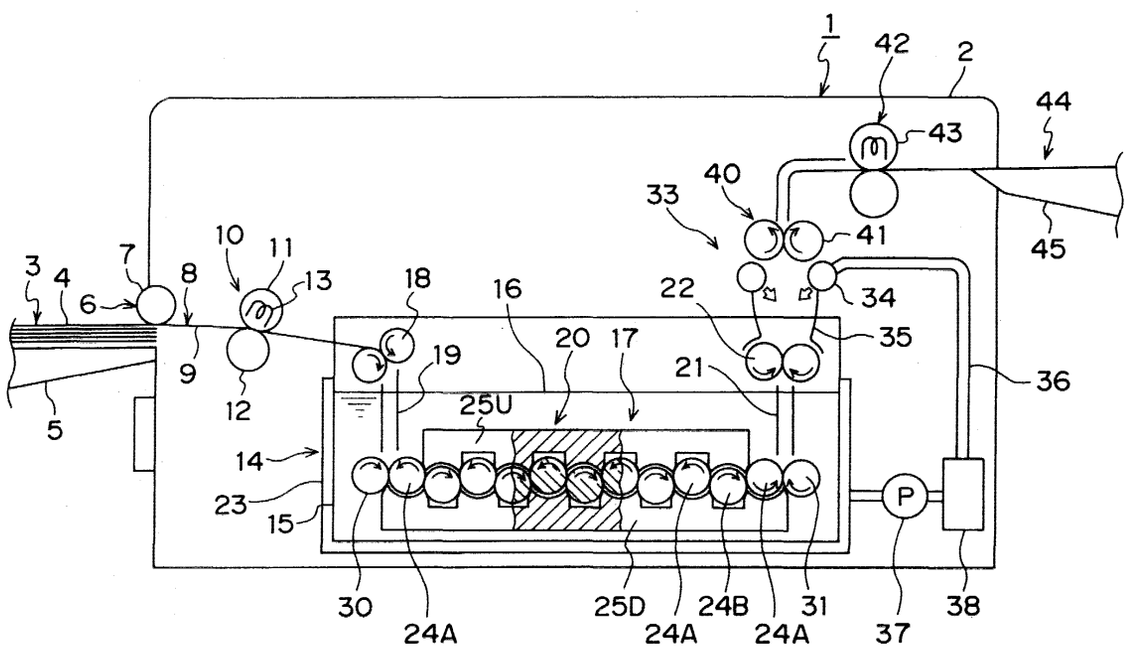
(54) Apparatus and method for removing a print material on a recording medium

(57) The present invention provides a removing apparatus (1) for applying a liquid (16) to a printed sheet (4) and thereby removing toner from the sheet. The sheet has a water-swelling type top layer. As the sheet is dipped in the liquid, it is curved by a sheet curving member (20) for at least 20 seconds. Preferably, the curved portion of the sheet has a radius of curvature of 10mm or less. This allows the dipping operation to be performed in a shorter period of time.

Fig.1



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Description

TECHNICAL FIELD

[0001] The present invention relates to a print material removing apparatus for removing a print material such as toner or ink on a recording medium. In particular, the present invention relates to a print material removing apparatus in which the recording medium bearing the print material, such as plain paper for copy and printing machines and plastic transparent film for an overhead projector, is brought into contact with a liquid to remove the print material therefrom. Further, the present invention relates to a print material removing method in which a recording medium bearing a print material is brought into contact with the liquid to remove the print material therefrom.

BACKGROUND OF THE INVENTION

[0002] Conventionally, from the point of view of the reuse of natural resources, there have been proposed a variety of devices and methods for removing toner on a copied or printed sheet.

[0003] For example, Japanese Patent Publication 11-218955 discloses a print material removing device which employs a special sheet having a water-swelling type top layer. Note that the "water-swelling" means absorbing water-based solvent or water to swell but not being dissolved therein. With the device, the sheet having a toner image thereon is dipped in the liquid mainly composed of water to absorb the liquid in the top layer, so that the adhesive force between the top layer and the toner on the surface thereof is reduced. As a result, the toner can be separated from the surface of the top layer using a toner removing member such as brush for applying a mechanical brushing force thereto.

[0004] It has been discovered that the toner can be satisfactorily removed from the sheet having a water-swelling type top layer when the black/white ratio of the image formed on the sheet is relatively low. However, it has also been discovered that the dipping time for the top layer of the sheet to absorb the liquid sufficiently is greatly increased when the black/white ratio is relatively high. This may be because the toner adhered on the sheet, which is herein referred to as toner layer (broadly, print material layer), prevents the permeation of the liquid into the top layer thereof. More specifically, the liquid generally permeates the top layer region beneath the toner layer through the uncovered top layer region, i.e., the liquid penetrates the uncovered region and then prevails substantially along the top layer surface to the covered region.

[0005] Also, in case where an image is formed by a monochrome toner, the liquid can permeate into the top layer through the space formed between the toner particles in the toner layer. However, in case of a color toner, the amount of toner adhered on the sheet is greater and the degree to which the toner is melted is higher than the counterparts of a monochrome toner. Therefore, the space is not formed between the toner particles, which further increases the dipping time.

[0006] In an embodiment in which the dipping operation is performed by transporting a sheet in the liquid, in order that the liquid permeates sufficiently into the top layer of the sheet, it is necessary to reduce the transporting speed or extend the sheet transport path in the liquid. As a result, the throughput of the removing apparatus is lowered, the space that the apparatus occupies is increased and/or a large amount of liquid is needed for the dipping process.

SUMMARY OF THE INVENTION

[0007] Therefore, an object of the present invention is to provide a print material removing apparatus that includes means for reducing the dipping time.

[0008] To achieve the above object, the print material removing apparatus according to the present invention comprises a reservoir for receiving a liquid so that a sheet having a water-swelling type top layer supporting a print material thereon is dipped in the liquid; and a curving means for curving at least a portion of the sheet on which the print material has been formed as the sheet is dipped in the liquid. The portion of the sheet is curved by the curving means in the liquid for at least 20 seconds.

[0009] Preferably, the curved portion of the sheet may have a radius of curvature of 10mm or less.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

Fig. 1 is a cross-sectional view of a print material removing device according to one embodiment of the present invention;
Fig. 2A is a cross-sectional view of a three-layered sheet having a water-swelling type top layer;
Fig. 2B is a cross-sectional view of a five-layered sheet having a water-swelling type top layer;
Fig. 3 is an enlarged partial cross-sectional view of the sheet curving member shown in Fig. 1;
Fig. 4A is an enlarged partial cross-sectional view of the top layer of the sheet, showing permeation of the liquid into the top layer in case where the sheet is not curved;
Fig. 4B is an enlarged partial cross-sectional view of the top layer of the sheet, showing permeation of the liquid into the top layer in case where the sheet is curved;
Fig. 5A is an enlarged partial side view of another embodiment of the sheet curving member;
Fig. 5B is a partial top view of the member shown in Fig. 5A;
Fig. 6 is a top view of yet another embodiment of

the sheet curving member;

Fig. 7 is a side view of another embodiment of the dip station;

Fig. 8 is a cross-sectional view of yet another embodiment of the dip station; and

Fig. 9 is a variant of the station shown in Fig. 8.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0011] Fig. 1 schematically shows a print material removing device according to the present invention. The device, generally indicated by reference numeral 1, is used for removing toner from a tailor-made, copied or printed sheet and thereby regenerating the sheet into a condition in which it can be reused for further copying and printing.

