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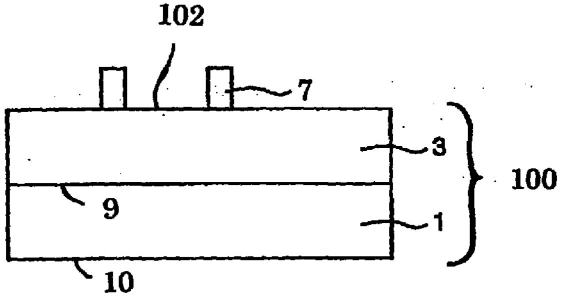
(54) Recyclable image-recording medium

(57) A recyclable image-recording medium comprising a base member and a water-swelling surface layer,

wherein the base member comprises pulp fibers treated to have water-resistance.

Fig.1



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Description

Related Applications

[0001] This application is based on Japanese Patent Application No. Hei11-016881, the contents of which are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

1. Field of the invention

[0002] The present invention relates to a recyclable image-recording medium. In particular, the present invention relates to the repeatedly recyclable image-recording medium suitable for physically removing printed materials by brushing with the use of an aqueous solution such as water.

2. Description of the Related Art

[0003] Electrophotographic copying techniques using toners (so called copy simply) are popular now. Image-recording media such as sheets of papers and OHP sheets are used in large quantities.

[0004] Printed materials printed or copied on such image-recording media are not easily removed. Techniques for removing such printed materials are not yet ready for practical use. It is true that printings generated in large quantities in offices are discarded when they become unnecessary.

[0005] This is clearly not desirable from the viewpoint of environmental protection and natural resource preservation. Therefore, researches on techniques for reproducing or recycling image-recording media which would otherwise be discarded have been vigorously conducted. Japanese Patent Application Laid-Open No. Hei 7-311523 and EP0601502 A2, for example, disclose methods wherein a water-swelling layer which swells by absorbing water is formed on the surface of an image-recording medium and images printed on the image-recording medium are removed by swelling the water-swelling layer with water.

[0006] In the case where the printed materials (image) are removed from the image-recording medium by the above-described conventional method, some water is supplied to the image-recording medium and then the medium is dried. Accordingly, the image-recording medium requires some water-resistance and must dry with a small amount of energy.

[0007] If the image-recording medium includes a base member formed from a water-resistant material such as polyethylene terephthalate (PET), the above-mentioned requirements are satisfied. However, the image-recording medium including the base member formed from PET cannot provide the same feel as or be folded down like paper. If the image-recording medium includes the base member formed from paper in order to provide the same feel as paper, the strength of the base layer is extremely reduced and a large amount of energy is required to dry the image-recording medium. If the strength of the base layer is not enough, a problem occurs in that the image-recording medium is damaged when the printed materials are removed by applying a physical force after an immersion of the medium into a swelling solution. In addition, if the base member absorbs too much water, problems occur in that it becomes hard to dry the image-recording medium by applying heat and the large amount of energy is required to dry it, because a surface layer is formed on or over the base member.

SUMMARY OF THE INVENTION

[0008] The present invention is to provide a recyclable image-recording medium which can provide the same feel as or be folded down like paper.

[0009] In addition, the present invention is to provide a recyclable image-recording medium having excellent water resistance and strength in which the printed materials can be removed sufficiently from the medium, even when used repeatedly through water-supply, water-immersion and printed material-removing processes.

[0010] The present invention relates to a recyclable image-recording medium comprising a base member and a water-swelling surface layer, wherein the base member comprises pulp fibers treated to have water-resistance.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

Figure 1 is a schematic cross sectional view of a recyclable image-recording medium according to the present invention.

Figure 2 is a schematic cross sectional view illustrating one example of a base member included in the recyclable image-recording medium according to the present invention.

Figure 3 is a schematic cross sectional view illustrating another example of the base layer included in the recyclable image-recording medium according to the present invention.

Figure 4 is a schematic cross sectional view illustrating another example of the base member included in the recyclable image-recording medium according to the present invention.

Figure 5A is a schematic perspective illustration of a fiber structure in a base member.

Figure 5B is a schematic cross sectional view of a recyclable image-recording medium including a base member formed of the fibers shown in Figure 5A.

Figure 6 is a process sequence diagram for explaining a method for removing printed materials on the image-recording medium.

Figure 7 is a schematic view showing one example of a cleaning apparatus.

Figure 8 is a schematic view illustrating another example of a cleaning apparatus.

Figure 9 is a schematic view illustrating another example of a cleaning apparatus.

DETAILED DESCRIPTION OF THE INVENTION

[0012] The present invention provides a recyclable image-recording medium comprising a base member and a water-swelling surface layer, wherein the base member comprises pulp fibers treated to have water-resistance. The present invention will be described by way of example with reference, to the accompanying figures.

[0013] Figures 1 shows a schematic cross sectional view of one example of a recyclable image-recording medium according to the present invention. The image-recording medium 100 as shown in Figure 1 includes a base member 1 and a surface layer 3 laminated on the base member 1. Printed materials 7 are printed on a surface 102 of the surface layer 3 in Figure 1. The surface layer 3 may be formed on both sides 9 and 10 of the base member 1, although the surface layer 3 is formed on one side 9 of the base member 1 in Figure 1.

[0014] In the image-recording medium 100, the base member 1 is formed from pulp paper which contains pulp fibers as the main component, and the base member 1 is treated to have water-resistance. In the specification, the expression "pulp fibers" means fibers derived from plant fibers. It should be noted that the pulp fibers are not limited by kinds of plants and a manufacturing method.

[0015] According to the present invention, since the base member 1 contains the pulp fibers as the main component, the image-recording medium 100 including the base member 1 can provide the same feel as or be folded down like paper. Pulp paper is not limited as long as it is able to keep its flatness through the printing and removal of the printed materials 7. Therefore, pulp paper forming the base member 1 includes paper which is produced by mixing the pulp fibers with or adhering the pulp fibers to other types of fibers. A content of the pulp fibers is about 30 % by weight or more, preferably 50 % by weight or more, based on the whole fibers contained in the base member 1. If the content of the pulp fibers is less than about 30 %, the image-recording medium cannot sufficiently provide the same feel as and be folded down like paper. Examples of the fibers other than pulp fibers include known plastic fibers such as polyethylene, polyester, polypropylene, polyurethane, and polyvinylacetal.

[0016] According to the present invention, examples of pulp paper include plain paper, fine quality paper, intermediate quality paper, book paper, photogravure paper, art paper, coat paper, embossed paper, cast-coated paper, kraft paper, office automation (OA) paper, no-carbon paper, form paper, special paper, and Al-deposited paper. Among them, coat paper and special paper which have been treated to have water-resistance can be used as the base member 1 without a further treatment.

[0017] The base member 1 has water-resistance by the following methods (1) to (3), but not limited thereto.

(1) The water-resistant layer 2 is formed on both surface sides 83 and 85 of the base layer 8 as shown in Figure 2.
(2) The water-resistant layer 2 is formed on the surface of each fiber 5 included in the base member 1 as shown in Figure 3.
(3) The water-resistant layer 2 is formed to fill spaces between the fibers 5 included in the base member 1 as shown in Figure 4.

[0018] The base member 1 shown in Figure 2 may be prepared by forming the water-resistant layer 2 on both sides 83 and 85 of the base layer 8 by means of a wet-coating method and a laminating method etc.

[0019] The material of the water-resistant layer 2 (referred to as "water-resistant material" herein after) is not specifically limited as long as it does not dissolve or swell in water, can form a layer and has appropriate water-resistance and mechanical strength. For example, resin, known size agent, metal and the like, are preferably used as the material of the water-resistant layer 2. Considering an adhesion to the base layer 8 and the surface layer 3, the ease of the coating method, price, and so on, a water-resistant resin is preferably used. Examples of the water-resistant resin include polyurethane resins, polyester resins, polycarbonate resins, poly(vinyl chloride) resins, poly(vinyl acetate) resins, polyethylene resins, polypropylene resins, polyacryl resins, poly(vinyl acetal) resins, and poly(ethylene imine) resins. Examples of the size agent include rosins, starchs, urea resins, melamine resins, and cellulose esters. Among them, the resin which can adhere well to a water-swelling resin layer (a surface layer 3) such as polyurethane resins, polyester resins, poly(vinyl acetate) resins, and poly(vinyl acetal) resins are more suitable for the material of the water-resistant layer 2. Two or more of the above listed materials can be used alone or in combination.

