(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 020 772 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
19.07.2000 Bulletin 2000/29

(51) Int. Cl.^{7}: **G03G 7/00**, B41M 7/00

(21) Application number: **00100588.3**

(22) Date of filing: **12.01.2000**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **13.01.1999 JP 633899**
14.01.1999 JP 745099

(71) Applicant: **MINOLTA CO., LTD.**
Chuo-Ku, Osaka-Shi, Osaka 541-8556 (JP)

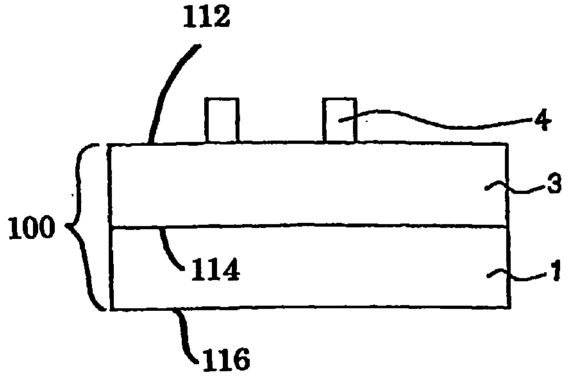
(72) Inventors:
- **Yoshie, Naoki,**
  c/o Minolta Co., Ltd.
  Chuo-Ku, Osaka-shi, Osaka (JP)
- **Yamaoka, Chiaki,**
  c/o Minolta Co., Ltd.
  Chuo-Ku Osaka-Shi, Osaka (JP)
- **Fujiwara, Toshimitsu,**
  c/o Minolta Co., Ltd.
  Chuo-Ku, Osaka-Shi, Osaka (JP)

(74) Representative:
Glawe, Delfs, Moll & Partner
Patentanwälte
Postfach 26 01 62
80058 München (DE)

(54) Recyclable image-recording medium

(57) This invention relates to a recyclable image-recording medium comprising a base member and a water-swelling surface layer, wherein a coefficient μ_s of static friction on a surface of the water-swelling surface layer is in the range from about 0.15 to 0.70 at 25°C and 60 % RH.

Fig.1



Printed by Xerox (UK) Business Services
2.16.7 (HRS)/3.6

Description

Related Applications

[0001] This application is based on Japanese Patent Application Nos. Hei11-6338 and Hei11-7450, each content of which being 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 an image-recording medium capable of being reused repeatedly wherein printed materials made to adhere to the image-recording medium by a copying machine, printer or the like are removable from the image-recording medium.

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 paper and OHP (overhead projector) 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 the printed image-recording media 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. EP0601502, for example, disclose a method 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] It has been required that such image-recording medium is provided with sufficient removability, that is, printed materials on the medium are removed sufficiently. In addition, it has been required that the image-recording medium is smoothly fed and printed in an image recording apparatus such as a copying machine and printer.

[0007] Accordingly, it is desirable that the image-recording medium is provided with passing properties equal to those of paper or OHP sheets so that mis-feeding or double-feeding can be prevented and that the medium is not be jammed in the image recording apparatus, when the recording media are fed in the apparatus.

SUMMARY OF THE INVENTION

[0008] The present invention is to provide a recyclable image-recording medium with excellent removability of printed materials, paper-feeding properties, and paper-passing properties.

[0009] The present invention is also to provide recyclable image-recording media which are hard to be stuck together and can be easily separated, even when the media are preserved in pile under high temperature and humidity.

[0010] In addition, the present invention is to provide a recyclable image-recording medium with excellent removability of printed materials, paper-feeding properties, and paper-passing properties under high temperature and humidity.

[0011] The present invention relates to a recyclable image-recording medium comprising a base member and a water-swelling surface layer, wherein a coefficient μ_s of static friction on a surface of the water-swelling surface layer is in the range from about 0.15 to 0.70 at 25°C and 60 % RH.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012]

Figure 1 is a schematic cross sectional view of one example of an image-recording medium of the present invention.

Figure 2 is a schematic cross sectional view of another example of an image-recording medium of the present invention.

Figure 3 is a process sequence diagram for explaining a method for removing printed materials on the image-recording medium.

Figure 4 is a schematic view showing one example of a cleaning apparatus.

DETAILED DESCRIPTION OF THE INVENTION

[0013] The present invention provides a recyclable image-recording medium comprising a base member and a water-swelling surface layer, wherein a coefficient μ_s of static friction on a surface of the water-swelling surface layer is in the range from about 0.15 to 0.70 at 25°C and 60 % RH. The present invention will be described by way of example with reference, to the accompanying figures.

[0014] Figure 1 shows a schematic cross sectional view of one example of an image-recording medium of 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. Printing materials 4 are printed on a surface 112 of the surface layer 3. The surface layer 3 may be formed on both sides 114 and 116 of the base member 1, although the surface layer 3 is formed on one side 114 of the base member 1 in Figure 1.

[0015] As a base member 1, a transparent plastic film that has water-resistance (strength) or a plastic film opacified by adding inorganic fine particles, is preferably used. The material of the plastic film is not specifically limited. When heat resistance, for example, is considered, polyester, polycarbonate, polyimide, polymethyle methacrylate, and the like, are preferably used as the material of the plastic film. When versatility, price, durability, and so on, in addition to the heat resistance, are considered, polyester, in particular, polyethylene terephthalate (PET), polyethylene naphthalate (PEN), and the like, are preferably used as the material of the plastic film. Various sheets available as OHP sheets can also be used. In addition, synthetic paper made from plastic fibers such as PET fibers which is available in the market can be also used as a material to form the base member 1. Metal foils, paper with improved water-resistance, and even composite materials made from resin, paper, and metal can also be used. Any other materials may be used so far as the material has water-resistance and appropriate mechanical strength and is able to keep its flatness through the printing and removal of the printed materials 4.

[0016] If desired, an additive such as an antistatic agent, coloring agent, and biological decomposition promoter may be added to the base member 1, unless the base member 1 loses original required characteristics. The surfaces 114 and 116 of the base member 1 may be activated by a discharge treatment and other appropriate methods in order to improve an adhesion of the base member 1 to the surface layer 3 or to an intermediate layer 2 (see Figure 2, described below). A thickness of the base member 1 is preferably in the range of from about 30 to 200 µm, more suitably in the range of from about 50 to 150 µm.

[0017] The surface layer 3 formed on the base member 1 includes a water-swelling resin and if desired, appropriate additives, and a coefficient μ_s of static friction on the surface 112 of the surface layer 3 is adjusted to be in the range from about 0.15 to 0.70 at 25°C and 60 % RH. 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.