[0012] The tailor-made sheet has a three-layered structure of base, intermediate adhesive, and top layers as shown in Fig. 2A or a five-layered structure in which the base layer supports intermediate and then top layers on its opposite sides as shown in Fig. 2B. Preferably, the base layer is made of plastic film or paper. Also, the intermediate adhesive layer is used to bond the base and top layers and may be made of resin such as urethane, acrylic, and styrene. Note that the intermediate adhesive layer may be omitted when the sufficient adhesion between the base and top layers can be obtained. Further, the top layer may be made of water-swelling type resin, preferably obtained by cross-linking the water soluble resin. Components of the sheet and each of the layers of the sheet are described in detail in Japanese Patent Publication 11-218955, which is incorporated herein by reference.

[0013] Referring to Fig. 1, descriptions will be made to the removing device 1 in detail below. The removing device 1 has a housing 2 or casing that defines an appearance thereof. In the drawing, the housing 2 has a supply station 3 on its left wall for receiving a stack of sheets 4 and supplying each of the sheets for regeneration thereof. Similar to the typical sheet supply station provided for the copying and printing machines, the supply station 3 has a tray 5 or cassette for supporting the stack of sheets and a supply mechanism 6 for transporting the uppermost sheet 4 to a first sheet transporting mechanism. Typically, the supply mechanism 6 has a supply roller 7 capable of making a frictional contact with a top surface of the uppermost sheet 4 and a motor (not shown) for driving the supply roller 7.

[0014] The first sheet transporting mechanism 8, which is extended from the supply station 3 to a dip station 14 which will be described below, has a sheet guide 9 for guiding the sheet 4 during the transport of the sheet 4 and, if necessary, one or more transporting rollers (not shown) for providing the sheet with a transporting force. In order to attain a smooth supply of the sheet 4 into the contact region of a first pair of rollers, which will be described below, in the dip station 14, one end positioned on the downstream side of the sheet guide 9 is extended to the dip station 14, terminating at the upstream side of and the vicinity of the contact region of the first pair of rollers.

[0015] A pre-drying station 10 is preferably provided in the mid portion of the first sheet transporting mechanism 8. The pre-drying station 10 is used for the preheating of the sheet to some extent so that, upon making a contact with water, the dried sheet can absorb water to swell in a short period of time. More specifically, in this embodiment, the pre-drying station 10 has a pair of rollers 11 and 12 provided on opposite, i.e., upper and lower, sides of the sheet path defined by and along the sheet guide 9. In this embodiment, the upper roller 11 of the pair of rollers has a heat source or heater 13 provided therein. Preferably, in order to reduce a time necessary for pre-drying of the sheet, in particular the five-layered sheet, the lower roller 12 may also include the heater therein to heat and dry the opposite surfaces of the sheet 4. The rollers 11 and 12, either of which being drivingly connected with a motor not shown, are supported in a parallel fashion, so that they make an elongated, peripheral contact with each other.

[0016] It should be noted that the pre-drying station 10 is not limited to the pair of rollers 11 and 12 and may be another structure such as belt or device such as heater with heated-air, dehumidifying device, and vacuum heating device, provided that it can dehydrate the sheet.

[0017] The dip station 14 includes a reservoir 15 with a predetermined shape and size to accommodate a certain amount of liquid 16. Typically, the liquid 16 is composed of water and surfactant that improves a permeability of the water into the top layer of the sheet 4. It should be noted that the surfactant is not necessarily contained and the liquid may include only water. Also, another material may be added to the liquid as required.

[0018] Although the dip station 14 includes one reservoir 15, another reservoir for the supplement of the liquid may be provided to maintain a certain amount of liquid in the reservoir 15. In this instance, the reservoir may be fluidly connected with the supplemental reservoir through a suitable liquid feed tube.

[0019] Preferably, the temperature of the liquid 16 is maintained by the use of a heater 23 in the range of about 5 to 65 degrees centigrade, more preferably about 25 to 45 degrees centigrade, most preferably about 35 degrees centigrade. The heater 23 may employ heating wires not shown that surround the reservoir 15. The toner on the sheet 4 is hard to be removed in the liquid 16 at a relatively low temperature. On the other hand, the liquid 16 in the reservoir 15 may be easy to be evaporated at a relatively high temperature and at the same time the toner may be melted and therefore hard to be removed.

[0020] A second sheet transport mechanism 17 is provided in the reservoir 15 so that the sheet fed from the upstream side of the reservoir 15 with respect to the sheet transporting direction toward the downstream

side thereof is transported through the liquid 16 as the sheet is curved. The second sheet transport mechanism 17 has a first pair of rollers 18, a first sheet guide 19, a sheet curving member 20, a second sheet guide 21, and a second pair of rollers 22 along the sheet transporting direction.

[0021] Referring to Figs. 1 and 3, the sheet curving member 20 has a plurality of identical rollers arranged from the left to the right direction in the drawings (along the horizontal direction) and upper and lower guides 25U, 25D located on the upper and lower side of the rollers 24, respectively, so that the peripheral outer surfaces of the rollers 24 and the outer surfaces of the upper and lower guides 25U, 25D define a curved sheet transport path.

[0022] More specifically, the plurality of rollers 24 are composed of a set of first rollers 24A (which are six in the embodiment shown) mounted for rotation in the counterclockwise direction and a set of second rollers 24B (which are five in the embodiment shown) mounted for rotation in the clockwise direction. The rollers 24 are designed so that they rotate at the same rotational speed. The first and second rollers 24A and 24B are alternately located along the transporting direction and arranged in a parallel fashion so that each of rollers 24 forms a nip with its neighboring roller(s).

[0023] As best shown in Fig. 3, the horizontal plane including shafts 28A of the first rollers 24A is located slightly above the counterpart including shafts 28B of the second rollers 24B. The upper and lower guides 25U, 25D have a plurality of ribs 29U, 29D, respectively. The outer surface of each rib 29U is spaced at a distance from the upper peripheral outer surface portion of the corresponding second roller 24B. Likewise, the outer surface of each rib 29D is spaced at a distance from the lower peripheral outer surface portion of the corresponding first roller 24A.

[0024] With the sheet curving member 20 so constructed, the rotation of the first and second rollers 24A, 24B provides the sheet 4 with a transporting force, so that the sheet 4 is transported and curved though the gap between the first rollers 24A and lower guide 25D and the gap between the second rollers 24B and upper guide 25U.

[0025] More specifically, referring to Fig. 3, the leading edge of the sheet 4 moves past the nip between the second left roller 24B and first roller 24A and then is brought into contact with the rib 29D of the lower guide 25D. The sheet 4 is next applied with a transporting force by the second left roller 24B and first roller 24A so that the sheet 4 is transported along the outer surface of the rib 29D, so that the leading edge is fed into the nip between the first roller 24A and second right roller 24B. The sheet 4 is then applied with a transporting force by the first roller 24A and second right roller 24B so that the leading edge of the sheet 4 moves past the nip between the first roller 24A and second right roller 24B and is brought into contact with the rib 29U of the upper guide 25U. Thus, the sheet 4 is transported though the curved member 20 while the sheet 4 is repeatedly curved by the curved member 20.

[0026] As described above, the conventional removing method includes the step of dipping the sheet 4 in the liquid 16 without curving it, as shown in Fig. 4A. Accordingly, the liquid is supplied to the top layer portion beneath the toner layer mainly through top layer portion (s) uncovered with the toner layer. Therefore, a relatively long period of time is necessary until the liquid 16 permeates the entire portion of the top layer of the sheet 4, i.e., until the top layer sufficiently swells. Note that the arrows in Fig. 4A and also Fig. 4B show the direction of the permeation.