[0020] It is preferable that a reactive compound having a functional group chemically bondable to the resin which forms the surface layer 3 is added to the water-resistant layer 2 so as to improve the adhesion of the surface layer 3 to the water-resistant layer 2. Examples of the reactive compound include methylol compounds, epoxy compounds, isocyanate compounds, aldehyde compounds, and aziridine compounds.

[0021] Examples of methylol compounds include methylol melamines such as dimethylol melamine and trimethylol melamine, dimethylol ureas, melamine-formaldehyde resins and various other methylol compounds. Considering that a compound having an appropriately high molecular weight and long molecular chain is preferably used, melamine-formaldehyde resins are most preferable among the above listed methylol compounds.

[0022] Examples of epoxy compounds include polyethylene glycol diglycidyl ether, polypropylene glycol diglycidyl ether, sorbitol polyglycidyl ether, sorbitan polyglycidyl ether, polyglycerol polyglycidylether and various other epoxy compounds.

[0023] In the case where an isocyanate compound having two or more isocyanate groups within a molecule is added to the water-resistant layer 2, the adhesion of the water-resistant layer 2 to the surface layer 3 can be improved more efficiently.

[0024] Examples of such isocyanate compounds include 4, 4'-diphenylmethane di-isocyanate, 4,4'-methylene biscyclohexyl isocyanate, tris(p-isocyanatephenyl)thiophosphate, tris(p-isocyanatephenyl) methane, adduct of trimethylolpropane with three tolylene di-isocyanates, and aliphatic polyisocyanates containing a hydrophilic group within a molecule. Isocyanates compounds used in the present invention, including the above listed compounds, may be protected by phenol, sulfurous acid, etc.

[0025] Examples of aldehyde compounds include glyoxal, glutaraldehyde and various other aldehyde compounds.

[0026] Examples of aziridine compounds include diphenylmethane-bis-4,4'-N,N'-diethyl urea and 2,2-bishydroxylmethylbutanol-tris-[3-(1-aziridinyl)propionate]. Polymers containing an oxazoline group can also be used.

[0027] When the reactive compound is added to the water-resistant layer 2, about 0.1 parts to about 100 parts by weight, more preferably about 1 part to about 30 parts by weight of the reactive compound may be added based on 100 parts by weight of the water-resistant material which forms the water-resistant layer 2.

[0028] The manufacturing method for the water-resistant layer 2 as shown in Figure 2 will be described.

[0029] In order to form the water-resistant layer 2 as shown in Figure 2, a wet coating method or a melt coating method such as a laminate method, for example, is employed. In the wet coating method, a solution prepared by dissolving or dispersing the water-resistant material and, if desired, the reactive compound in a solvent is coated onto the base layer 8. In the melt coating method such as a laminate method, the water-resistant layer 2 is formed on the base layer 8 with heating. A suitable method for forming the water-resistant layer 2 depends on the water-resistant material as used.

[0030] In the wet coating method, for example, a solvent coating method can be employed. In the solvent coating method, for example, a solution prepared by dissolving the water-resistant material and, if desired, the reactive compound, in a solvent (for example, tetrahydrofuran (THF), dioxane, acetone, ethyl acetate, or methyl ethyl ketone (MEK)) is coated and dried. Alternatively, a solution prepared by dissolving or dispersing a resin such as water-soluble or hydrophilic polyurethane or polyester in water may be applied.

[0031] By means of the solvent coating method or the melt coating method described above, the water-resistant layer 2 is formed to have a thickness of about 0.5 μm to about 20 μm, preferably about 0.5 μm to about 7 μm. If the thickness of the water-resistant layer 2 is less than about 0.5 μm, the water-resistant layer 2 tends to be unevenly coated on the base layer 8. If the thickness of the water-resistant layer 2 is more than about 20 μm, there may arise such a problem in terms of the feel of the image-recording medium 100.

[0032] The manufacturing method for the water-resistant layer 2 as shown in Figures 3 and 4 will be described. In order to form the water-resistant layer 2 as shown in Figures 3 and 4, the above-described water-resistant material can be used and, if necessary, the above-described reactant compound is preferably added to the water-resistant material. The water-resistant layer 2 as shown in Figures 3 and 4 is formed by performing a water-resistant treatment when a fibrous aggregation is being made (or when paper is being made), or after the fibrous aggregation has been made (or after paper has been made). In the specification, the expression "fibrous aggregation" means pulp paper which has not been provided with water-resistance.

[0033] In the case where the water-resistant treatment is performed when the fibrous aggregation is being made, the water-resistant material (which provides water-resistance after dried) is added to a solution containing fibers for paper and dissolved or dispersed.

[0034] In the case where the water-resistant treatment is performed after the fibrous aggregation has been made, the fibrous aggregation (paper sheet) is immersed in or coated with a solution prepared by dissolving or dispersed the water-resistant material in the solvent.

[0035] In the case where the water-resistant treatment is performed when the fibrous aggregation is being made, or after the fibrous aggregation has been made, the base member 1 including water-resistant layers 2 formed both surfaces 83 and 85 of the base layer as shown in Figure 2, the base member 1 including the fibers independently coated with the water-resistant layer 2 as shown in Figure 3, and the base member 1 including the water-resistant layer 2, which fills the spaces between the fibers 5 as shown in Figure 4, may be formed by optimizing the following conditions: a concentration of the water-resistant material in a solution in which the water-resistant material is dissolved or dispersed; a viscosity of the solution; a temperature for drying the base member 1 coated with or immersed in the solution; a speed of coating with the solution; a speed of taking out the fibrous aggregation from the solution (when immersed in the solution).

[0036] In the case where the water-resistant treatment is performed after the fibrous aggregation has been made and the water-resistant resin is used for the material of the water-resistant layer 2, the base members 1 as shown in Figures 2 to 4 are formed as follows:

(1) The fibrous aggregation (base layer 8 which has not been provided with the water-resistant treatment) is coated with the water-resistant resin solution having relatively high viscosity with the use of the bar coater and then quickly dried, to give the base member 1 as shown Figure 2.

(2) The fibrous aggregation is immersed in the resin solution having a relatively low viscosity, drained water off well, and then dried, to give the base member 1 as shown Figure 3.

(3) The fibrous aggregation is immersed in the resin solution having a medium viscosity and then dried, to give the base member 1 as shown Figure 4.

(4) The fibrous aggregation is well soaked in the resin solution having a relatively high concentration of the resin and then slowly dried, to give the base member 1 as shown Figure 4.

(5) The fibrous aggregation is quickly coated with the resin solution having a relatively low concentration of the resin and then quickly dried, to give the base member 1 as shown Figure 2.

(6) A concentration and viscosity of the resin solution and a drying speed is appropriately changed, so as to form the base member having a mixed structure of Figures 2, 3 and 4. For example, the water-resistant layer is independently formed on the fiber as shown in Figure 3 in some part of the base member, and the water-resistant layer fills the spaces between the fibers as shown in Figure 4 in other part of the base member. A viscosity generally increases with an increase in a concentration of the resin solution.

[0037] In the base member 1 including the water-resistant layers 2 independently formed on the fiber 5 as shown in Figure 3, the water-resistant layers 2 preferably have a thickness of about 0.3 μm to about 20 μm, more preferably about 1 μm to about 5 μm. If the thickness is less than about 0.3 μm, each of the fibers 5 may not be sufficiently covered with the water-resistant layer 2. If the thickness is more than about 20 μm, problems on the paper-feel of the image-recording medium 100 may occur. The thickness of the water-resistant layer 2 can be appropriately adjusted by changing a viscosity or concentration of the resin solution. In the case where the water-resistant layers 2 are formed both surfaces 83 and 85 of the base layer 8 as shown in Figure 2, the thickness of the water-resistant layers 2 can be adjusted by changing an amount of the coating resin solution.

[0038] In the base member 1 including the water-resistant layer 2 which fills the spaces between the fibers 5 as shown in Figure 4, the base member 1 contains the water-resistant material (water-resistant layer 2) preferably about 100 % by weight or less, more preferably about 50 % by weight or less based on the weight of fibers included in the base member 1. If the amount is more than about 100 % by weight, a problem on the paper-feel of the image-recording medium 100 may occur.

[0039] In the present invention, the base member 1 with water-resistance as shown in Figures 3 and 4 may be provided with the water-resistant treatment so as to further form the water-resistant layers on both sides 83 and 85 of the base member 1 as shown in Figure 2.