[0018] A water-soluble resin containing within a molecule a functional group having an active hydrogen atom, 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.

[0019] 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 rate of the surface layer 3 can be increased.

[0020] 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 a metal atom substituted for an active hydrogen atom, and a group containing a substituent which has at the end 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 a quarternary ammonium group substituted for an active hydrogen atom included in the cationic functional group.

[0021] 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 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.

[0022] When a water-soluble or hydrophilic material is used for the crosslinking agent, the surface layer 3 can be formed by using water, which serves to coat the surface layer 3 safely and prevent an organic solvent from remaining in the surface layer 3.

[0023] In the present invention, a coefficient μ_s of static friction on the surface 112 of the surface layer 3 is adjusted in the range of from about 0.15 to 0.70 at a temperature of 25°C and relative humidity (RH) of 60 %. A coefficient μ_s of static friction on the surface 112 of the surface layer 3 is measured in accordance with JIS (Japanese Industrial Standards) P8147 (Method for determining coefficient of friction of paper and board). If a coefficient μ_s of static friction is less than about 0.15, the image-recording medium 100 may not be smoothly passed through by a roller and cause mis-feeding (mis-passing) in a printing apparatus. On the other hand, if a coefficient μ_s of static friction is more than about 0.70, the following problems may occur. The image-recording media 100 are stuck strongly each other. When the media 100 are preserved in piles, especially, under high temperature and high humidity (H/H), the media 100 are easily stuck together and cannot be separated. Even if the media 100 are pressed by external force, the media 100 tend to be stuck together.

[0024] A coefficient μ_s of static friction on the surface 112 of the surface layer 3 may be adjusted in the range of from about 0.15 to 0.70 at 25°C and 60 % RH by using any methods, which do not provide an adverse affect on removability of the printed materials 4 on the image-recording medium 100. A coefficient μ_s of static friction can be adjusted, for example, by (1) appropriately selecting materials for forming the surface layer 3, and kinds and amounts of an additive (which is added if desired) such as inorganic fine particles and a surface active agent, or (2) mechanically rubbing the surface 112 of the surface layer 3. These methods will be described below in detail. The following methods may be employed alone or in combination to adjust a coefficient μ_s of static friction of about $0.15 \leq \mu \leq 0.70$ on the surface 112 of the surface layer 3 at 25°C and 60 % RH.

[0025] A method in which a coefficient μ_s of static friction is adjusted by adding the inorganic fine particles to the surface layer 3 will be described.

[0026] When the inorganic fine particles are added to the surface layer 3, a coefficient μ_s of static friction decreases. Examples of the inorganic fine particles include silica, alumina, titanium oxide, zinc oxide, calcium carbonate, calcium oxide, magnesium oxide, and copper oxide, but not limited thereon. Among them, silica, alumina, titanium oxide, zinc oxide and calcium carbonate are preferably used. Silica is more preferably used.

[0027] An average particle size of the inorganic fine particles is preferably in the range from about 7 to 30 μm, more preferably about 10 to 20 μm. In the specification, the expression "average particle size" as used herein means a secondary particle size. The secondary particle size refers to the particle size when an agglomerate of primary fine particles is regarded as a single particle. The secondary particle size can be measured, for example, by means of a microscope, SALD-1000 (made by SHIMADZU Corporation).

[0028] An amount of the inorganic fine particles to be added is preferably about 150 parts by weight or less, more suitably about 30 parts by weight or less, based on about 100 parts by weight of the water-soluble resin contained in the surface layer 3, although the appropriate amount of the inorganic fine particles depends on the kind of the added particles and the kind and amount of other materials contained in the surface layer 3. If the amount of the inorganic fine particles is too large, the following problems may occur. The inorganic fine particles cover the surface 112 of the surface layer 3 and the printed materials 4 printed on such surface are extremely hard to be removed, since the inorganic fine particles themselves are not swollen. In addition, a coefficient μ_s of static friction is hard to be adjusted within the above-mentioned appropriate range, since a coefficient μ_s is remarkably decreased.

[0029] It is preferable to adjust a coefficient μ_s of static friction on the surface 112 of the surface layer 3 by adding the inorganic fine particles to the surface layer 3, although it is not necessary to add the inorganic fine particles to the surface layer 3 if a coefficient μ_s on the surface 112 itself is in the above-mentioned appropriate range. An amount of the inorganic fine particles to be added is preferably about 1 part by weight or more, more suitably about 3 parts by weight or more, based on 100 parts by weight of the water-soluble resin contained in the surface layer 3.

[0030] A method in which a coefficient μ_s of static friction is adjusted by adjusting appropriately water-absorption properties (hygroscopic properties) of the water-swelling resin contained in the surface layer 3 so as not to provide an adverse affect on removability of the printed materials 4 on the medium 100 will be described.

[0031] Generally, a coefficient μ_s of static friction on the surface 112 of the surface layer 3 is increased, when water-absorption properties of the water-swelling resin are improved. On the other hand, a coefficient μ_s of static friction on the surface 112 of the surface layer 3 is decreased, when water-absorption properties of a water-swelling resin are lowered.

[0032] Water-absorption properties of the water-swelling resin can be adjusted, for example, by changing the kind and amount of the crosslinking agent in the case where the water-swelling resin is formed by crosslinking the water-soluble resin. When the amount of the crosslinking agent to be added is decreased, water-absorption properties of a water-swelling resin are improved. Accordingly, the surface 112 of the surface layer 3 is soft and easily absorbs moisture. As a result, a coefficient μ_s of static friction on the surface 112 of the surface layer 3 is increased. On the other hand, when the amount of the crosslinking agent to be added is increased, water-absorption properties of the water-swelling resin is lowered. Accordingly, the surface 112 of the surface layer 3 becomes hard and smooth. As a result, a coefficient μ_s of static friction on the surface 112 of the surface layer 3 is decreased.

[0033] The amount of the crosslinking agent to be added is preferably in the range from about 0.5 to 50 parts by weight, more suitably about 1 to 40 parts by weight, based on 100 parts by weight of the water-soluble resin, although the appropriate amount of the crosslinking agent to be added depends on the kind, molecular weight and reaction condition of a water-soluble resin and a crosslinking agent. If the amount of the crosslinking agent to be added is too small, a strength of the surface layer 3 may be insufficient and dissolved when swollen. On the other hand, if the amount of the crosslinking agent to be added is too large, the following problems may occur. The surface layer 3 cannot be sufficiently swollen, since molecular chains in the water-soluble resin contained in the surface layer 3 are remarkably restricted each other. Accordingly, the printed materials 4 cannot be sufficiently removed from the image-recording medium 100. In addition, a coefficient μ_s of static friction is hard to be adjusted within the above-mentioned appropriate range, since a coefficient μ_s is remarkably decreased.