[0027] Contrary to this, the removing method of the present invention includes the step of dipping and curving the sheet 4 in the liquid 16, as shown in Fig. 4B. In this method, the toner layer is partially removed so that the liquid 16 is able to penetrate through the removed region into the top layer, which allows the dipping time to be reduced. In addition, according to the present invention, since the sheet 4 is repeatedly curved, the toner layer can be removed from the sheet 4 without a mechanical brush force applied thereto. However, for the purpose of reducing the dipping time of the sheet 4, any suitable brushing means may be provided for applying a mechanical brushing force to the sheet 4 on the downstream side, which may be in the liquid or out of the liquid, of the sheet curving member 20.

[0028] Referring again to Fig. 1, a roller 30 is located in a peripheral contact with the leftmost roller of the set of first rollers 24A to guide the sheet 4 through the contact region therebetween from the first guide 19 into the sheet curving member 20. Likewise, a roller 31 is located in a peripheral contact with the rightmost roller of the set of first rollers 24A to guide the sheet 4 through the contact region therebetween from the sheet curving member 20 to the second guide 21.

[0029] To rinse off foreign matters remaining on the sheet 4 that has passed through the dip station 14, a rinse station 33 is provided on the downstream side of the second pair of transporting rollers 22 in the dip station 14 with respect to the sheet transporting direction. The rinse station 33 has a spray tube 34 provided with many jet holes not shown for spraying a rinsing liquid onto the opposite surfaces of the sheet 4. A guide 35 surrounds a sheet transport path from the second pair of transporting rollers 22 to the spray tube 34. In this embodiment, the rinsing liquid is the liquid 16 received in the reservoir 15. The rinsing station 33 also includes a tube 36 for fluidly connecting between the spray tube 34 and the reservoir 15, a pump 37 for pumping the liquid 16 (or rinsing liquid) through the tube 36 from the reservoir 15 to the spray tube 34. Further, a filter 38 may be provided in the tube 36 for collecting foreign matters in the liquid 16, for example, toner separated from the sheets 4.

[0030] To remove the liquid 16 from the sheet 4 that

has been sprayed with the rinsing liquid by the rinse station 33, a liquid removing station 40 is provided on the downstream side of the rinse station 33. In this embodiment, the liquid removing station 40 employs a squeezing technique for nipping the sheet from its opposite surfaces and then pressing the liquid away from the sheet. To this end, the liquid removing station 40 includes a pair of squeezing rollers 41 mounted above the second pair of transporting rollers 22 on the left and right sides of the sheet transport path. One of the squeezing rollers 41 is drivingly connected with a motor not shown. The squeezing rollers 41 are supported in a parallel fashion with their peripheral surfaces biased into contact with each other.

[0031] In order to dry the sheet 4 into a condition in which the squeezed sheet can be reused in the copying machine for example, a post-drying station 42 is preferably provided on the downstream side of the liquid removing station 40. In this embodiment the post-drying station 42 employs a roller type heater 43 similar to that used in the pre-drying station 10. Alternatively, a fan without heater capable of applying ambient air to the sheet or a fan with heater capable of applying heated air to the sheet may be used.

[0032] A discharge station 44 has a receiving tray 45 mounted on the right wall of the housing 2 for receiving the sheet 4 that has passed the post-drying station 42.

[0033] In operation of the removing device 1, the sheets 4 to be regenerated are stacked one on top the other on the tray 5 of the supply station 3. The stacked sheets 4 are fed from the uppermost one that is in contact with the supply roller 7 onto the sheet guide 9 of the first sheet transporting mechanism 8 and then into the pre-drying station 10. By the pre-drying station 10, the sheet 4 is heated, so that the liquid absorption capacity of the surfaces in the sheet 4 is enhanced.

[0034] The sheet is then fed into the reservoir 15 of the dip station 14 where it is transported along the curved sheet path defined by the sheet curving member 20 and is dipped in the liquid 16 for a certain period of time. As a result, the entire portion of top layer of the sheet absorbs the liquid 16 so that the adhesive force between the toner and the top layer supporting the toner is eliminated. At the same time the bending force applied to the sheet 4 enables the toner to be removed from the sheet 4.

[0035] The sheet 4 is then sprayed with the rinsing liquid from the spray tube 34 in the rinse station 33 to remove the residual material on both the surfaces thereof. Further, the sheet 4 is squeezed at the liquid removing station 40 to remove the liquid 16 therefrom, then heated at the post-drying station 42, and finally discharged onto the discharge tray 45 of the discharge station 44.

[0036] In this embodiment, the time for dipping the sheet 4 in the liquid 16 depends on the number of the rollers 24A, 24B and their rotational speed. For example, in case where the downsizing of the device 1 is given priority to, the reduced number of the rollers 24A, 24B and the lowered rotational speed thereof enable the sufficient dipping time to be obtained. On the other hand, in case where the throughput of the sheets 4 is given priority to, the increased number of the rollers 24A, 24B and the increased rotational speed thereof enable the sufficient dipping time to be obtained.

[0037] As described above, the dipping time which it takes the top layer of the sheet 4 to absorb the liquid 16 varies depending on whether the sheet 4 is formed with a monochrome image or a color image thereon. Therefore, it is preferable to adjust the dipping time based on the type of the image by changing the rotational speed of the rollers 24A, 24B. Alternatively, the dipping time may be adjusted by stopping the rotation of rollers 24A, 24B for a certain period of time, with the sheet 4 dipped in the liquid 16.

[0038] Figs. 5A and 5B show partial side and top views of the sheet curving member of another embodiment, respectively. Note that, for clarity, the entire portion of the upper and lower guides except for the ribs of the lower guide is omitted in Fig. 5A. Each roller of the first and second rollers 124A, 124B of the sheet curving member 120 is composed of a plurality of separate small rollers spaced from each other along the axis direction. A rib 129D of the lower guide 125D is provided between each pair of the neighboring small rollers of the first roller 124A. As shown in Fig. 5A, a portion of the rib 129D extends to the region between the neighboring small rollers of the second roller 124B. Likewise, a rib 129U of the upper guide 125U is provided between each pair of the neighboring small rollers of the second roller 124B. As shown in Fig. 5A, a portion of the rib 129U extends to the region between the neighboring small rollers of the first roller 124A.

[0039] With the arrangement, the sheet curving member 120 has an advantage of providing more smooth transport of the sheet, as compared to the sheet curving member 20 shown in Fig. 3.

[0040] Fig. 6 shows another embodiment of the sheet curving member in which the upper and/or lower guides 225U, 225D are formed with apertures 46 in the region where the ribs 229U, 229D are not provided. With this construction, the toner separated from the sheet 4 in the curved sheet path can be discharged out of the sheet curving member.

[0041] Fig. 7 shows a schematic view of another embodiment of the dip station. The sheet transport path of the dip station 314 is composed of linear and curved paths.

[0042] Specifically, a sheet transporting mechanism 50 is provided in the reservoir 315 of the dip station 314 so that the sheet is transported in the vertical downwards direction, then deflected through substantially 180 degrees along the curved path, and finally transported in the vertical upwards direction.

[0043] The sheet transporting mechanism 50 includes an upper drive roller 52U, which is mounted for

rotation in the direction shown by an arrow and is in contact at its left and right peripheral outer surface portions with upper rollers 53L, 53R, respectively. The mechanism 50 also includes a lower drive roller 52D, which is mounted for rotation in the direction shown by an arrow and is in contact at its left and right peripheral outer surface portions with lower rollers 54L, 54R, respectively. The upper drive roller 52U and upper left roller 53L are positioned so that the sheet that has passed the pre-drying station is guided through the contact region therebetween into the liquid 16. The upper drive roller 52U and upper right roller 53R are positioned so that the sheet is guided through the contact region therebetween out of the liquid 16 toward the rinse station.