[0040] Since the base member 1 has been provided with water-resistance as described above, the base member 1 does not absorb water unreasonably and a strength of the base member is increased even when the recording medium is immersed in a solution. Accordingly, the base member 1 is prevented from being damaged by physical forces applied for removing the printed materials from the layer 1 after immersed and swelled.

[0041] Water-resistance of the base member 1 can be more improved by controlling a density thereof. The reason is as follows. Generally, paper has a twined structure of fibers with a lot of spaces between the fibers. If paper has a structure highly filled with the fibers, the volume of the spaces into which water penetrates is decreased. Accordingly, water becomes hard to penetrate into paper and water-resistance of the base member is improved.

[0042] The inventors found that it was preferable that the base member has a density D of about 0.7 g/cm^3 ≤ D ≤ 1.5 g/cm^3. If a density D is less than about 0.7 g/cm^3, water easily penetrates into the base member 1 when the layer 1 is immersed in water. Due to water penetrating into the base member 1, the image-recording medium 100 wrinkles and thus it may have a negative affect on paper-feeding properties in the image recording apparatus such as a copy machine and printer. If a density D is more than about 1.5 g/cm^3, water-resistance of the medium 100 is improved, however, paper-feeding properties are deteriorated.

[0043] The expression "density D" as used herein means a density of the base member 1 which has been provided with water-resistance. The base member 1 includes, for example, the water-resistant layer 2 as explained in Figures 2, 3, 4, and 5A.

[0044] It is preferable that the base member 1 absorbs water between about 0.03 mg/cm^2 and about 1 mg/cm^2, more preferably, between about 0.03 mg/cm^2 and about 0.7 mg/cm^2 when the base member 1 is immersed in water for 3 minutes. Generally, plain paper formed from the pulp fibers without water-resistance absorbs water about 1 g/g, (that is, plain paper absorbs water about same weight as thereof). Normal OA paper (thickness; about 60 μm to about 90 μm, weight; about 60 g/m^2 to about 90 g/m^2) absorbs water about 5 mg/cm^2 to about 9 mg/cm^2, even though it depends on its thickness and basic weight. The amount of water absorbed into paper tends to increase with an increase of the basic weight.

[0045] As a result of researches conducted by the inventors, it was found that the base member 1 which absorbed water about 0.03 mg/cm^2 or more and about 1 mg/cm^2 was preferable, according to the following reasons. When the base member 1 absorbed water more than about 1 mg/cm^2, a strength of the base member 1 which had been absorbed water was decreased and the image-recording medium 100 was damaged by the physical forces. When the base member 1 was formed from the fibers, no matter how much the base member 1 was provided with water-resistance, the base member 1 absorbed water at least about 0.03 mg/cm^2 substantially. Accordingly, the lower limit was set to be about 0.03 mg/cm^2. When the base member 1 absorbed water less than about 0.03 mg/cm^2, it was not able to provide the same feel as and be folded like paper substantially.

[0046] It should be noted that the above-described amount of water absorbed into the base member 1 is shown by using the weight of absorbed water per area of the base member 1 . The reason is as follows. When the basic weight is large, even though the absorbed amount is small, the weight of absorbed water per volume is increased and the base member 1 is hard to be dried. Accordingly, the weight of absorbed water per area of the base member 1 is more practical condition compared with the weight of absorbed water per weight of the base member 1.

[0047] The amount of water absorbed into the base member 1 is measured as follows. The base member 1 (5 cm × 5 cm) is immersed in water (100 cc) of 30°C for 3 minutes, thereafter, water is squeezed from the base member 1 by passing the base member between rollers faced with each other. The amount of water absorbed into the base member 1 is determined from subtracting a weight (mg/cm^2) of the base member 1 before immersed from a weight (mg/cm^2) of the base member 1 from which water has been squeezed. In the case where a water-soluble organic solvent or a mixed solvent of water and a water-soluble organic solvent is used as a swelling solution instead of water in order to recycle the image-recording medium, the amount of the swelling solution absorbed into the base member 1 is within the above-described range. It should be noted that the amount of the swelling solution absorbed into the base member 1 is measured in the same manners as in the above-described amount of water absorbed into the base member 1 (by using subtraction of a weight (mg/cm^2) of the base member 1 before immersed from a weight (mg/cm^2) of the base member 1 from which the swelling solution has been squeezed).

[0048] A thickness of the base member 1 with water-resistance is preferably in the range of about 50 μm to about 150 μm, more preferably about 60 μm to about 130 μm.

[0049] The image-recording medium 100 of the present invention includes the above-mentioned base member 1 and a water-swelling surface layer 3 formed on the base member 1 as shown in Figure 1. The water-swelling surface layer 3 is formed from a water-swelling resin. In this specification, the expression "water-swelling" is defined to swell with water or an aqueous solvent but not dissolve in it. The water-swelling resin may be produced by crosslinking a water-soluble resin. Alternatively, the water-swelling resin may be produced by adding a water-insoluble component to the water-soluble resin.

[0050] A water-soluble resin containing within a molecule a functional group having active hydrogen, such as a hydroxyl group, an amino group, an amide group, a thiol group, a carboxyl group, or a sulfonic group, can be used as the above mentioned water-soluble resin, examples of which include polyvinyl alcohol, methyl cellulose, polyacrylic acid, carboxymethyl cellulose, hydroxyethyl cellulose, polyvinyl pyrrolidone, polyacrylamide, and diacetone acrylamide. Preferably, polyvinyl alcohol, methyl cellulose, or polyacrylic acid is used. Among them, polyvinyl alcohol which has many hydroxyl groups is preferred, with a polymerization degree of about 300 to about 3,000, preferably about 500 to about 2,000, and more preferably about 500 to about 1,700. It is appropriate for use that such a water-soluble resin of about 2 parts to about 30 parts by weight, preferably about 5 parts to about 10 parts by weight, is dissolved in an aqueous solvent of 100 parts by weight.

[0051] In addition, an ion-modified water-soluble resin may be used as the above-mentioned water-soluble resin.

The expression "ion-modified water-soluble resin" as used herein means that the water-soluble resin includes an ionized functional group. If the water-soluble resin is ion-modified, hydrophilic properties of the resin are improved. Accordingly, water-absorption properties of the surface layer 3 can be improved and the swelling speed of the surface layer 3 can be increased.

[0052] The ionized functional group may be anionic or cationic. The anionic functional group is not specifically limited and examples include a carboxyl group and sulphonic acid group with metal atom substituted for active hydrogen, and a group containing a substituent which has at the end of a chain a carboxyl group and sulphonic acid group with metal atom substituted for active hydrogen. The cationic functional group is not specifically limited and examples include a quarternary ammonium group, a group containing a substituent which has at the end of a chain a quarternary ammonium group substituted for active hydrogen included in the cationic functional group.

[0053] In order to crosslink the water-soluble resin, a crosslinking agent and, if necessary, an initiator is added to the aqueous solution of the resin. Any crosslinking agent may be used as long as it is water-soluble or dispersible in water and has reactivity with the functional groups, such as a hydroxyl group, an amide group, a carboxyl group, etc., contained in the water-soluble resin molecules, and is capable of crosslinking the water-soluble resin. Examples include epoxy compounds, isocyanate compounds, glyoxals, methylol compounds, melamine resin, dicarboxylic acids, aziridine compounds, dihydrazide, and compounds having double bonds such as diacrylate compounds, dimetacrylate compounds. The same compounds as those previously listed as examples of the reactive compound added to the water-resistant layer 2 can be used.

[0054] When adding the above listed compounds as the crosslinking agent, about 0.1 parts to about 100 parts by weight, preferably about 1 part to about 50 parts by weight, is added based on 100 parts by weight of the water-soluble resin. If the amount is too low, a strength of the surface layer may be insufficient when swollen or the surface layer may be dissolved. If the amount is too large, the crosslinking agent may become a bulk component, causing problems in terms of a strength of the surface layer.

[0055] When the water-soluble resin is made insoluble by adding a water-insoluble component, it is preferable that a monomer or an oligomer having two or more vinyl groups and their polymerization initiator are added to a resin solution and the insoluble component is formed by heat polymerization or ultraviolet (UV) radiation curing.

[0056] Examples of the monomer or oligomer having two or more vinyl groups include diacrylates, dimethacrylates, and urethane acrylate-based monomers or oligomers.

[0057] The amount of such a monomer or oligomer to be added is determined by considering a strength of the resulting surface layer when swollen with water and easiness of removal of the printed materials 7. From this viewpoint, about 10 parts to about 150 parts by weight, preferably about 30 parts to about 100 parts by weight, may be added based on 100 parts by weight of the water-soluble resin.