[0034] A coefficient μ_s of static friction can be increased within the appropriate range by the following method. Above-described ion-modified water-soluble resin can be used for forming the surface layer 3 or a hydrophilic group is introduced into a crosslinking agent, so that water-absorption properties are improved. Alternatively, a high adhesive material may be added to the surface layer 3.

[0035] A method for decreasing a coefficient μ_s of static friction within the appropriate range by adding a surface active agent to the surface layer 3 will be described. A resin solution for forming the surface layer 3 may be added with the surface active agent and then cast so that the surface layer 3 contains the surface active agent. Alternatively, the surface active agent may be directly coated or sprayed on the surface layer 3. It is preferable that the surface active agent is contained in the surface layer 3, considering durability of the surface layer 3. In addition, in the case where the surface layer 3 is coated with an aqueous solution, when the aqueous solution to be coated contains the surface active agent, the surface layer 3 can be easily coated.

[0036] Any known surface active agents including anionic, cationic and nonionic surface active agents can be used. Examples of anionic surface active agent include fatty acid sulfonate, alkylbenzenesulfonate, alkyl sulfonate, ester salt of higher alcohol, and phosphorate salt. Examples of the cationic surface active agents include quaternary ammonium salt. Examples of the nonionic surface active agents include polyoxyethylene nonyl phenyl ether.

[0037] Although an appropriate amount of the surface active agent to be added depends on the kind of the surface active agent and the kind and amount of other materials contained in the surface layer 3, the amount of the surface active agent, which is added to the surface layer 3, is preferably in the range from about 0.1 to 20 parts by weight, more suitably about 0.5 to 10 parts by weight, based on 100 parts by weight of the water-soluble resin contained in the surface layer 3. If the amount of the surface active agent to be added is too large, a coefficient μ_s of static friction on the surface 112 of the surface layer 3 is remarkably decreased. Accordingly, a coefficient μ_s of static friction on the surface 112 of the surface layer 3 may be hard to be adjusted within the above-mentioned appropriate range. On the other hand, if the amount of the surface active agent is too small, the effect of the addition of the surface active agent to the surface layer 3 may be insufficient.

[0038] As described above, the above methods for adjusting a coefficient μ_s may be employed alone or in combination of two or more methods in order to set a coefficient μ_s of static friction within the appropriate range. For example, the methods for adjusting a coefficient μ_s of static friction can be employed in combination of two or more methods as follows. Anion-modified poly(vinyl alcohol) (KL-318: made by KURARAY Co., LTD.) as a water-soluble resin, epoxy crosslinking agent (Dinacol EX-313; made by Nagase Chemicals Ltd.) as a crosslinking agent, silica fine particles (SYLYSIA 450: made by Fuji Silysia Chemical Ltd.) as inorganic fine particles and polyoxyethylene nonyl phenyl ether as a surface active agent are used to form the surface layer 3. The use of about 5 to 20 parts by weight of the water-soluble resin, about 12.5 to 25 parts by weight of the inorganic fine particles, and about 2.5 parts by weight of the surface active agent, based on 100 parts by weight of the water-soluble resin, can give the surface layer 3 having a coefficient μ_s of static friction in the range of about 0.16 to 0.69.

[0039] A method in which a coefficient μ_s of static friction is adjusted by mechanically rubbing the surface 112 of the surface layer 3 will be described. Any mechanical methods for changing a coefficient μ_s of static friction can be employed. For example, the surface layer 3 may be treated by a blasting or a surface treatment so that the surface 112 of the surface layer 3 is roughened. Therefore, a coefficient μ_s of static friction can be decreased within the appropriate range.

[0040] In order to adjust a coefficient μ_s of static friction within the appropriate range within the appropriate range, a shape and smoothness of the surface layer 3 can be changed by appropriately changing conditions for forming the surface layer 3 such as a coating method, drying time, and temperature.

[0041] A method in which a coefficient μ_s of static friction is adjusted within the appropriate range by supplying fine particles onto the surface 112 of the surface layer 3 will be described. When the fine particles are supplied onto the water-swelling surface layer 3, the printed materials 4 can be easily removed so that the image recording-medium 100 can be easily recycled. In addition, passing properties of the image-recording media in a printing apparatus can be also improved. The average particle size of the fine particles (secondary particle size) as used is preferably about 0.1 to 20 μm, more preferably about 0.5 to 10 μm. If the average particle size is more than about 20 μm, sufficient passing properties are not obtained since the fine particles cannot be uniformly dispersed on the surface 112 of the surface layer 3. If the average particle size is less than about 0.1 μm, a problem occurs in that the fine particles tend to aggregate. The amount of the fine particles supplied onto the surface 112 is preferably about 0.005 g/m^2 to about 1 g/m^2, more suitably about 0.01 g/m^2 to about 0.5 g/m^2. If the amount is more than about 1 g/m^2, light-transmittance of the image-recording medium 100 is deteriorated, the fine particles have an adverse affect on the image recording apparatus such as a copy machine, and the printing materials 4 are poorly printed on the surface 112. On the other hand, if the amount is less than about 0.005 g/m^2, sufficient passing properties of the image-recording media 100 are not obtained. Any kind of the fine particles which are useful for improving passing properties of the image-recording medium 100 can be used. Examples of the fine particles include inorganic fine particles such as silica, titanium oxide, alumina, zinc oxide, calcium carbonate, and calcium oxide, resin particles such as polymethacrylate, polyester, and polyurethane, and organic fine particles such as an organic pigment.

[0042] A method for forming the surface layer 3 will be described. A solvent-coating method can be used to form the surface layer 3. To describe more specifically, a 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. The materials of the water-swelling surface layer 3 are, for example, a mixture of the water-soluble resin and crosslinking agent, or a mixture of the water-soluble resin and monomer or oligomer including two or more of vinyl groups and, if necessary, other additives such as the inorganic particles and surface active agent. 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 dried, although the appropriate thickness of the surface layer 3 depends on a strength of the materials and the additives. When the thickness of the surface layer 3 is too small, the surface layer 3 cannot be sufficiently swollen so that the printed materials 4 are not sufficiently removed from the image-recording medium 100. On the other hand, when the thickness of the surface layer 3 is too large, a strength of the surface layer 3 itself is deteriorated so that a problem on durability of the surface layer 3 arises in that the surface layer 3 is exfoliated or damaged.