[0044] A sheet guide 55L is mounted between the contact region of the upper rollers 52U, 53L and the contact region of the lower rollers 52D, 54L. Similarly, a sheet guide 55R is mounted between the contact region of the upper rollers 52U, 53R and the contact region of the lower rollers 52D, 54R. A reversing guide member 56 is also provided, the outer surface of which forms a constant gap with the lower peripheral outer surface portion of the lower drive roller 52D, so that the sheet is transported through the gap from the guide 55L to the guide 55R.

[0045] It should be noted that the lower rollers 52D, 54L, 54R and the reversing guide member 56 are preferably positioned and configured similarly to the first roller 24A, second left and right rollers 24B and the rib 25D shown in Fig. 3.

[0046] With the dip station 314 so constructed, the sheet which has passed the pre-drying station is dipped in the liquid 16 as it is transported through the guide 55L, the gap between the lower drive roller 52D and the reversing guide member 56, and the guide 55R. In this embodiment, the sheet is transported in the curved sheet path defined by the lower drive roller 52 and the revering guide member 56 for more than a predetermined period of time in order to provide the sheet with a sufficient bending force.

[0047] Although in the embodiment shown the upper rollers 52U, 53L and 53R are located above the liquid level, they may be mounted in the liquid. Also, a plurality of sheet transporting mechanisms similar to the mechanism 50 may be provided in the dip station.

[0048] Fig. 8 shows another embodiment of the dip station. In this embodiment, the dipping operation is performed by holding the sheet 4 stationary and curving it in the liquid 16.

[0049] Specifically, in the reservoir 415 of the dip station 414 is provided a guide member 60 having a cylindrical hollow, which is partially opened so that the sheet can move into and out of the hollow of the guide member or container 60. Above the dip station 414 is located a switching guide 61, which moves between the solid line position where the sheet that has passed the pre-drying station is guided toward the reservoir 415 and the dotted line position where the sheet that has been discharged out of the reservoir 415 is guided toward the rinse station.

[0050] A pair of reverse rollers 62 is provided between the switching guide 61 and the guide member 60. The reverse rollers 62 form a nip and either of them (the right roller in the embodiment shown) is drivingly connected with a motor not shown. The motor is designed so that it rotates both in the clockwise and counterclockwise directions, so that the sheet 4 is selectively guided through the nip into or out of the hollow of the guide member 60.

[0051] With this arrangement, the sheet 4 fed from the pre-drying station to the dip station 414 is guided by the rotation of the reverse rollers 62 into the hollow of the guide member 60. At the same time, the sheet 4 is curved or curled along the cylindrical surface of the guide member 60 (or the inner wall of the container). The rollers 62 then stop to rotate with the trailing edge of the sheet 4 retained in the nip so that the sheet 4 is curved and held stationary in the liquid 16 for a certain period of time. Finally, the rollers 62 are rotated in reverse so that the sheet 4 is discharged out of the dip station 414.

[0052] In this embodiment, the dipping time of the sheet 4 can be controlled based on the stop time of the reverse rollers 62. In this embodiment, only the adjustment of the stop time allows for the control over the dipping time according to the type of image (i.e., monochrome or color image) formed on the sheet. In other words, the dip station in this embodiment has an advantage of controlling the dipping time more easily than in the case where the dipping time is controlled based on the rotational speed of the rollers 24 of the sheet curving member 20 shown in Fig. 1.

[0053] Fig. 9 shows a variant of the dip station in Fig. 8. In the hollow of the guide member 560 of the dip station 514 is provided a guide roller 63, which has a smaller diameter than that of the cylindrical inner wall of the guide member 560 and is drivingly connected with a motor not shown that is designed to rotate both in the clockwise and counterclockwise directions. In the open region of the guide member 560 is located an opposed roller 64, which forms a nip with the guide roller 63 and is rotated with the movement of the guide roller 63. A guide 65 is also provided between the nip of the reverse rollers 62 and the nip of the rollers 63, 64.

[0054] With this arrangement, the sheet 4 fed from the pre-drying station to the dip station 514 is guided by the rotation of the reverse rollers 62 along the guide 65 and supplied into the nip between the guide roller 63 and the opposed roller 64. The guide roller 63 is then rotated in the clockwise direction so that the sheet 4 is moved and curved along the gap formed between the guide roller 63 and the guide member 560. Next, the guide roller 63 stops to rotate with the trailing edge of the sheet 4 retained in the nip between the guide roller 63 and the opposed roller 64 so that the sheet 4 is curved and held stationary in the liquid 16 for a certain period of time. Finally, the guide roller 63 is rotated in reverse so that

the sheet 4 is discharged through the guide 65 and then the reverse rollers 62 out of the dip station 514.

[0055] Note that in this variant the reverse rollers 62 may be located above the liquid level. Also, in case where a relatively large sheet is to be regenerated, the sheet may be superimposed on the guide roller 63.

[0056] Further, in the previous embodiments shown in Figs. 8 and 9, the guide members 60, 560 may preferably be formed with apertures so that the toner separated from the sheet is discharged out of the hollow or curved sheet path. In addition, a suitable means may be provided in the liquid for applying a mechanical brushing force to the sheet to promote the separation of the toner therefrom.

[0057] Furthermore, in the previous embodiments shown in Figs. 8 and 9, as compared to the arrangement shown in Fig. 1 in which the sheet 4 is partially curved along the substantially linear sheet path or the arrangement shown in Fig. 7 in which the linear sheet path is used, the space that the sheet path occupies is small, which is advantageous for the downsizing of the dip station. Therefore, the overall dimensions of the removing device can be reduced. Also, the volume of the liquid 16 to be used can be decreased, which results in the reduced energy for heating the liquid 16.

Test

[0058] A test was conducted to remove toner from a sheet formed with a monochrome or color image thereon by dipping and curving the sheet with a predetermined radius of curvature in the liquid for a predetermined period of time (examples 1-7). For comparison, the sheet was dipped in the liquid for a predetermined period of time without being curved (comparative examples 1-2). After the dipping process, the sheet was rinsed by a rinsing liquid (pure water) and then a removability of toner was evaluated for each of the examples.

(i) Sheet

[0059] The five-layered sheet was used. The base layer of the sheet was a PET (polyethylene terephthalate) film having a thickness of 100μm, which is commercially available from Toray Industries under the tradename of "Lumirror T".

[0060] A solution for the intermediate adhesive layer was made by preparing 100g of water dispersible urethane resin solution (available from Asahidennka under the tradename of "HUX-232"), adding 5g of melamine-formaldehyde resin (available from Sumitomo Chemical under the tradename of "Sumirase 613") and 0.2g of higher alcohol alkylene oxide adduct (available from Sanyokaseikogyo under the tradename of "Narrowacty 95N"), and then agitating the mixture thereof for five minutes. The solution was applied onto the opposite surfaces of the base layer by the use of a coating bar. The amount of the applied solution for each surface was set to be 5g per square meters. After application, the base layer with the solution was dried for two minutes at 120 degrees centigrade and then subjected to corona discharge treatment to form the intermediate adhesive layer having a thickness of 5μm.

[0061] A solution for the top layer was prepared by mixing 80g of polyacrylic acid solution (available from Nihon Junyaku under the tradename of "Jurimer AC-10H") with 120g of pure water and 0.6g of sodium hydroxide. The solution was mixed with 2.4g of glycerin poly(glycidyl ether) as cross-linker (available from Nagasekasei under the tradename of "Denacol EX-313"), 0.4g of higher alcohol alkylene oxide adduct as surfactant (available from Sanyokaseikogyo under the tradename of "Narrowacty 95N"), and 0.1g of silica particles (available from Fuji Silysia under the tradename of "Sylisia 450") and then was agitated for 5 minutes. The prepared solution was coated on the intermediate adhesive layers by the use of the. coating bar. The amount of the applied solution for each surface was set to be 5g per square meters. The applied solution was then heated at 160 degrees centigrade for two minutes to form the top layer having a thickness of 5μm.