[0058] When a water-soluble or hydrophilic material is used as the crosslinking agent or the monomer or oligomer for forming the insoluble component, there is such an advantage as the surface layer 3 can be formed with water. This serves to prevent an organic solvent from remaining in the surface layer 3, while at the same time, securing the safety during the coating process.

[0059] A surface active agent may be added to the resin solution to form the surface layer 3, in order to enhance the wettability and water permeability. The surface active agent is not limited to a specific type, but various surface active agents, anionic, cationic, or non-ionic, may be used.

[0060] Inorganic fine particles, such as silica, titanium oxide, alumina, zinc oxide and calcium carbonate, or resin fine particles, such as acrylic resin, styrene resin, may be added to the surface layer 3 to improve writing or printing properties.

[0061] If desired, an antistatic treatment may be applied to the surface layer 3 in order to enhance the paper-feeding ability. The antistatic agent may be added to the material of the surface layer 3, or may be dissolved and dispersed in a suitable solvent and coated after the surface layer 3 is formed. Examples of the antistatic agent include cationic surface active agent such as quaternary ammonium salt.

[0062] The solution-applying method (coating or immersion) can be used to form the surface layer 3. To describe more specifically, the solution is prepared by dissolving and/or dispersing the materials of the water-swelling surface layer 3 in a suitable solvent such as water, a water/organic mixed solvent, and an organic solvent. As described above, the materials of the water-swelling surface layer 3 are, for example, a mixture of water-soluble resin and crosslinking agent, or water-soluble resin and monomer or oligomer including two or more of vinyl groups and, if necessary, other additives are included. Then, the resultant solution is coated onto the base member 1 with water-resistance to form a layer thereon to have a thickness of about 0.5 μm to about 30 μm, preferably about 5 μm to about 20 μm, after heating and drying.

[0063] After coated or immersed, the surface layer 3 is heated at about 50°C to about 180°C, preferably at about 80°C to about 150°C. If the water-soluble resin is made water-swelling by polymerizing a compound having double bonds, the heating is performed after or simultaneously with a light irradiation.

[0064] When a fiber has a water-resistant layer on the surface thereof, a surface layer may be formed on the water-resistant layer as shown in Figure 5A.

[0065] Figure 5A is a schematic perspective view of a fiber 5 coated with a water-resistant layer 2 and a surface layer 70. The surface layer 70 may be formed by an immersion-coating method. In the immersion-coating method, for example, the base member 6 with the water-resistant layer 2 is immersed in a solution so that a thickness of the surface layer 70 after dried is about 1 μm to about 30 μm, preferably about 3 μm to about 20 μm. The thickness depends on a viscosity of the immersion solution and a concentration of the water-soluble resin in the solution. About 1 part to about 30 parts by weight of the water-soluble resin is preferably dissolved in 100 parts by weight of an aqueous solvent so that the immersion solution has a viscosity of about 5 cps to about 100 cps.

[0066] Figure 5B is a schematic cross sectional view of the recyclable image-recording medium 102, which is formed of fibers, each of which has the water-resistant layer 2 and the surface layer (water-swelling resin layer) 70.

[0067] The base members 6 and surface layers 70 are included in the medium 102. The printed materials 7 are printed on the one surface side of the image-recording medium 102. Since the fibers 5 are coated with the surface layer 70 as described above, the printed materials are substantially printed on the surface layers formed on the fibers.

[0068] The above obtained image-recording medium can be used repeatedly in a recycling system in which printed image-removing method involves the processes of a surface layer-swelling process, a physical friction process, such as brushing, and a drying process. In addition, the image-recording medium can provide the same feel as and be folded like paper, the printed materials on the medium can be removed satisfactorily, and the strength of the medium is not deteriorated even if the image-recording medium is supplied with water and the entire of the medium is immersed in water.

[0069] The following description is about a method for removing printed materials from the image-recording medium whose surface is printed with the printed materials such as toner. In the removing method, the medium is supplied with a solvent capable of swelling the surface layer of the medium, and then the printed materials are removed from the swollen surface of the image-recording medium by a physical force. The method will be further described in detail with reference to figures.

[0070] Figure 6 is a process sequence diagram for explaining a method for removing the printed materials on the image-recording medium.

[0071] In Figure 6, the surface layer 3 is formed on both sides 9 and 10 of the base member 1 included in the image-recording medium 100. At least one surface 102 of the image-recording medium 100 is printed with a material for printing (referred to as "printing material" hereinafter) 7 such as toner. Toner used in electrophotography is preferably used as the printing material 7. Other types of the printing materials can be also used, including (1) hot-melt ink used in an ink jet method, (2) recording materials used in a thermal transfer method or other printing methods, and (3) oil paint agent that adheres to and covers the surface of the image-recording medium to form an image.

[0072] In Figure 6, the image-recording medium 100 is transported from right to left.

[0073] The printed materials 7 are removed from the image-recording medium 100 according to the following steps, for example.

[0074] The image-recording medium 100 printed with the printing materials 7 is supplied on its surface layer with a solution which can swell the surface layer 3 of the medium 100 (hereinafter, referred to as a "swelling solution") so as to form a swollen layer 13 from a shower device 11 (a solvent supplier). Various solvents, including an aqueous solvent such as water, a water-soluble organic solvent, or a mixed solvent of water and a water-soluble organic solvent can be used as the swelling solution 30. A desired additive such as a surface active agent may be added to the swelling solution 30. This removing method has an advantage that the printed materials can be removed from the image-recording medium with the use of water. The following description deals with the case in which water is used as the swelling solution 30.

[0075] Water (swelling solution 30) may be supplied by spraying a shower of water over the surface layer 3 of the image-recording medium 100 from a shower device 11, as shown in Figure 6. Alternatively, the surface layer 3 of the image-recording medium 100 may be immersed in water (not shown in Figure 6). The surface layer 3 of the medium 100 may be contacted with water for about 15 seconds to about 1500 seconds, to allow water to soak into the surface layer 3 of the image-recording medium 100. As the contact time increases, the water can be made to soak sufficiently, but the processing time increases correspondingly. It is appropriate that the water temperature is in the range of about 15°C to about 45°C. If the temperature is too high, the amount of water evaporation increases. If the temperature is too low, the printed materials 7 may not be sufficiently removed from the image-recording medium 100.

[0076] When water soaks into the surface layer 3 of the image-recording medium 100, the surface layer 3 swells (the swollen surface layer is shown by reference number 13) and the adhesion between the printing materials 7 and the swollen surface layer 13 decreases.

[0077] After the water has sufficiently soaked through the surface layer 3 of the image-recording medium 100, the image-recording medium 100 is transported to the region for removing the printed materials 7 where a brush 14 is applied. The brush 14 is rotating so that the printed materials 7 on the image-recording medium 100 are removed by the brush 14. A length of the brush 14 may be about 5 mm to about 20 mm and a thickness about 10 μm to about 60 µm. The material of the brush 14 is not specifically limited, but nylon or the like is suitable. Although the brush 14 in Figure 6 is not placed in a solution, the brush 14 may be placed in a solution. A removing means other than the brush 14 may be used, for example, a means such as a blade or a cloth that rubs or scrapes the surface by applying a physical or mechanical force to the surface of the medium 100.

[0078] The paper feed speed, i.e., the speed at which the image-recording medium 100 passes under the brush 14, is determined by considering the balance between the processing time and cleaning performance; for example, the speed is set within the range of about 0.5 cm/second to about 5 cm/second. Preferably, the rotational speed of the brush 14 is set at about 5 or more times the paper feed speed, and more preferably at about 10 or more times.

[0079] After the printed materials 7 have been removed from the image-recording medium 100, the medium 100 is transported to a shower device 15 region where a cleaning solution 70 is supplied to the surface of the medium 100 to wash out any remaining printed materials on the surface of the image-recording medium. An aqueous solvent similar to the one used as the swelling solution 30 may be used as the cleaning solution 70 from the shower device 15. It is particularly preferable to use water.

[0080] After subjected to the cleaning solution 70 with the use of the shower device 15, the image-recording medium is transported to a drying region where it is dried by a dryer 16. The drying method may be accomplished either by a contact type such as a heat roller or by a non-contact type such as a far infrared lamp. A heating temperature is suitably in the range of about 70°C to about 150°C.