[0043] After the surface layer 3 is coated on the base member 1, the surface layer 3 is heated at about 50 to 180°C, preferably about 80°C to 150°C.

[0044] Figure 2 is a schematic cross sectional view of another example of an image-recording medium of the present invention. As shown in Figure 2, the image-recording medium 100 of the present invention may include an intermediate layer 2 between the base member 1 and the surface layer 3 in order to adhere the surface layer 3 stronger to the base member 1. The intermediate layer 2 and the surface layer 3 may be formed on both sides 114 and 116 of the base member 1, although the intermediate layer 2 and the surface layer 3 are formed on one side 114 of the base member 1 in Figure 2. Identical elements previously discussed with respect to Figure 1 point out identical reference numerals and descriptions thereof are omitted.

[0045] The intermediate layer 2 will be described. The intermediate layer 2 is formed from a resin having high adhesive properties. The intermediate layer 2 preferably contains a compound (reactive compound) 5 having a functional group chemically bondable to the resin which forms the surface layer 3 so that an adhesion or bonding between the intermediate layer 2 and the surface layer 3 can be improved.

[0046] Examples of the resin having high adhesive properties for forming the intermediate layer 2 include acrylate resins, styrene resins, polyester resins, polycarbonate resins, vinyl acetate resins, vinyl chloride resins, urethane resins, etc., among which polymethyl methacrylate resins, polyester resins, polycarbonate resins, vinyl chloride resins, and urethane resins are preferable. In particular, resins having high adhesivity to the base member 1 are preferred for use.

[0047] The reactive compound 5 contained in the intermediate layer 2 is not limited to a specific compound as long as it has a functional group capable of chemically bonding to the resin which forms the surface layer 3. For example, methylol compounds, isocyanate compounds, aldehyde compounds, epoxy compounds, aziridine compounds, etc. can be used. Among them, methylol compounds, isocyanate compounds, aldehyde compounds, and epoxy compounds are preferable in the case where the resin having a hydroxyl group such as poly(vinyl alcohol) and methyl cellulose is used to form the surface layer 3. Among them, isocyanate compounds, epoxy compoundsand, and aziridine compounds compounds are preferable in the case where the resin having a carboxyl group such as polyacrylic acid is used to form the surface layer 3. These compounds can be also used as the crosslinking agent for crosslinking the water-soluble resin to form the surface layer 3.

[0048] Examples of methylol compounds include methylol melamines such as dimethylol melamine and trimethylol melamine, dimethylol ureas, and melamine-formaldehyde resins. Various other methylol compounds can also be used; those having an appropriately high molecular weight and appropriately long molecular chain are more preferable. From this point of view, melamine-formaldehyde resins are preferable among the above listed methylol compounds.

[0049] Examples of aldehyde compounds include glyoxal and glutaraldehyde. Various other aldehyde compounds can also be used.

[0050] Examples of epoxy compounds include polyethylene glycol diglycidyl ether, polypropylene glycol diglycidyl ether, sorbitol polyglycidyl ether, sorbitan polyglycidyl ether, and polyglycerol polyglycidyl ether. Various other epoxy compounds can also be used.

[0051] For isocyanate compounds, a compound containing two or more isocyanate groups within one molecule can be used so that the surface layer 3 can be more strongly adhered to the base member 1. Such isocyanates include, for example, 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. The isocyanates used in the present invention, including the above listed compounds, may be protected by phenol, sulfurous acid, etc.

[0052] Examples of aziridine compounds include, for example, 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.

[0053] For the above described reactive compounds, compounds that are in the form of a solid or wax at normal temperatures or in the form of a viscous liquid at normal temperatures are more preferable. When the reactive compound is in the form of a solid or wax or a viscous liquid at normal temperatures, the advantage is that the compound does not evaporate when dried in the process for forming the intermediate layer 2 and, also, the surface does not become sticky after dried, which makes the surface coating easier. Further, when the reactive compound soluble in water or having affinity for water is used, there is no need to use an organic solvent when forming the intermediate layer 2, which serves to prevent an organic solvent from remaining in the intermediate layer 2.

[0054] In order to apply the intermediate layer 2 onto the base member 1, a solution-coating method, a melt-coating method etc. can be employed. In the solution-coating method, a solution prepared by dissolving the resin and, if necssary, the reactive compound in a suitable solvent, such as tetrahydrofuran (THF), dioxane, acetone, ethyl acetate or methyl ethyl ketone (MEK), is applied and dried. A solution of a water-soluble or hydrophilic polyurethane, polyester, or other resin dispersed or dissolved in water can also be used. Such resin solutions and resin emulsions are commercially available. Such solutions or emulsions have the advantage that the coating can be performed without use of an organic solvent, especially, a nonaqueous organic solvent. This effects to improve the safety during manufacturing. This also effects to prevent problems such as generation of residual solvent gases from within the image-recording medium 100 when it is fed, for example, into a copying machine and heated. The use of an aqueous solvent has an effect of facilitating the application of the intermediate layer 2 when a surface active agent is added. When both the intermediate layer 2 and the surface layer 3 are formed by use of an aqueous solvent, it becomes possible to prepare an image-recording medium 100 without use of a non-aqueous organic solvent. Safety is secured and the remaining of the non-aqueous organic solvent in the image-recording medium 100 may be avoided. By means of the solution-coating method or the melt-coating method described above, the intermediate layer 2 is formed to have a layer thickness of about 0.5 μm to 20 μm, preferably about 0.5 μm to 10 μm, more preferably about 0.5 μm to 6 μm. If a thickness is less than about 0.5 μm, coating irregularities tend to occur, tending to resulting in the formation of uncoated portions. If a thickness exceeds about 20 μm, problems may arise in strength and heat resistance etc. of the image-recording medium 100.

[0055] The reactive compound can itself be dissolved in a solvent or the like and then applied and dried for formation of the intermediate layer 2, when it is a high molecular weight compound that has a layer-forming capability by itself and excellent adhesivity to the base member 1. When adding the compound to the resin solution for coating, about 5 to 50 parts by weight of the reactive compound may be added based on 100 parts by weight of the resin for forming the intermediate layer 2.

[0056] Further the intermediate layer 2 may be subjected to a corona discharge treatment.

[0057] When a fibrous material such as paper is used as the base member 1, the base member 1 may be immersed in a coating solution for forming the intermediate layer 2, thereby impregnating the base member 1 with the coating solution and filling spaces between the fibers with the material of the intermediate layer 2.