(ii) Printing condition (Printer)

[0062] A printer commercially available from EPSON under the tradename of EPL 5500 was used for examples 1-3 and comparative example 1. Also, a printer commercially available from Minolta under the tradename of LIMOS 910 was used for examples 4-7 and comparative example 2. A black/white ratio of the printed image was 100% (solid image). The image was printed on the A4-sized sheet.

(iii) Toner

[0063] A black toner for monochrome image used with the printer from EPSON under the tradename of EPL 5500 was used for examples 1-3 and comparative example 1. Also, a black toner for color image used with the printer from Minolta under the tradename of LIMOS 910 was used for examples 4-7 and comparative example 2.

(iv) Dip station

[0064] The liquid was prepared by mixing 0.01% of surfactant (available from Sanyokaseikogyo under the tradename of "Nonypol 60") and 99.9% of pure water. 3 lit. of the liquid was received in the reservoir and kept at 30 degrees centigrade.

(v) Removability of toner

[0065]

A: All of the toner on the printed area was removed.

B: The toner on more than 90% of the printed area was removed.
C: The toner on less than 90% of the printed area was removed.

Test results

[0066] The test results are shown in the following table.

		RADIUS OF CURVATURE	DIPPING TIME							
			15sec	20sec	30sec	1min	1.5min	2min	3min	5min	10min
MONOCHROME IMAGE	Ex.1	5mm	C	B	A						
	Ex.2	10mm	C	B	A	A	A				
	Ex.3	15mm			C	B	A				
	Com.Ex.1						C	B	A		
COLOR IMAGE	Ex.4	5mm		C	B	A					
	Ex.5	10mm			C	B	A				
	Ex.6	15mm					C	B	A		
	Ex.7	25mm							C	B	A
	Com.Ex.2										C

Evaluation

[0067] The table indicates that the curving of the sheet is effective for removing the toner therefrom. More specifically, in the case of a monochrome image, when the sheet is not curved, the toner is not removed completely until the sheet is dipped in the liquid for at least three minutes. On the other hand, the curving of the sheet enables the toner to be completely removed in a shorter period of time. The decrease in the radius of curvature of the sheet allows the dipping time to be reduced. In particular, when the sheet is dipped in the liquid and curved with a radius of curvature of less than 10mm for more than 20 seconds, preferably more than 30 seconds, the toner is substantially removed from the sheet.

[0068] In the case of a color image, when the sheet is not curved, the toner can not be removed from the sheet even if it is dipped in the liquid for ten minutes. In contrast, the curving of the sheet allows the toner to be removed therefrom. Also, the decrease in the radius of curvature of the sheet allows the dipping time to be reduced.

[0069] As described above, according to the removing apparatus and method of the present invention, the dipping time can be reduced by curving the sheet in the liquid. This has various advantages such as the downsizing of the dip station or improved effectiveness in the regeneration of sheets. Also, a print material can be removed from the sheet without a brushing means for applying a mechanical brushing force to the sheet.

Claims

1. A print material removing apparatus for applying a liquid (16) to a sheet (4) having a water-swelling type top layer supporting a print material thereon and thereby removing the print material from the sheet, comprising:

a reservoir (15) for receiving said liquid so that the sheet is dipped in said liquid; and
a curving means for curving at least a portion of said sheet on which said print material has been formed as said sheet is dipped in said liquid,

wherein said portion of said sheet is curved by said curving means in the liquid for at least 20 seconds.

2. A removing apparatus in accordance with claim 1, wherein said curved portion of said sheet has a radius of curvature of 10mm or less.

3. A removing apparatus in accordance with claim 1, wherein said curving means includes

a roller (52D) for transporting and curving said sheet along the peripheral outer surface thereof so that said sheet is deflected through substantially 180 degrees; and
a pair of linear sheet paths (55L, 55R) provided in a substantially parallel fashion on the upper and downstream sides of said roller with respect to a transporting direction.

4. A removing apparatus in accordance with claim 1, further comprising a heater (23) for maintaining said liquid (16) in said reservoir (15) at a predetermined temperature.

5. A removing apparatus in accordance with claim 1, further comprising a pre-drying means (10) for drying said sheet (4) before it is dipped in said liquid (16).

6. A removing apparatus in accordance with claim 1, further comprising a rinsing means (33) for applying a rinsing liquid to said sheet (4) which has been dipped in said liquid (16) in said reservoir (15); and a liquid removing means (40) for removing said liquid in said reservoir and/or said rinsing liquid on said sheet.

7. A print material removing apparatus for applying a liquid (16) to a sheet (4) having a water-swelling type top layer supporting a print material thereon and thereby removing the print material from the sheet, comprising:

a reservoir (15) for receiving said liquid so that the sheet is dipped in said liquid; and
a curving means (20) for curving said sheet as said sheet is dipped in said liquid,

wherein said curving means includes a set of first rollers (24A; 124A) mounted for rotation in a first direction and a set of second rollers (24B; 124B) mounted for rotation in the opposite direction to the first direction, said first and second rollers being alternately located along a transporting direction so that each of said rollers forms a nip with its neighboring roller(s) so that said sheet is transported along the peripheral outer surfaces of said rollers and through said nips.

8. A removing apparatus in accordance with claim 7, wherein said curving means (20) further comprises more than one guides (25U, 25D; 125U, 125D) which are located adjacent to said corresponding first and second rollers (24A, 24B) so that said guides and said rollers define a sheet transport path.

9. A removing apparatus in accordance with claim 7,

wherein the dipping time during which said sheet (4) is dipped in said liquid (16) is controlled based on the rotational speed of said first and second rollers (24A, 24B).

10. A removing apparatus in accordance with claim 7, wherein the dipping time during which said sheet (4) is dipped in said liquid (16) is controlled by stopping the rotation of said first and second rollers (24A, 24B; 124A, 124B) for a predetermined period of time.

11. A removing apparatus in accordance with claim 7, further comprising a heater (23) for maintaining said liquid (16) in said reservoir (15) at a predetermined temperature.

12. A removing apparatus in accordance with claim 7, further comprising a pre-drying means (10) for drying said sheet (4) before it is dipped in said liquid (16).

13. A removing apparatus in accordance with claim 7, further comprising a rinsing means (33) for applying a rinsing liquid to said sheet (4) which has been dipped in said liquid (16) in said reservoir (15); and a liquid removing means (40) for removing said liquid in said reservoir and/or said rinsing liquid on said sheet.

14. A print material removing apparatus for applying a liquid (16) to a sheet (4) having a water-swelling type top layer supporting a print material thereon and thereby removing the print material from the sheet, comprising:

a reservoir (415; 515) for receiving said liquid so that the sheet is dipped in said liquid; and
a curving means for curving said sheet as said sheet is dipped in said liquid,

wherein said curving means includes a container (60; 560) which is filled with said liquid and designed to contain said sheet, said container having an inner wall for holding said sheet curled along said inner wall.

15. A removing apparatus in accordance with claim 14, wherein a pair of rollers (62) is provided for rotation adjacent to said container (60; 560) so that said rollers nip said sheet (4) and are rotated to move said sheet into or out of said container.

16. A removing apparatus in accordance with claim 14, wherein said inner wall of said container (60) is cylindrically formed.

17. A removing apparatus in accordance with claim 16, wherein said curving means further includes a guide roller (63) mounted in said container (560), said guide roller forming a gap with said inner wall of said container so that said sheet (4) is contained in said gap.