[0081] Figure 7 is a schematic view showing one embodiment of a cleaning apparatus to which the above-described removing method can be applied. The cleaning apparatus 400 as shown in Figure 7 includes a cleaning tank 22, mounted inside a casing 23, for accommodating a swelling solution 30. To the cleaning tank 22 is connected a pump 20 equipped with a filter for removing the printed materials contained in the swelling solution 30 in the tank 22, and the pump 20 is further connected via a pipe 31 to the shower devices 11 and 15.

[0082] The swelling solution 30 in the cleaning tank 22, after being purified by the filter in the pump 20, is fed through the pipe 31 to the shower devices 11 and 15. The solution 30 in the cleaning tank 22 is not only supplied to the image-recording medium 100 by the shower device 11 so as to swell the surface layer 3, but also supplied to the medium 100 by the shower device 15 so as to rinse the medium 100.

[0083] The image-recording medium 100 is fed into the apparatus by means of a paper feeding roller 21 and sprayed with the swelling solution 30 from the shower device 11. Then, the image-recording medium 100 is transported via a guide 26 and a transport roller 24 and immersed in the swelling solution 30 in the cleaning tank 22. The medium 100 stops in the swelling solution 30 for a prescribed time period, thereafter, the image-recording medium 100 is fed by means of the transport roller 24 and a guide 28 to a position facing to the brush 14, where the printed materials are removed.

[0084] The image-recording medium 100 is transported via the guide 29, the transport roller 25, and a guide 27, and then the medium 100 is sprayed with the rinse solution (swelling solution 30) from the shower device 15 and washed. The medium 100 is finally dried by a drying roller 17 and discharged to the outside of the casing 23.

[0085] Figure 8 is a schematic view showing another embodiment of a cleaning apparatus. Identical elements previously discussed with respect to Figure 7 point out identical reference numerals and descriptions thereof are omitted.

[0086] In the apparatus 450 of Figure 8, the image-recording medium 100 fed by means of a paper feeding roller 21 is transported directly into a cleaning tank 22 by means of transport rollers 32, 33 and a guide 26, and immersed in a swelling solution 30 to allow water to soak into the surface layer 3 of the image-recording medium 100 before brushing. After passing the position facing to a brush 14, the image-recording medium 100 is passed through the swelling solution 30 for a prescribed time period before being fed to a drying roller 17, thereby obtaining the rinsing effect.

[0087] Figure 9 is a schematic view showing another embodiment of the cleaning apparatus. Identical elements previously discussed with respect to Figure 7 point out identical reference numerals and descriptions thereof are omitted.

[0088] In the cleaning apparatus 500, a tank 43 for accommodating the swelling solution 30 so as to swell the surface layer 3 of the medium 100, and a tank 42 for accommodating the rinse solution 70 so as to wash the medium after its surface has been rubbed by a brush 14, are provided independently of each other.

[0089] The swelling solution 30 accommodated in the tank 43 is pumped up by a pump 20 equipped with a filter, and fed through a pipe 31 to the shower device 11 where the swelling solution 30 is sprayed for a prescribed period of time or in a prescribed quantity over the image-recording medium 100 being fed by a paper feed roller 21. The swelling solution 30 sprayed on the image-recording medium 100 from the shower device 11 drops downward and is returned to the tank 43, located under the shower device 11, and the swelling solution 30 is thus circulated for reuse.

[0090] Then, the image-recording medium 100 is fed by means of the guide 26 and transport rollers 24 and 25 to a position facing to the brush 14, where the printed materials are removed. The image-recording medium 100 from which the printed materials have been removed by the brush 14 is transported under a shower device 15 where the rinse solution 70 is supplied to the surface of the image-recording medium 100.

[0091] The rinse solution 70 accommodated in the tank 42 is pumped up by a pump 40 equipped with a filter, and supplied to the shower device 15 through a pipe 41. The printed materials scraped off by the brush 14 and washed off by the rinse solution 70 fall onto a filter 45 provided above the tank 42, while the shower liquid falling from the shower device 15 also drops onto the filter 45, the printed materials are filtered out, and the rinse solution 70 is returned to the tank 42 and circulated for reuse.

[0092] The image-recording medium 100 passed through the shower device 15 is transported via a guide 27 and is finally dried by a drying roller 17 with a built-in heater and discharged to the outside of the casing 23.

[0093] The present invention will be more clearly understood with reference to the following examples:

(Example 1)

[0094] Base member: 30 % polyurethane aqueous solution (50 cps) was coated onto both surfaces of plain paper (EP paper 64 made by MINOLTA Co., LTD., a thickness of 64 μm) by a bar coater and then plain paper was dried under 100°C for 10 minutes, so that both surfaces of plain paper were coated with water-resistant layers having a thickness of 5 μm. The resulting plain paper with the water-resistant layers is denoted as a base member A. When the surface of the base member A is observed by means of an electron microscope, the surface of the paper was uniformly coated with the water-resistant layer and fibers were not found.

[0095] Surface layer: A resin solution was prepared by dissolving 16 parts by weight of polyvinyl alcohol (CM-318; made by KURARAY Co., LTD.) in 184 parts by weight of water. The resin solution was added with 4 parts by weight of polyisocyanate (SBU0772), 1 part by weight of sodium dodecylbenzenesulfonate, and 0.3 parts by weight of polyoxyethylene coconut oil fatty acid ethanolamide and stirred for 15 minutes. The resulting solution was coated onto the base member A by the bar coater, and then heated at 140°C for 60 minutes to form a surface layer having a thickness of 7 μm.

(Example 2)

[0096] Base member: Polyethylene laminate paper available in the market was used as a base member. The base member is denoted as a base member B.

[0097] Surface layer: A surface layer was coated onto the base member B in the same manner as in the Example 1.

(Example 3)

[0098] Base member: A resin solution was prepared by adding a melamine-formaldehyde resin (SUMIREZ 613: made by Sumitomo Chemical Company, Limited) to 100 g of 7 % polycarbonate dioxane solution (80 cps). The resin solution was coated onto both surfaces of plain paper (CF paper 80 made by MINOLTA Co., LTD., a thickness of 114 μm) by the bar coater and then plain paper was dried under 120°C for 5 minutes, so that both surfaces of plain paper were coated with water-resistant layers having a thickness of 6 μm. The resulting plain paper with water-resistant layers is denoted as a base member C. The observation of the surface of the base member C by means of the electron microscope revealed that the base member C had a surface state similar to the base member A.

[0099] Surface layer: 200 g of 8 % polyvinyl alcohol aqueous solution (KM-618; made by KURARAY Co., LTD.) was added with 3 g of glycerol polyglycidyl ether (Dinacol EX-313; made by Nagase Chemicals Ltd.) as a crosslinking agent and 0.4 g of polyoxyethylene nonyl phenyl ether as a surface active agent, and then stirred for 5 minutes. The resultant solution was coated onto the base member C by the bar coater, and then heated at 120°C for 2 hours to form a surface layer having a thickness of 9 μm.

(Example 4)

[0100] Base member: A resin solution was prepared by adding 1 part by weight of melamine-formaldehyde resin (SUMIREZ 613: made by Sumitomo Chemical Company, Limited) based on 100 parts by weight of 6 % polyurethane aqueous solution (5 cps). Plain paper (CF paper 80 made by MINOLTA Co., LTD., a thickness of 114 μm) was immersed in the resin solution for a minute, pulled up from the solution at 10 cm/s, drained water off sufficiently, and dried under normal temperature so as to prepare a base member D. When the surface of the base member D was observed by means of the electron microscope, fibers were found and each of the fibers was coated with a water-resistant layer having a thickness of about 1 μm.

[0101] Surface layer: 200 g of 8 % polyvinyl alcohol aqueous solution (KM-618; made by KURARAY Co., LTD.) was added with 3.2 g of glycerol polyglycidyl ether (Dinacol EX-313; made by Nagase Chemicals Ltd.) as a crosslinking agent and 0.4 g of polyoxyethylene nonyl phenyl ether as a surface active agent, and then stirred for 5 minutes. The resultant solution was coated onto the base member D by the bar coater, and heated at 120°C for 2 hours to form a surface layer having a thickness of 12 μm.

(Example 5)

[0102] Base member: The base member D in the Example 4 was used.

[0103] Surface layer: the concentration of the resin solution to form the surface layer in the Example 4 was diluted three times (30 cps). The base member was immersed in the diluted resin solution, pulled up from the solution, drained water off sufficiently, and heated at 120°C for 2 hours. When the surface of the base member D was observed by means of the electron microscope, each of the fibers was coated with a surface layer having a thickness of about 3 µm.