[0058] The above obtained image-recording medium 100 can be suitably used repeatedly in a recycling system in which printed image-removing method involves processes of a surface layer-swelling process, a physical friction process such as brushing, and a drying process. The image-recording medium 100 is excellent in passing properties and conventional problems can also be solved. The above conventional problems are as follows: The media 100 are easily stuck together and hard to be separated when the media 100 are preserved in piles, especially, under high temperature and high humidity (H/H).

[0059] The following description is about a method for removing printed materials 4 from the image-recording medium 100 whose surface 112 is printed with the printing materials 4 such as toner. In the removing method, the medium 100 is supplied with a solvent capable of swelling the surface layer 3 of the medium 100, and then the printed materials 4 are removed from the swollen surface of the image-recording medium 100 by a physical force. The method will be further described in detail with reference to figures.

[0060] Figure 3 is a process sequence diagram for explaining the method for removing the printed materials 4 from the image-recording medium 100.

[0061] In Figure 3, the intermediate layer 2 and the surface layer 3 (see, Figures 1 and 2) are formed on both sides 114 and 116 of the base member 1 included in the image-recording medium 100. The intermediate layer 2 and the surface layer 3 are designated in Figure 3 by reference number 12. At least one surface 112 of the image-recording medium 100 is printed with a material for printing (referred to as "printing material" hereinafter) 4 such as toner. Toner used in electrophotography is preferably used as the printing material 4. 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.

[0062] In Figure 3, the image-recording medium 100 is transported from right to left.

[0063] The printed materials 4 are removed from the image-recording medium 100 according to the following steps, for example.

[0064] The image-recording medium 100 printed with the printing materials 4 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 and inorganic particles may be added to the swelling solution 30. This removing method has an advantage that the printed materials 4 can be removed from the image-recording medium 100 with the use of water. The following description deals with the case in which water is used as the swelling solution 30.

[0065] 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 3. Alternatively, the surface layer 3 of the image-recording medium 100 may be immersed in water (not shown in Figure 3). The surface layer 3 of the medium 100 may be contacted with water for about 15 seconds to about 150 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 4 may not be sufficiently removed from the image-recording medium 100. 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 4 and the swollen surface layer 13 decreases.

[0066] 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 4 where a brush 14 is applied. The brush 14 is rotating so that the printed materials 4 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 3 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 112 by applying a physical or mechanical force to the surface of the medium 100.

[0067] 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.

[0068] After the printed materials 4 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 112 of the image-recording medium 100. 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.

[0069] After subjected to the cleaning solution 70 with the use of the shower device 15, the image-recording medium 100 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.

[0070] Figure 4 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 4 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.

[0071] 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.

[0072] 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.

[0073] 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.

[0074] The present invention will be more clearly understood with reference to the following examples:

(Example 1)

[0075]

Base member: A polyethyleneterephthalate (PET) sheet with a thickness of 100 μm was used as a base member.

Intermediate layer: Five grams of melamine-formaldehyde resin (Sumirez 613; made by Sumitomo Chemical Company, Limited) and 0.1 g of polyoxyethylene nonyl phenyl ether were added to 100g of a resin solution of urethane dispersed in water (HUX-232: made by ASAHI DENKA KOGYOU K.K.), and then stirred for 5 minutes to form a resin solution for an intermediate layer. The resin solution for an intermediate layer was applied onto the base member by a bar coater, and dried at 120°C for 5 minutes, followed by a corona discharge treatment, to form an intermediate layer with a thickness of 5 μm.

Surface layer: A resin solution was prepared by dissolving 16 g of anion-modified polyvinyl alcohol (KL-318: made by KURARAY Co., LTD.) as a water-soluble resin in 184 g of water. The resin solution was added with 3.2 g of epoxy crosslinking agent (Dinacol EX-3l3: made by Nagase Chemicals Ltd.), 0.4 g of polyoxyethylene nonyl phenyl ether, and 2 g of silica fine particles (SYLYSIA 450: made by Fuji Silysia Chemical Ltd.) and then, stirred for 15 minutes. The resulting solution was applied onto the intermediate layer by a bar coater, and heated at 120°C for 2 hours to form a surface layer with a thickness of 7 μm.

[0076] The resultant image-recording medium was refereed to as Paper 1. A coefficient μ_s of static friction was 0.46 on the surface of the Paper 1, when measured in accordance with JIS (Japanese Industrial Standards) P8147 (Method for determining coefficient of friction of paper and board) at 25°C and 60 % RH. A coefficient μ_s of static friction of the following Paper 2 to 5, was measured in the same manner as in the Paper 1.

(Example 2)

[0077] An image-recording medium was formed in a manner similar to the Paper 1 with exception that 0.8 g instead of 3.2 g of epoxy crosslinking agent was added so as to form the surface layer. The resultant image-recording medium was refereed to as Paper 2. A thickness of the surface layer included in the Paper 2 was 7 μm and a coefficient μ_s of static friction of the Paper 2 was 0.69 on its surface.

(Example 3)

[0078] An image-recording medium was formed in a manner similar to the Paper 1 with exception that 4 g instead of 2 g of silica fine particles were added so as to form the surface layer. The resultant image-recording medium was refereed to as Paper 3. A thickness of the surface layer included in the Paper 3 was 7 μm and a coefficient μ_s of static friction of the Paper 3 was 0.16 on its surface.

(Comparative example 1)

[0079] An image-recording medium was formed in a manner similar to the Paper 1 with exception that KM-618 (made by KURAPAY Co., LTD.) instead of KL-318 was used as a water-soluble resin and 0.2 g instead of 3.2 g of epoxy crosslinking agent was further added so as to form the surface layer. The resultant image-recording medium was refereed to as Paper 4. A thickness of the surface layer included in the Paper 4 was 7 μm and a coefficient μ_s of static friction of the Paper 4 was 0.75 on its surface.

(Comparative example 2)

[0080] An image-recording medium was formed in a manner similar to the Paper 1 with exception that 0.5 g of nonionic surface active agent (NONYPOLE 90: made by SANYO CHEMICAL INDUSTRIES, LTD) was further added so as to form the surface layer. The resultant image-recording medium was referred to as Paper 5. A thickness of the surface layer included in the Paper 5 was 7 μm and a coefficient μ_s of static friction of the Paper 5 was 0.13 on its surface.

(Evaluation)

[0081] Each of the Paper 1-5 obtained in the Examples 1-3 and Comparative examples 1,2 was evaluated as follows and the results were summarized in Table 1.