18. A print material removing method for removing a print material from a sheet (4) having a water-swelling type top layer supporting said print material thereon, comprising the steps of dipping said sheet in a liquid (16) and curving said sheet dipped in said liquid for at least 20 seconds.

19. A print material removing method for removing a print material from a sheet (4) having a water-swelling type top layer supporting said print material thereon, comprising the steps of

dipping said sheet in a liquid (16); and
curving said sheet by transporting it along a curved transport path, wherein said curved transport path is defined by a set of first rollers (24A) mounted for rotation in a first direction and a set of second rollers (24B) mounted for rotation in the opposite direction to the first direction, said first and second rollers being alternately located along a transporting direction so that each of said rollers forms a nip with its neighboring roller(s) so that said sheet is transported along the peripheral outer surfaces of said rollers and through said nips.

Fig.1

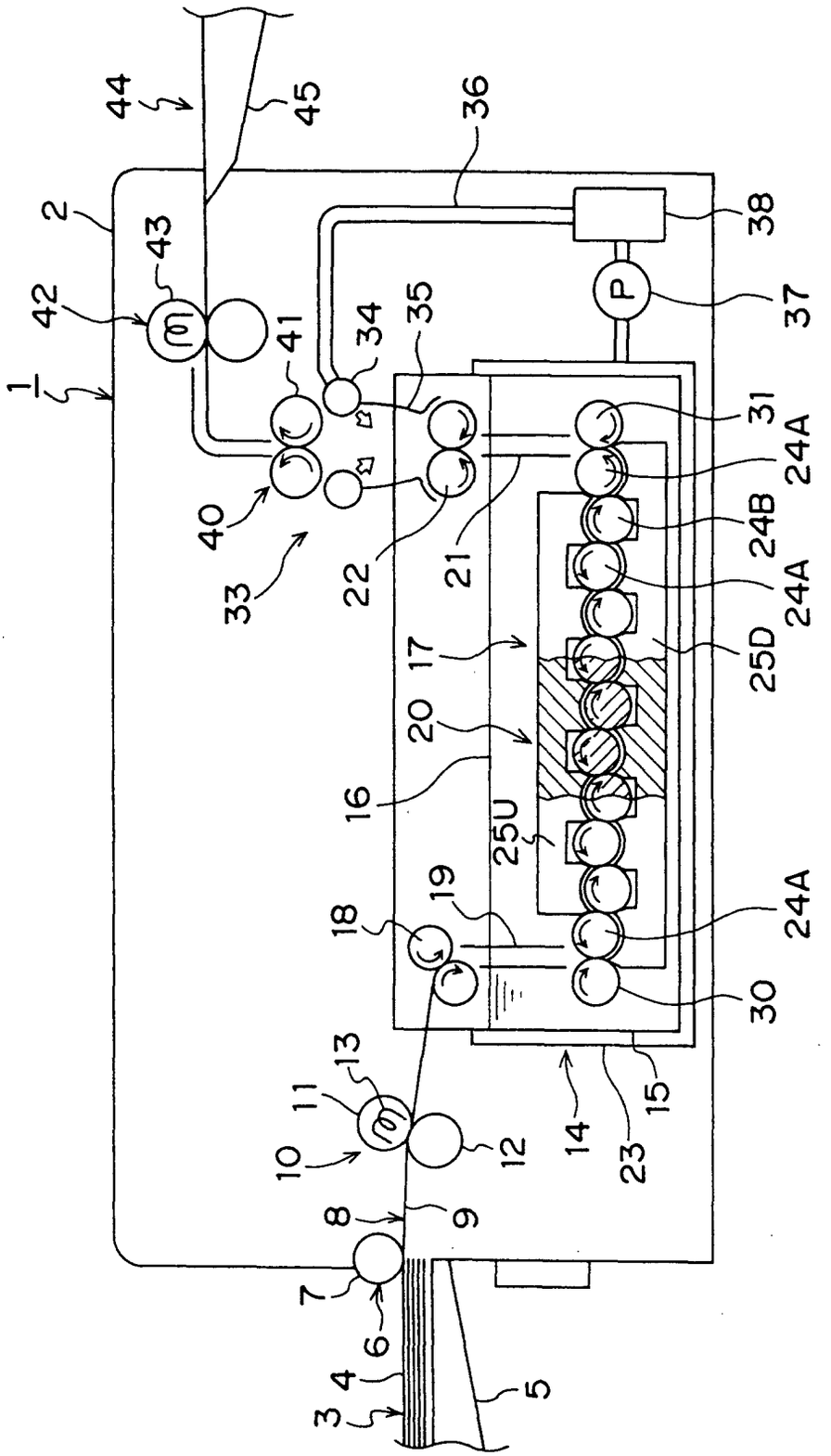

44
45
36
2
43
38
42
41
34
35
P
37
1
31
24A
40
24B
33
22
21
24A
17
25D
20
16
25U
19
18
24A
30
13
11
10
12
14
23
15
8
9
7
6
4
3
5