(Example 6)

[0104] Base member: A resin solution was prepared by adding 5 parts by weight of melamine-formaldehyde resin based on 100 parts by weight of 20 % polyurethane aqueous solution (35 cps). Plain paper (EP paper 64 made by MINOLTA Co., LTD., a thickness of 64 µm) was immersed in the resin solution for 15 minutes, pulled up from the solution at 1 cm/s, and dried at 100°C for 30 minutes. When the surface of the base member D was observed by means of the electron microscope, the resin filled the spaces between the fibers. The resin filling the spaces was 25 % by weight based on the weight of the base member before immersed. The resultant base member was denoted as a base member E.

[0105] Surface layer: The solution for coating was prepared, and coated onto the base member E, and then the coated base member was heated, in the same manner as in the Example 4.

(Example 7)

[0106] Base member: 30 % 100g of polyurethane aqueous solution (50 cps) was added with 5 g of a melamine-formaldehyde resin (SUMIREZ 613: made by Sumitomo Chemical Company, Limited). The base member E was coated with the resultant solution by the bar coater and then heated so as to form a water-resistant layer having a thickness of 5 µm on the base member E. The coated base member was denoted as a base member F. When the surface of the base member F was observed by means of the electron microscope, the surface of the base member F was substantially flat.

[0107] Surface layer: The solution for coating was prepared, and coated onto the base member F, and the coated base member was heated, in the same manner as in the Example 4.

(Example 8)

[0108] Base member: Paper (Mitsubishi Paper Co., Ltd.), in which polyethylene resin was treated when paper was being made, was coated with 30 % polyurethane aqueous solution (50 cps) by the bar coater and dried. The coated layer was 7 µm in thickness. This coated paper is refereed to as a base member 9.

[0109] Surface layer: The solution for coating was prepared and coated onto the base member G, and then the coated layer was heated in the same manner as in the Example 4.

(Comparative example 1)

[0110] Base member: Plain paper (new CK paper; made by Xerox Corp.) was used as a base member. The base member is denoted as a base member H.

[0111] Surface layer: The solution for coating was prepared and coated onto the base member, and then the coated layer was heated, in the same manner as in the Example 1.

(Comparative example 2)

[0112] Base member: A polyethylene terephthalate (PET) sheet having a thickness of 100 µm was used as a base member. The base member is denoted as a base member I.

[0113] Surface layer: The solution for coating was prepared and coated onto the base member, and then the coated layer was heated, in the same manner as in the Example 1.

Evaluation

[0114] Images (printed materials) were formed on the image-recording media obtained in the Examples 1 to 8 and Comparative examples 1 and 2 with the use of a laser beam printer (LP-1700; made by SEIKO EPSON CORPORATION) available in the market.

(1) Removability before recycled (initial stage)

[0115] The printed materials formed on the image-recording media obtained in the Examples and Comparative examples were removed with the use of the cleaning apparatus of Figure 7. In the case where the printed image-recording media were immersed in the solution 70 for 3 minutes so as to remove the printed materials, the removability of the printed materials on the image-recording media was evaluated in the ratio of the removed printed materials. The evaluation was ranked as follows and the results are summarized in Table 1.

◎: The ratio of the removed printed materials was 95 % or more.
○: The ratio of the removed printed materials was 80 % or more and less than 95 %
X: The ratio of the removed printed materials was less than 80 %

(2) Strength and removability after recycled

[0116] Each 10 image-recording media obtained in the Examples and Comparative examples were recycled 5 times (a copying process and toner-removing process). The strength of the image-recording media was evaluated in the number of the media which have been damaged and the evaluation was ranked as follows and the results are summarized in Table 1.

○: None of 10 image-recording media was damaged.
X: At least one of 10 image-recording media was damaged.

[0117] The removability of the printed materials on the media which have not been damaged after recycled was evaluated in the same manner as in the above-mentioned removability and the results are summarized in Table 1.

(3) Folding properties

[0118] Folding properties of each media obtained in the Examples and Comparative examples were evaluated and ranked as follows and the results are summarized in Table 1.

○: The image-recording medium was folded down.
X: The image-recording medium was hard to be folded down.

[0119] The operating conditions of the cleaning apparatus of Figure 7 were as follows:

- A brush 14; a metal core size of 12 mm having nylon brushing hair with length of 10 mm and thickness of 30 µm
- A temperature of the swelling solution 30 in the tank 22 at a temperature; 30°C
- A paper-feeding speed; 1 cm/second
- A ratio of the rotational speed of the brush 14 /paper-feeding speed; 30
- A temperature of the drying roller 17; 110°C

(4) Density of base member

[0120] The density of a base member included in each image-recording medium was determined from a division of weight per area (g/cm^2) by a thickness (cm) of the image-recording medium.

(5) Amount of water absorbed into base member

[0121] The base member (5 cm × 5 cm) was immersed in water (100 cc) of 30°C for 3 minutes, and then, water is squeezed from the base member with the use of a roller. The amount of water absorbed into the base member was determined from subtracting a weight (mg/cm^2) of the base member before it is immersed from a weight (mg/cm^2) of the base member from which water has been squeezed.

Table 1

	Density of base member	Amount of water absorbed into base member	Removability before recycled	Strength after recycled	Removability after recycled	Folding properties
Ex. 1	0.92	0.34	◎	○	○	○
Ex. 2	0.88	0.26	◎	○	○	○
Ex. 3	0.73	0.33	◎	○	○	○
Ex. 4	0.85	0.81	◎	○	◎	○
Ex. 5	0.85	0.81	◎	○	◎	○
Ex. 6	1.14	0.35	◎	○	◎	○
Ex. 7	1.41	0.13	◎	○	◎	○
Ex. 8	1.05	0.14	◎	○	◎	○
Com. ex. 1	0.69	6.25	◎	X	◎	○
Com. ex. 2	1.37	0	◎	○	◎	X

[0122] According to the present invention, the recyclable image-recording medium comprising a base member and a surface layer can provide the same feel as or be folded down like paper and the printed materials can be sufficiently removed from the medium. In addition, even when the surface layer included in the recyclable image-recording medium is applied with water and the entire medium is immersed in water, a strength of the medium is not deteriorated.

Claims

1. A recyclable image-recording medium comprising a base member and a water-swelling surface layer,
wherein the base member comprises pulp fibers treated to have water-resistance.

2. A recyclable image-recording medium according to claim 1, wherein the base member comprises a base layer and water-resistant layers formed on both surfaces of the base layer.

3. A recyclable image-recording medium according to claim 2, wherein the water-resistant layers are formed by a wet coating method or melt coating method.

4. A recyclable image-recording medium according to claim 1, wherein the pulp fibers are coated with a water-resistant layer.

5. A recyclable image-recording medium according to claim 4, wherein the water-resistant layer has a thickness of about 0.3 μm to about 20 μm.

6. A recyclable image-recording medium according to claim 1, wherein the base member comprises a water-resistant material filling spaces between the pulp fibers.

7. A recyclable image-recording medium according to any one of claims 2 and 4, wherein the water-resistant layer comprises a resin or a size agent, which is the water-resistant material.

8. A recyclable image-recording medium according to claim 7, wherein the water-resistant material is a resin with adhesive properties to the surface layer.

9. A recyclable image-recording medium according to claim 8, wherein the resin is selected from the group consisting of polyurethane, polyester, poly(vinyl acetate), poly(vinyl acetal), and a mixture thereof.

10. A recyclable image-recording medium according to any one of claims 2 and 4, wherein the water-resistant layers contain a reactive compound having a functional group chemically bondable to the surface layer.

11. A recyclable image-recording medium according to claim 10, wherein the reactive compound is selected from the group consisting of methylol compounds, epoxy compounds, isocyanate compounds, aldehyde compounds, aziridine compounds, and a mixture thereof.

12. A recyclable image-recording medium according to any one of the preceding claims, wherein the base member has a density of about 0.7 g/cm^3 to about 1.5 g/cm^3.

13. A recyclable image-recording medium according to any one of the preceding claims, wherein the base member absorbs water in a range between about 0.03 mg/cm^2 and about 1 mg/cm^2 when the base member is immersed in water for 3 minutes.

14. A recyclable image-recording medium according to claim 1,

wherein the water-resistant treatment is performed when a fibrous aggregation is being made to produce paper, or after the fibrous aggregation has been made.