(1) Stickiness

[0082] Two sheets each of the obtained Papers 1-5 were cut out to give an A4 size sheet (297 mm long and 210 mm wide). In each of the Papers 1-5, the two sheets were piled with the surface layers of the two sheets facing opposite each other. A metal block having the area of A4 size and a weight of 10 kg was put on the two sheets so that gravity of the block was uniformly applied to the whole surface of the sheets and then kept at 30°C and 65 % RH (H/H conditions) for 12 hours. Then the piled sheets were separated by hand.

[0083] Stickiness of each Paper 1-5 was evaluated and ranked as follows. The ranks "○" and "◎" were evaluated to be good.

◎: The sheets could be separated without any problems.
○: The sheets could be separated with a tearing sound.
X: The sheets could not be separated.

(2) Passing properties

[0084] A laser beam printer (LP-1700; made by SEIKO EPSON CORPORATION) available in the market was used for printing. In each of the Papers 1 to 5, 100 sheets were set in a stocking portion in the printer and then images (printed materials) were formed on each sheet with the use of the printer. All of the 100 sheets were continuously printed. The number of the occurrence of mis-feeding was counted, until all of the sheets were printed. Passing properties of each Paper 1-5 were evaluated and ranked as follows. The ranks "○" and "◎" were evaluated to be good.

◎: No mis-feeding occurred.
○: Mis-feeding occurred 1 to 4 times.
X: Mis-feeding occurred 5 or more times.

(3) Removability of printed materials

[0085] Images (printed materials (toner)) printed on the Papers 1 to 5 were removed with the use of the cleaning apparatus 400 of Figure 4. In the case where the printed Papers 1 to 5 were immersed in water 30 for 3 minutes so as to remove the printed toner, the removability of the printed toner was evaluated in a ratio of the removed toner. The evaluation was ranked as follows.

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

[0086] The operating conditions of the cleaning apparatus 400 of Figure 4 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 water (swelling solution) 30 in the tank 22; 30°C
- A rotational speed of the brush 14; 30 cm/second
- A temperature of the drying roller 17; 110°C

Table 1

	Composition of surface				μ_s	Results of evaluation		
	Type of resin	Amount of cross-crosslinking agent*	Additive			Stickiness (1)	Passing properties (2)	Removability (3)
			Type	Amount*				
Ex.1	KL-318	20	Silica	12.5	0.46	◎	◎	◎
Ex.2	KL-318	5	Silica	12.5	0.69	○	◎	◎
Ex.3	KL-318	20	Silica	25	0.16	◎	○	◎
Com. ex.1	KM-618	1.25	Silica	12.5	0.75	X	◎	◎
Com. ex.2	KL-318	20	Silica	12.5	0.13	◎	X	◎
			Surface active agent	3.1				

* Amount of crosslinking agent and additive is indicated by an amount based on 100 parts by weight of water-soluble resin.

(Example 4)

[0087] Base member: A polyethylene terephthalate (PET) sheet with a thickness of 100 μm was used as a base member.

[0088] Intermediate layer: The resin solution for an intermediate layer in Example 1 was applied onto the base member by a bar coater and dried at 120°C for 5 minutes to form an intermediate layer of 5 μm thickness.

[0089] Surface layer: A resin solution was prepared by dissolving 16 g of polyvinyl alcohol CM-318 (made by KURARAY Co., LTD.) in 184 g of water. The resin solution was added with 0.7 g of melamine-formaldehyde resin (Sumirez 613; made by Sumitomo Chemical Company, Limited), 0.6 g of ammonium chloride, and 0.2 g of polyoxyethylene nonyl phenyl ether as a surface active agent, and then stirred to prepare a resin solution for a surface layer. The resultant resin solution for a surface layer was applied onto the intermediate layer by a bar coater and heated at 120°C for 2 hours to form a surface layer of 8 μm thickness. As a result, a laminate sheet including three layers (base member, intermediate layer, and surface layer) was formed. The laminate sheet was immersed in a dispersion solution prepared by dispersing at 0.01 % by weight silica fine particles having an average particle size of 5 μm in water. Then the laminate sheet was dried so that the silica fine particles were provided to the surface of the laminate sheet at about 0.02 g/m^2. The resultant laminate sheet was refereed to as Paper 6. A coefficient μ_s of static friction of the Paper 6 was 0.59 on its surface.

(Example 5)

[0090]

Base member: EP paper (made by MINOLTA Co., LTD.) with a thickness of 100 μm was used as a base member.

Intermediate layer: The resin solution for an intermediate layer in Example 1 was applied onto the base member by a bar coater and dried at 120°C for 5 minutes to form an intermediate layer of 5 μm thickness.

Surface layer: A resin solution was prepared by dissolving 16 g of polyvinyl alcohol (KL-318: made by KURARAY Co., LTD.) in 184 g of water. The resin solution was added with 3 g of glycerol polyglycidyl ether (EX-313: made by Nagase Chemicals Ltd.) and 0.2 g of kalium hydroxide, 0.2 g of polyoxyethylene dodecyl phenyl ether of a surface active agent, and 3 g of alumina with an average particle size of 2 μm and then stirred for 5 minutes to form a resin solution for a surface layer. The resin solution for a surface layer was applied onto the intermediate layer by a bar coater, and heated at 140°C for 2 hours to form a surface layer of 10 μm thickness. As a result, a laminate sheet including three layers (base member, intermediate layer, and surface layer) was formed. The laminate sheet was immersed in a dispersion solution prepared by dispersing at 0.2 % by weight alumina fine particles having an average particle size of 2 μm in water. Then the laminate sheet was dried so that the alumina fine particles were adhered to the surface of the laminate sheet at a density of about 0.05 g/m^2. The resultant laminate sheet was referred to as Paper 7. A coefficient μ_s of static friction of the Paper 7 was 0.18 on its surface.

(Comparative example 3)

[0091] The laminate sheet including three layers obtained in the Example 5 without alumina was used as Paper 8. A coefficient μ_s of static friction of the Paper 8 was 0.77 on its surface.

(Evaluation)

[0092] Each of the Papers 6-8 obtained in the Examples 4,5 and Comparative example 3 was evaluated as follows and the results were summarized in Table 2.