Fig.2A

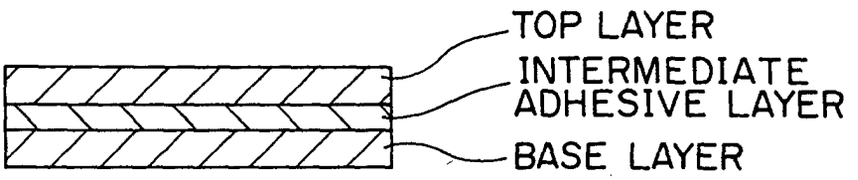

TOP LAYER
INTERMEDIATE ADHESIVE LAYER
BASE LAYER

Fig.2B

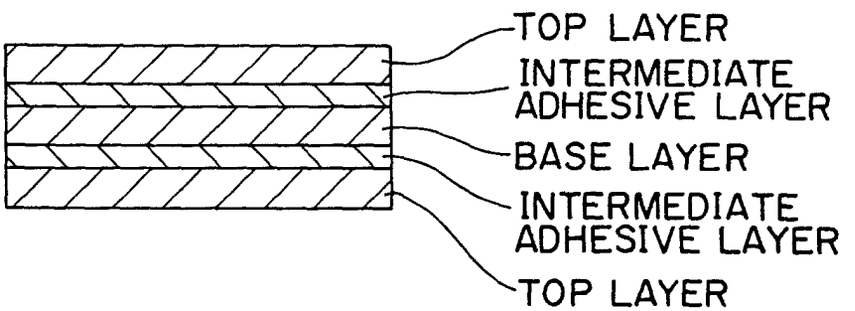

TOP LAYER
INTERMEDIATE ADHESIVE LAYER
BASE LAYER
INTERMEDIATE ADHESIVE LAYER
TOP LAYER

Fig.3

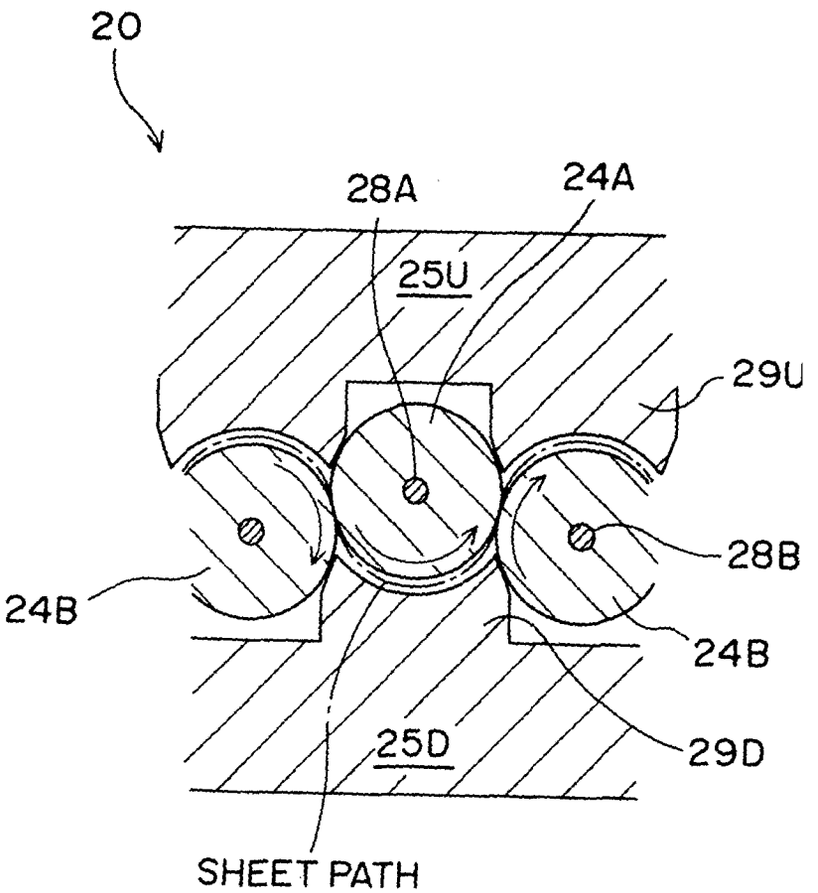


Fig.4A

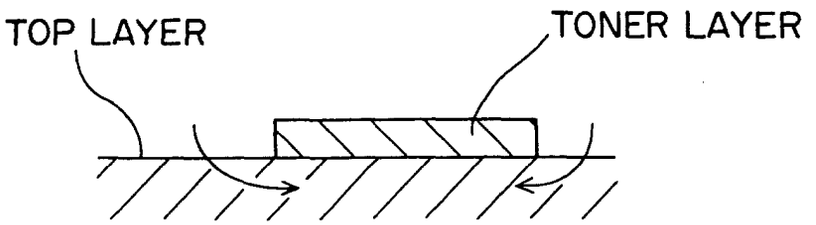


Fig.4B

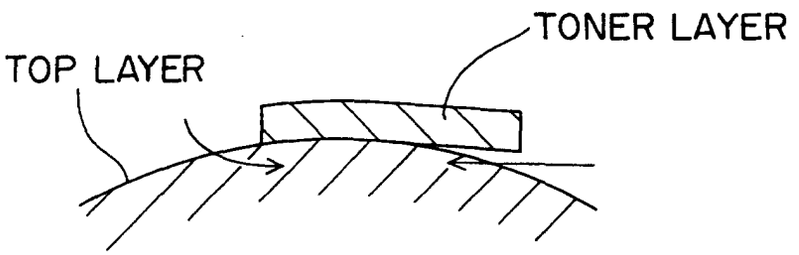


Fig.5A

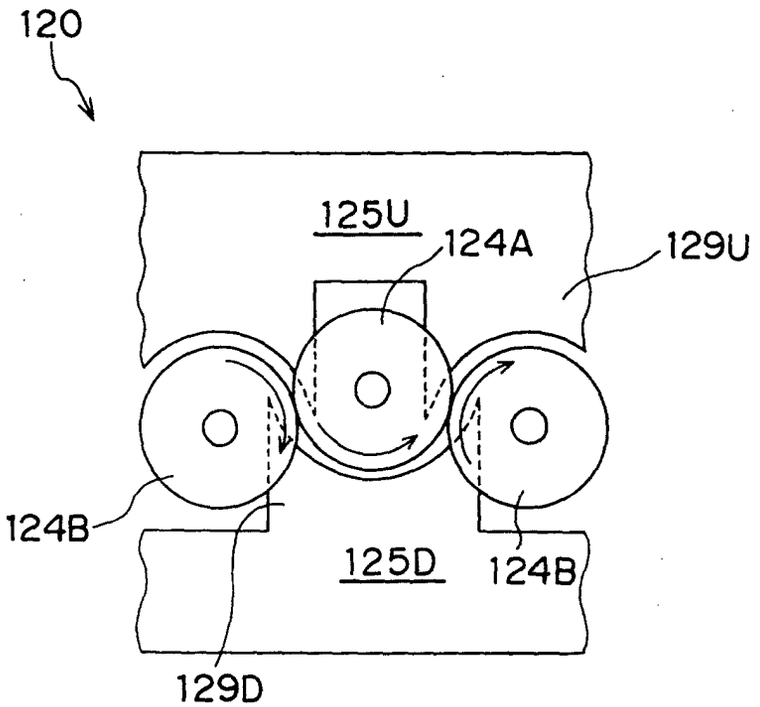

120
125U
124A
129U
124B
125D
124B
129D

Fig.5B