15. A recyclable image-recording medium according to claim 1, wherein the base member has a thickness of about 50 μm to about 150 μm.

16. A recyclable image-recording medium according to claim 1, wherein the surface layer comprises a water-swelling resin and the water-swelling resin is formed from a water-soluble resin crosslinked by a crosslinking agent.

17. A recyclable image-recording medium according to claim 16, wherein the water-soluble resin includes a functional group having an active hydrogen atom.

18. A recyclable image-recording medium according to claim 16, wherein the crosslinking agent is water-soluble or dispersible in water.

19. A recyclable image-recording medium according to claim 16, wherein the surface layer contains a surface active agent.

20. A recyclable image-recording medium according to claim 16, wherein the surface layer contains inorganic fine particles or resin fine particles.

Fig.1

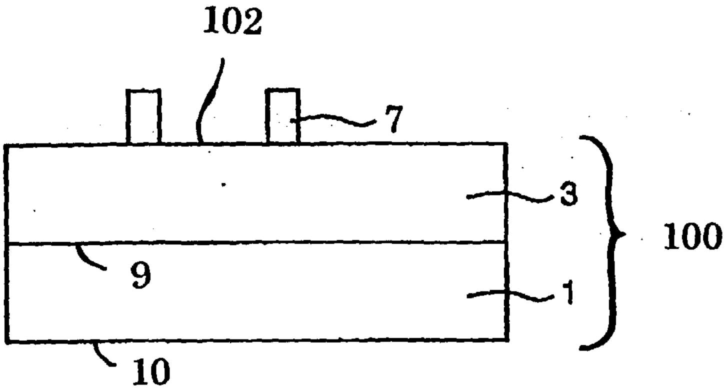

Fig.2

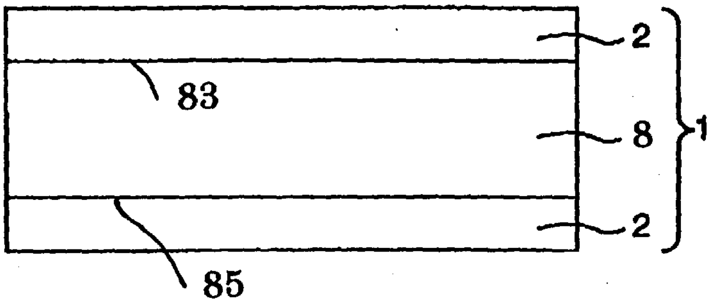

Fig.3

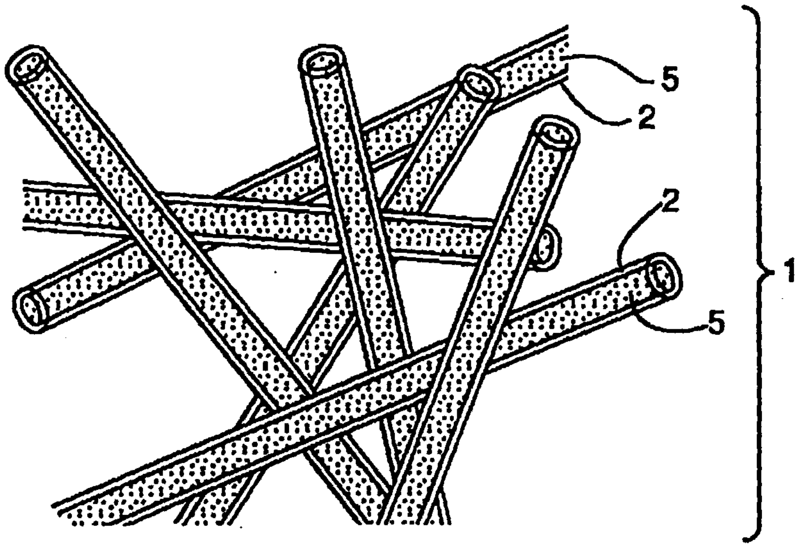

Fig.4

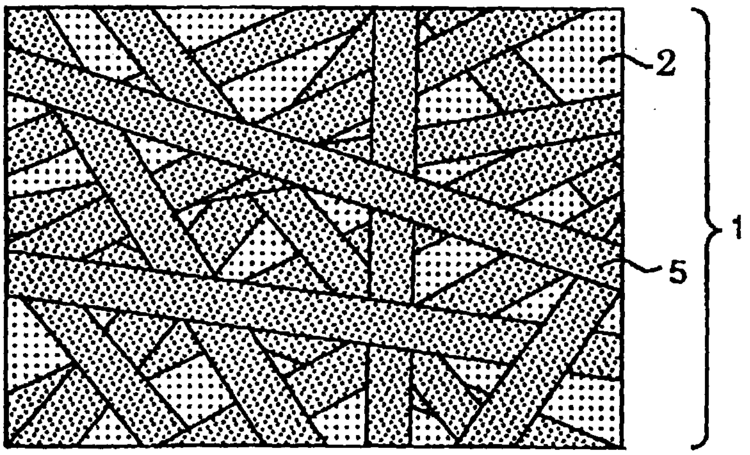

Fig.5A

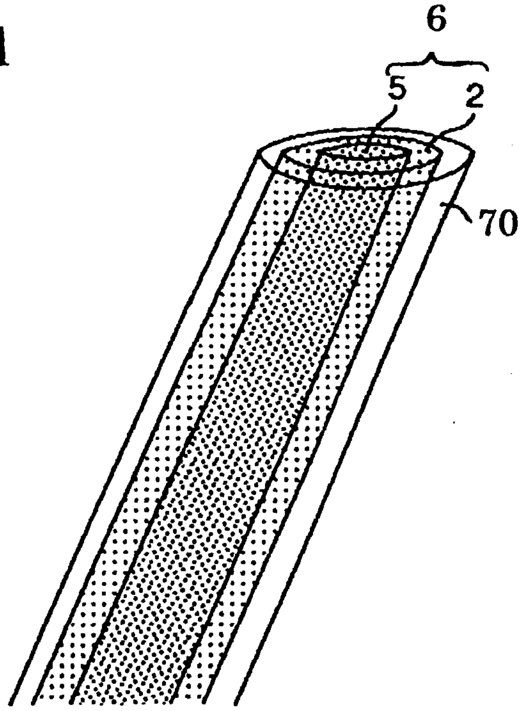

Fig.5B

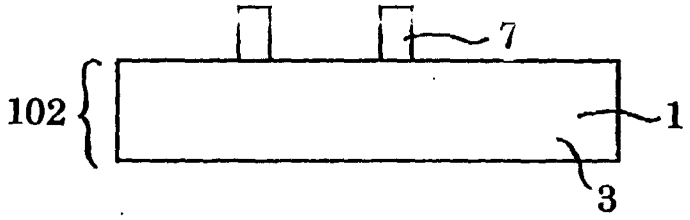

Fig.6

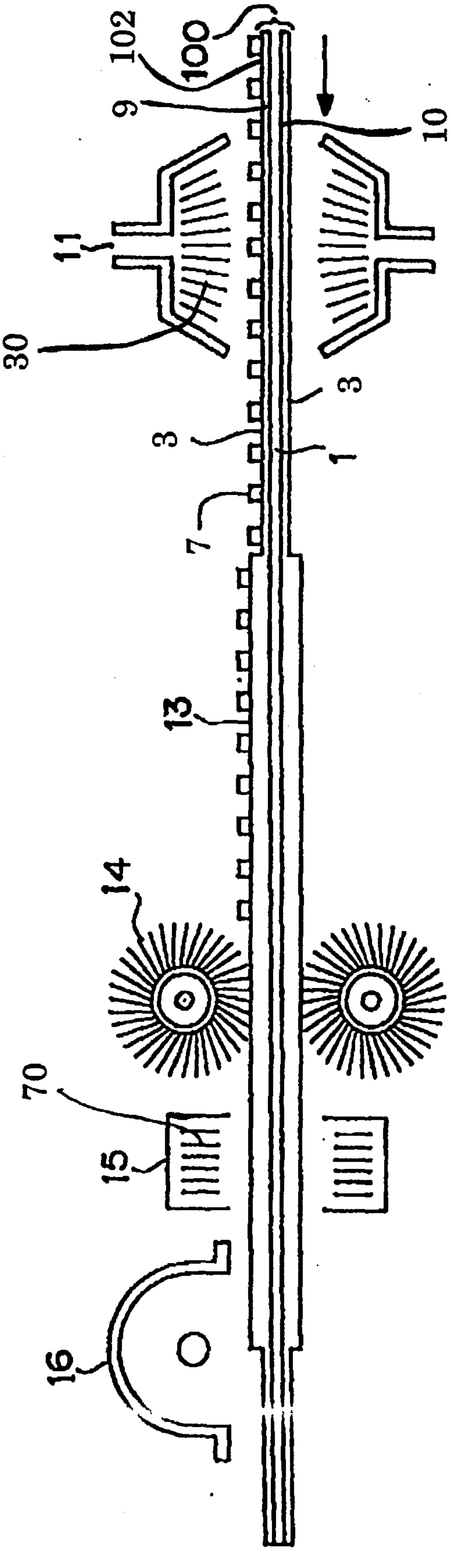

Fig. 7

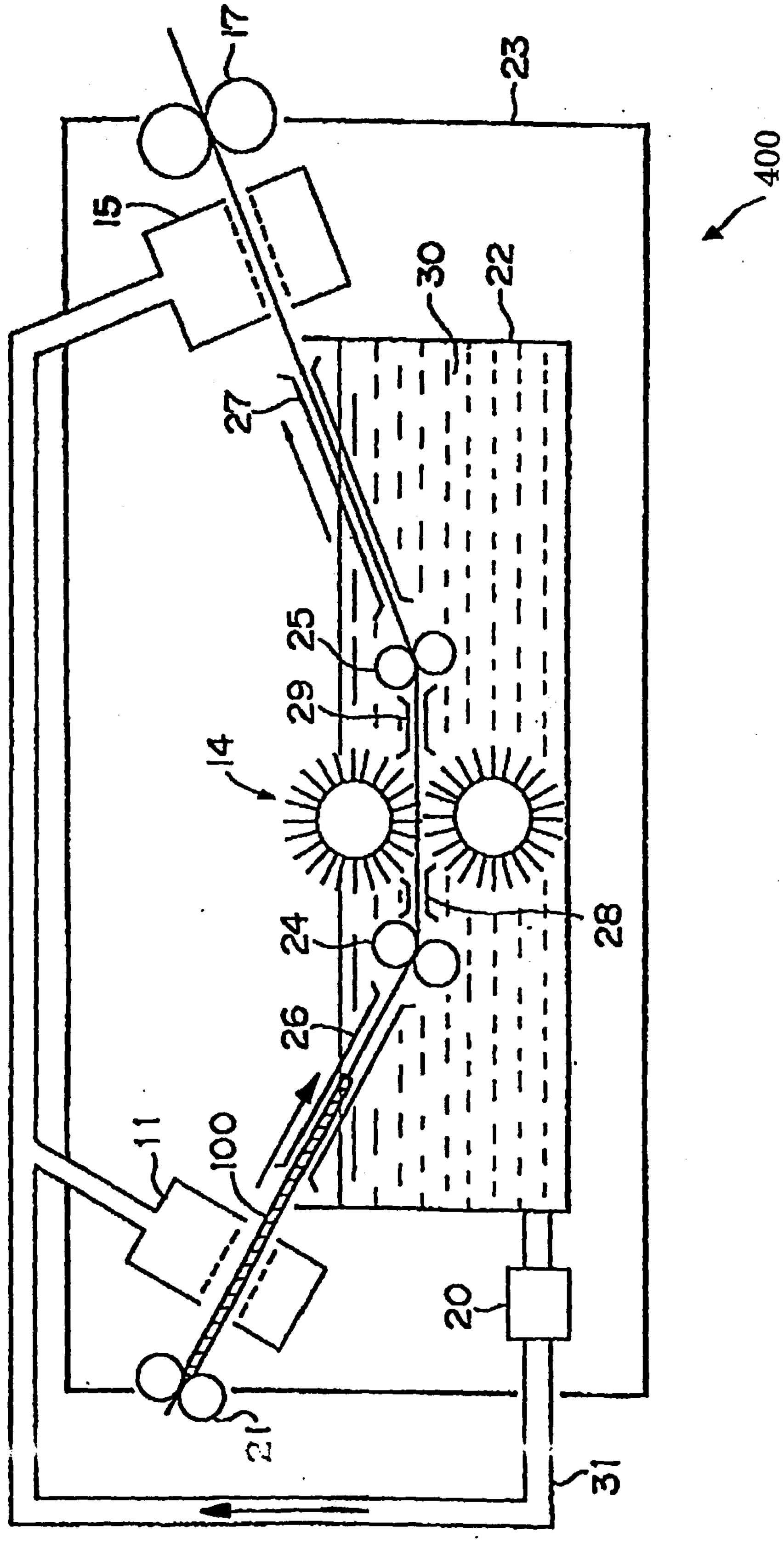

Fig.8

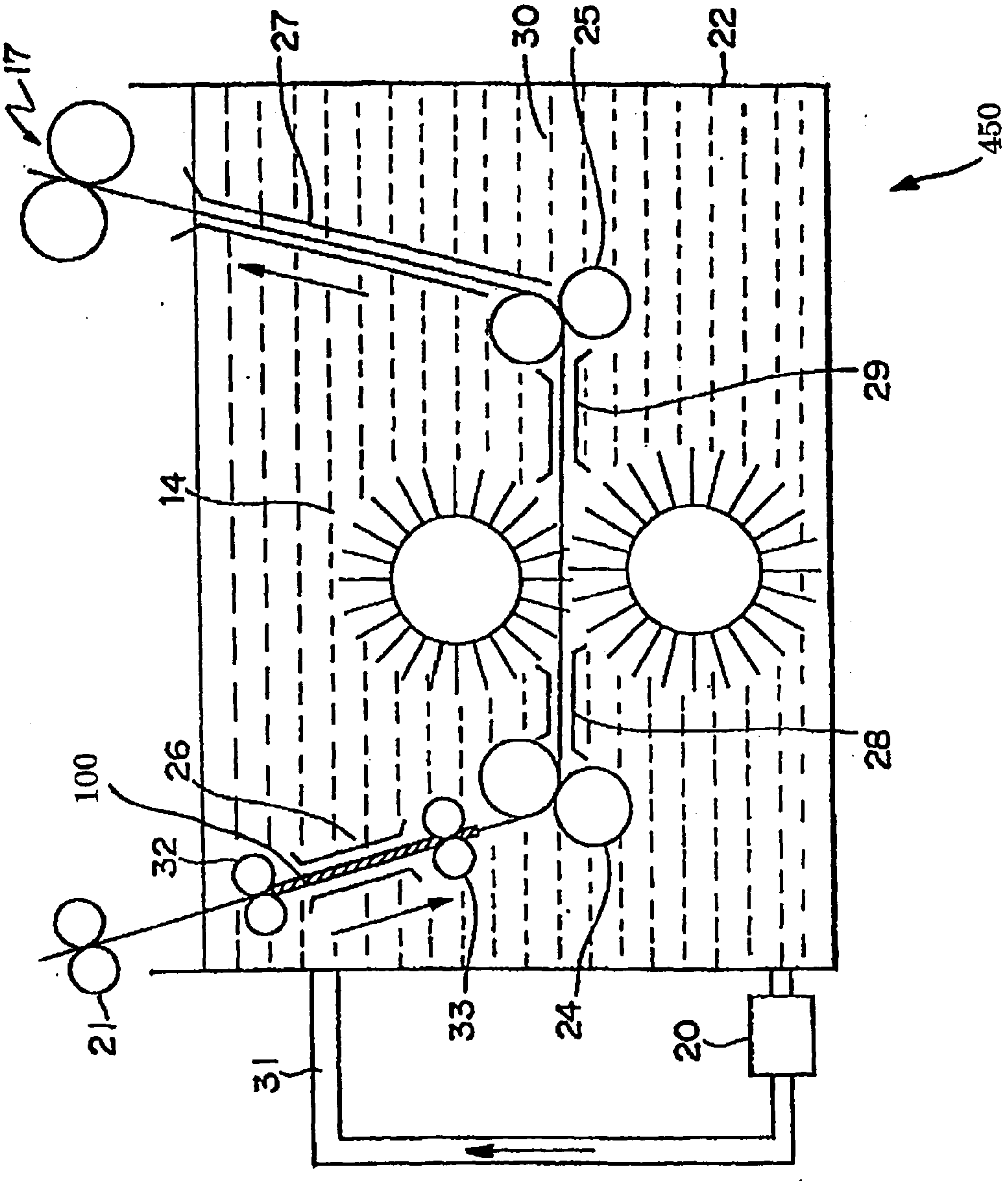

Fig.9