(4) Removability of printed materials

[0093] Images (printed materials) were printed on the Papers 6-8 by using a laser beam printer (LP-1700; made by SEIKO EPSON CORPORATION) available in the market. The printed materials (toner) fixed on the Papers 6-8 were removed with the use of the cleaning apparatus 400 of Figure 4. When the Papers 6 to 8 were passed under from the shower device 15 to the brush 14 for 3 minutes, the removability of the printed materials was evaluated in the ratio of the removed printed materials. The evaluation was ranked as follows.

◎: 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 %

[0094] The operating conditions of the cleaning apparatus 400 of Figure 4 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 water (swelling solution) 30 in the tank 22; 30°C
- A ratio of the rotational speed of the brush 14 / paper-feeding speed; 30
- A paper-feeding speed; 1 cm/second
- A temperature of the drying roller 17; 110°C

(5) Passing properties

[0095] A copy machine (EP-1082; made by MINOLTA Co., LTD.) available in the market was used for copying under 25°C and 85 % RH. Each Paper 6 to 8 was set in a stocking portion in the copy machine and then images (printed materials) were formed. All of the 100 sheets were continuously printed. The number of the occurrence of mis-passing was counted during the continuous copying. Passing properties of each Paper 6-8 were evaluated and ranked as follows.

○: Mis-passing occurred less than 3 times.
X: Mis-passing occurred 3 or more times.

(6) Removability of printed materials after recycled

[0096] After the recycling process (copy and removal of toner) was repeated 5 times, removability was evaluated and ranked in the same manner as in the removability before recycled described in (4).

Table 2

	Initial		After recycled
	Removability (4)	Passing properties (5)	Removability (6)
Example 4	◎	○	◎
Example 5	◎	○	◎
Comparative example 3	◎	X	◎

[0097] Although the present invention has been fully described by way of examples, it is to be noted that various changes and modification will be apparent to those skilled in the art.

[0098] Therefore, unless otherwise such changes and modifications depart from the scope of the present invention, they should be construed as being included therein.

Claims

1. A recyclable image-recording medium comprising a base member and a water-swelling surface layer,
   wherein a coefficient μ_S of static friction on a surface of the water-swelling surface layer is in the range from about 0.15 to 0.70 at 25°C and 60 % RH.

2. A recyclable image-recording medium according to claim 1, wherein the water-swelling surface layer comprises a water-swelling resin formed by crosslinking a watersoluble resin with a crosslinking agent.

3. A recyclable image-recording medium according to claim 2, wherein the water-swelling surface layer contains about 1 to 150 parts by weight of inorganic fine particles having an average particle size of about 7 to 30 μm based on 100 parts by weight of the water-soluble resin.

4. A recyclable image-recording medium according to claim 2, wherein the water-swelling surface layer contains about 0.1 to 20 parts by weight of a surface active agent based on 100 parts by weight of the water-soluble resin.

5. A recyclable image-recording medium according to claim 2, wherein the croslinking agent is contained at an amount of about 0.5 to 50 parts by weight based on 100 parts by weight of the water-soluble resin.

6. A recyclable image-recording medium according to claim 2, wherein the water-soluble resin comprises a functional group having an active hydrogen atom.

7. A recyclable image-recording medium according to claim 2, wherein the crosslinking agent is water-soluble or dispersible in water.

8. A recyclable image-recording medium according to claim 1, further comprising an intermediate layer between the base member and the water-swelling surface layer.

9. A recyclable image-recording medium according to claim 8, wherein the intermediate layer contains a reactive compound having a functional group chemically bondable to a resin contained in the water-swelling surface layer.

10. A recyclable image-recording medium according to claim 9, the intermediate layer comprises at least one selected from the group consisting of acrylic resins, styrene resins, polyester resins, polycarbonate resins, vinyl acetate resins, vinyl chloride resins, and urethane resins.

11. A recyclable image-recording medium according to claim 9, wherein the reactive compound is at least one selected from the group consisting of isocyanate compounds, methylol compounds, aldehyde compounds, epoxy compounds, and aziridine compounds.

12. A recyclable image-recording medium according to any of claims 1 to 11, wherein the base member and the water-swelling surface layer have a thickness of about 30 to 200 μm and about 0.5 to 30 μm respectively.

13. A recyclable image-recording medium according to any of claims 1 to 12, further comprising fine particles, wherein the fine particles having an average particle size of about 0.1 to 20 μm are supplied on a surface of the water-swelling surface layer.

14. A recyclable image-recording medium according to claim 13, wherein an amount of the supplied fine particles is in the range from about 0.005 to 1 g/m^2.

Fig.1

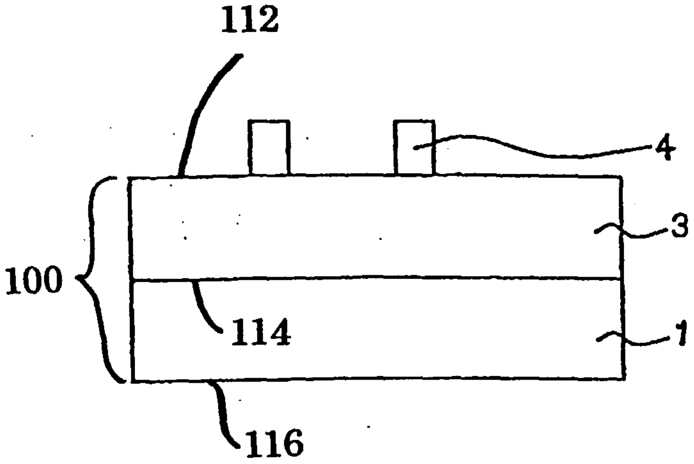
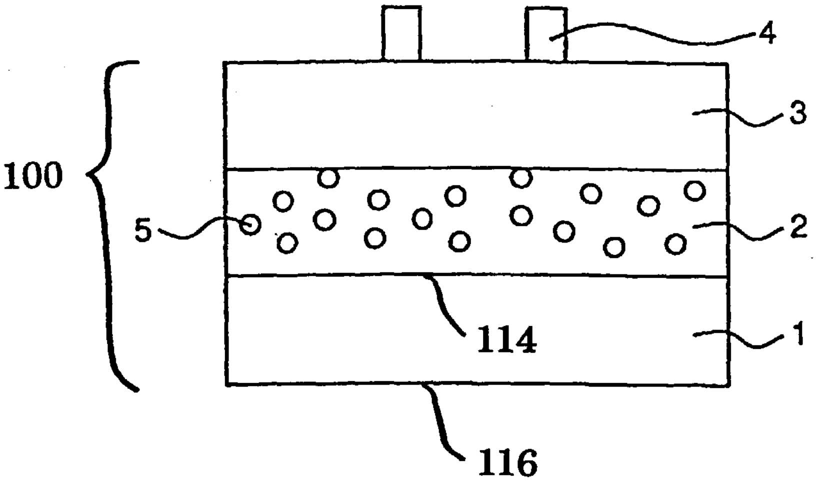