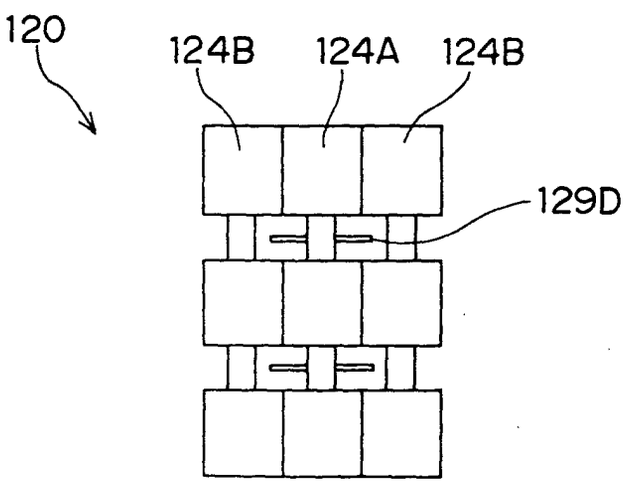

120
124B
124A
124B
129D

Fig.6

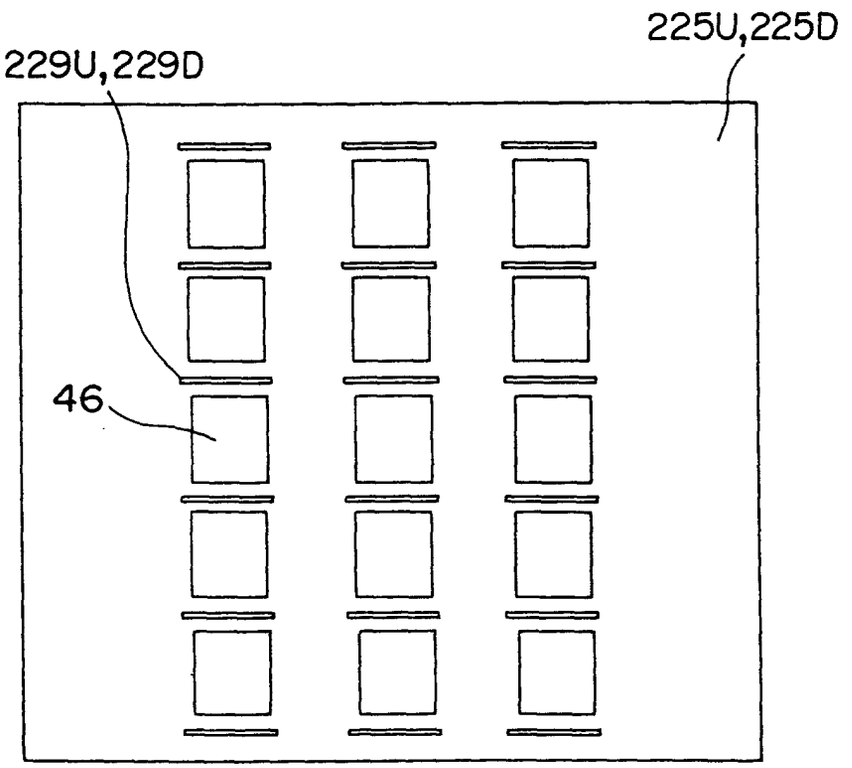


Fig.7

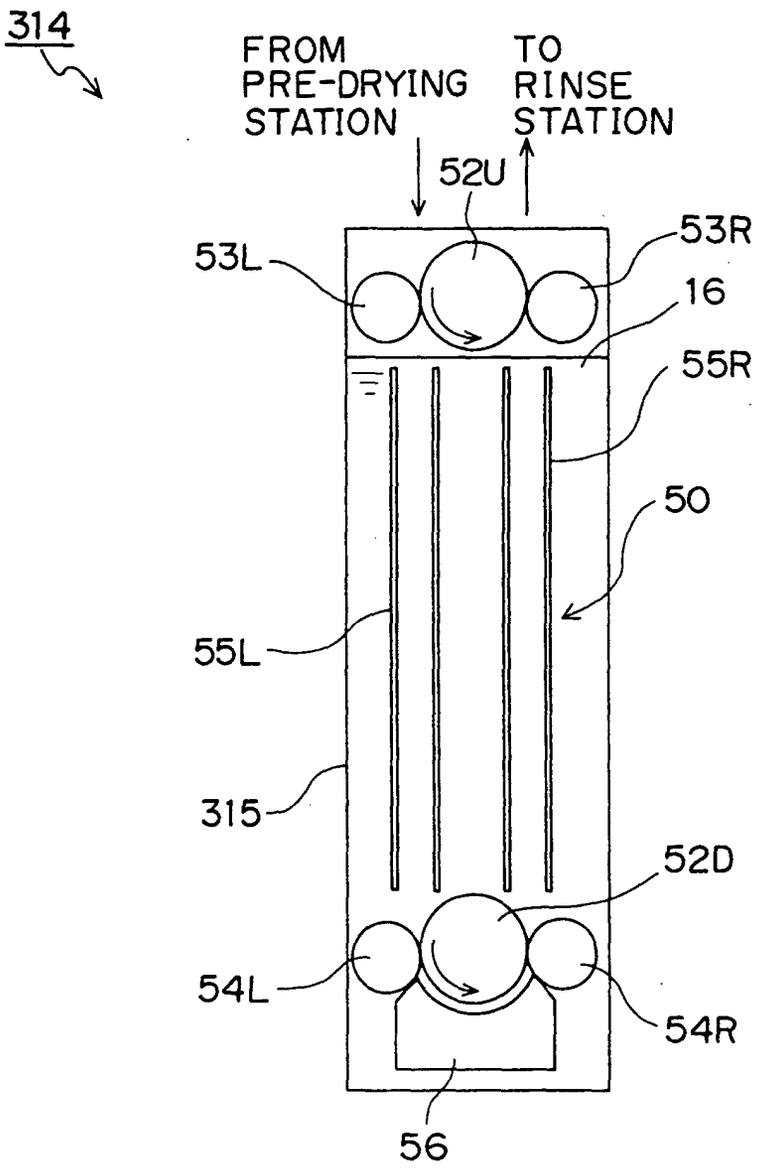

314
FROM PRE-DRYING STATION
TO RINSE STATION
52U
53L
53R
16
55R
50
55L
315
52D
54L
54R
56

Fig.8

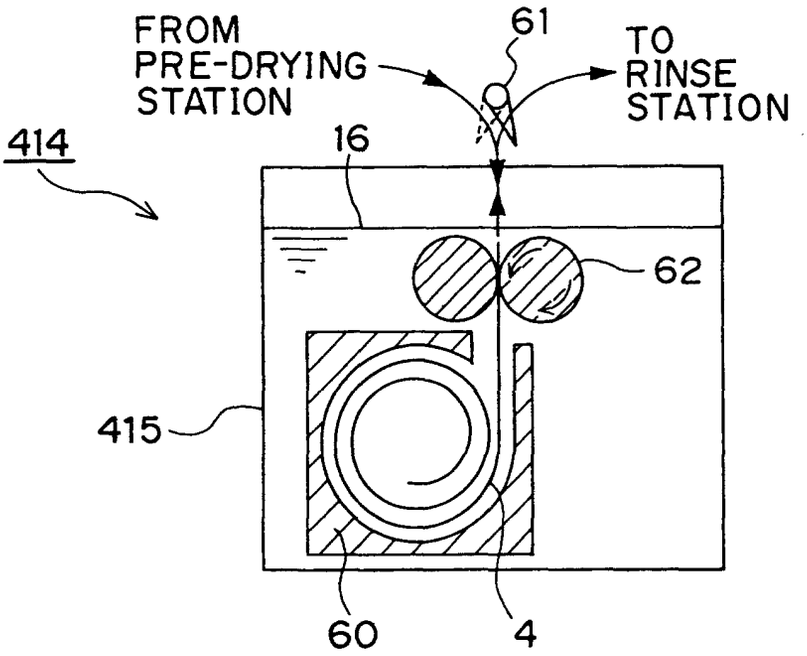
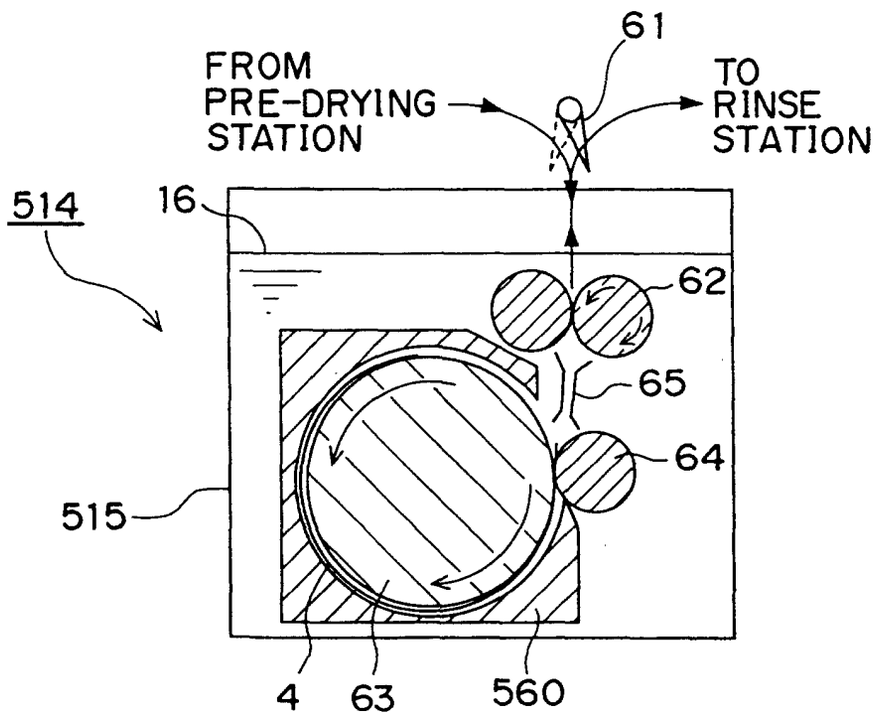

FROM
PRE-DRYING
STATION
61
TO
RINSE
STATION
414
16
62
415
60
4

Fig.9


61
FROM
PRE-DRYING
STATION
TO
RINSE
STATION
514
16
62
65
64
515
4
63
560