Fig.2



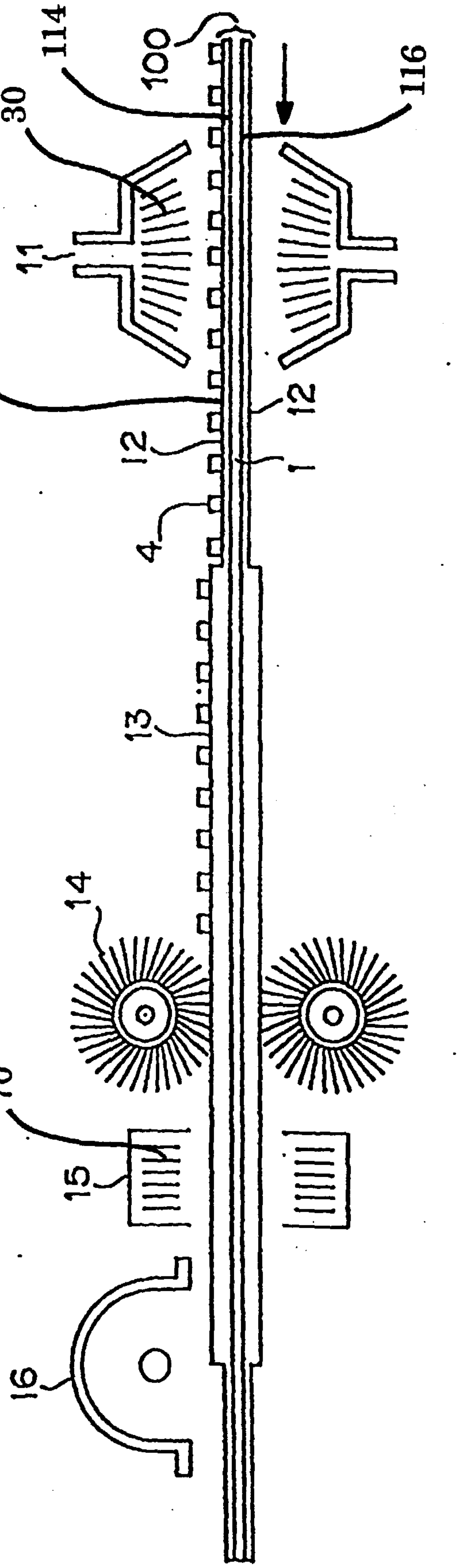


Fig.3

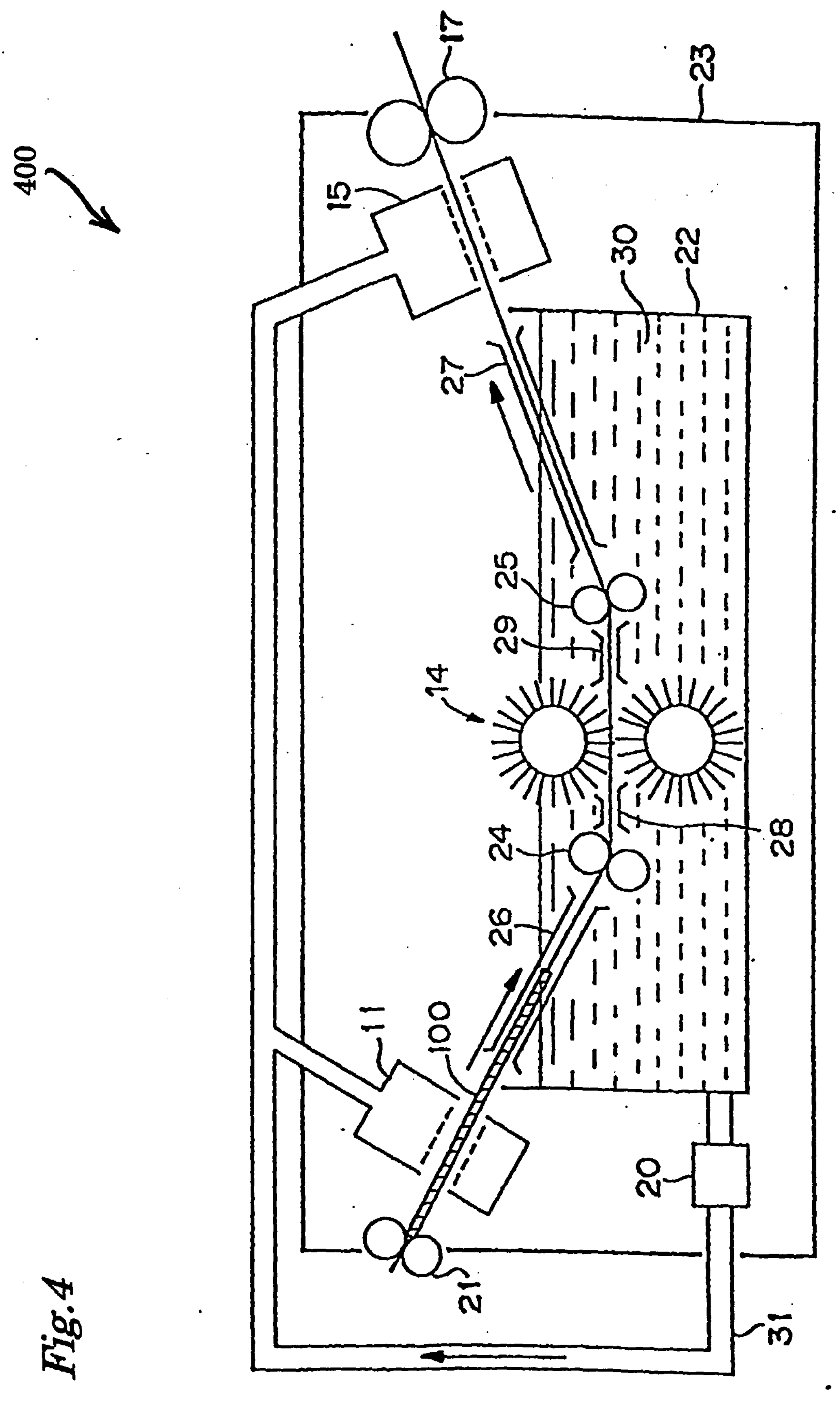


Fig.4