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(54) Thermosensitive stencil printing apparatus

(57) Provided is a printing apparatus provided with a liquid ejecting means by which a photothermal conversion material is transferred to a heat-sensitive stencil sheet to reproduce images thereon, a light irradiation means which irradiates the heat-sensitive stencil sheet with a visible or infrared ray to perforate the stencil sheet, an ink-permeable cylindrical printing drum, a heating means which heats a stencil printing ink which reversibly changes in its phase from solid state to liquid state in the printing drum, a squeeze means which internally contacts with the inner circumferential surface of the printing drum and feeds the ink to the inner surface, and a pressing means which presses at least one of the printing drum and a printing sheet, thereby to bring them into close contact with each other, so that the stencil printing ink is transferred to the printing sheet through the perforated heat-sensitive stencil sheet, wherein said liquid ejecting means further ejects a photothermal conversion material and/or a colorant onto the printing sheet, whereby images can be directly printed on the printing sheet. According to this printing apparatus, no wrinkling of the stencil sheet occurs and no failure in conveyance of the stencil sheet is caused, and prints of a small number to a large number can be efficiently obtained at a low running cost, and the resulting prints are superior in drying properties with neither set-off of ink nor seep through.

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Description

The present invention relates to a printing apparatus which can efficiently print a small to large number of copies in two printing modes and, besides, is excellent in drying characteristics of ink and causes less set-off of ink.

The "digital printing machines" have already become popular as printing machines which are high in printing speed and low in running cost. In the digital printing machines, a heat-sensitive stencil sheet composed of a thermoplastic film is molten and perforated by a heating means such as a thermal head which emits heat in the form of dots in accordance with image information of electric signals into which images such as letters, figures and photographs are transformed, then the stencil sheet is wound around a printing drum containing a stencil printing ink, and the printing ink is transferred through perforations of the stencil sheet onto a printing paper.

However, when the heat-sensitive stencil sheet is perforated in these digital printing machines, there often occur deficient perforation, failure of conveying and wrinkling of the stencil sheet due to unevenness of pressure exerted to press the stencil sheet to the thermal head. Furthermore, the conventional digital printing machines are useful to obtain a large number of the same prints, but they rather require higher cost for obtaining a small number of prints.

Under the circumstances, it is considered that printing machines are equipped with heat-sensitive recording paper or thermal transfer recording paper for obtaining a small number of prints. However, in this case, the printing machines become larger in size and, further, operation becomes complicated because both the printing paper and the recording paper must be prepared for the operation.

Furthermore, printing machines have been proposed according to which one kind of paper may be printed by electrophotographic process when a small number of prints are to be obtained or by stencil printing process using a heat-sensitive stencil sheet when a large number of prints are to be obtained. However, the printing system as a whole is expensive and is large in size.

On the other hand, when color prints are obtained by a digital printing machine, printing drums containing a stencil printing ink must be prepared for the respective colors. In partial color printing, printing drums must also be changed every one color printing. Thus, the operation is complicated and working efficiency is deteriorated.

Furthermore, conventionally employed emulsion inks for stencil printing require much time to be dried, and if printed paper is taken in hands, the ink is transferred to hands or if printed pieces of paper are superposed in continuous printing, set-off of the ink occurs, and this phenomenon is conspicuous in the case of postcard papers which are poor in permeability to ink. This is because drying of the emulsion ink is carried out only by permeation of oil phase and evaporation of water phase. In addition, such emulsion ink changes in its viscosity depending on the environmental temperature of use, and, for example, in the case of high temperature, the ink becomes soft to cause seep through and so-called side or end leakage (that is, a phenomenon of the ink leaking from edge or end portions of a stencil sheet wound around the printing drum).

The object of the present invention is to provide a printing apparatus which does not cause deficient perforation, wrinkling or failure in conveying at the time of perforation of heat-sensitive stencil sheets, can efficiently print a small to large number of copies at low running cost, and, besides, is excellent in drying characteristics of ink and can inhibit set-off or seep through of ink.

According to the present invention, the above object can be achieved by a printing apparatus which comprises

a liquid ejecting means for ejecting a photothermal conversion material contained in a liquid onto a heat-sensitive stencil sheet in accordance with image information, so that the photothermal conversion material is transferred to the stencil sheet to reproduce thereon an image based on the image information;

a light irradiation means for irradiating the heat-sensitive stencil sheet to which the photothermal conversion material has been transferred, with a visible or infrared ray to perforate the stencil sheet;

a cylindrical printing drum having an ink-permeable circumferential surface, which is rotated about a central axis thereof with the heat-sensitive stencil sheet wound around the circumferential surface;

a heating means for heating a stencil printing ink which reversibly changes in its phase from solid state to liquid state in said printing drum;

a squeeze means for internally contacting with the circumferential surface of said printing drum and feeds the ink to the surface; and

a pressing means for pressing at least one of said printing drum and a printing sheet which moves synchronously with the rotation of said printing drum, thereby to bring them into close contact with each other, so that the stencil printing ink in liquid state which is fed to the circumferential surface of said printing drum is transferred to the printing sheet through the perforated heat-sensitive stencil sheet;

wherein said liquid ejecting means further

ejects a photothermal conversion material and/or a colorant contained in a liquid onto the printing sheet in accordance with image information, whereby an image based on the image information can be directly printed on the printing sheet.

That is, the first feature of the printing apparatus of the present invention, which is different in stencil sheet perforation system from conventional rotary stencil printing apparatuses, is that it employs a method for perforating a heat-sensitive stencil sheet which comprises a first step of transferring a photothermal conversion material to a heat-sensitive stencil sheet by ejecting a liquid containing the photothermal conversion material onto the heat-sensitive stencil sheet from a liquid ejecting means and a second step of perforating the heat-sensitive stencil sheet specifically at sites to which the photothermal conversion material has been transferred, by irradiating the heat-sensitive stencil sheet with a visible or infrared ray.

The liquid ejecting means may be a device which comprises an ejecting head of nozzle, slit, porous material, porous film or the like having 10-2000 openings per inch (i.e., 10-2000 dpi) which is connected to piezoelectric elements, heating elements, liquid-conveying pumps or the like so as to eject the liquid containing the photothermal conversion material intermittently or continuously, that is, in the form of dots or lines in accordance with electric signals of letter images.

The first step can be performed, for example, by moving the ejecting head slightly spaced from a heat-sensitive stencil sheet and in parallel with the heat-sensitive stencil sheet and simultaneously controlling the liquid ejecting means so as to eject the liquid containing the photothermal conversion material onto the heat-sensitive stencil sheet from the ejecting head in accordance with image information previously converted to electric signals, and evaporating the liquid transferred to the heat-sensitive stencil sheet, thereby to reproduce the image as solid adherends mainly composed of the photothermal conversion material on the heat-sensitive stencil sheet.

In the second step, when the heat-sensitive stencil sheet to which the photothermal conversion material has been transferred is irradiated with a visible or infrared ray, the photothermal conversion material absorbs light to emit heat. As a result, the thermoplastic film of the heat-sensitive stencil sheet is molten and perforated to obtain a master directly from the stencil sheet itself. Irradiation of the stencil sheet with the visible or infrared ray can readily be carried out using xenon lamps, flash lamps, halogen lamps, infrared heaters or the like.

In this way, the present printing apparatus does not require the stencil sheet to contact any materials such as an original or a thermal head to make a master, but only requires the stencil sheet itself to be irradiated with a visible or infrared ray. Thus, no wrinkling occurs on stencil sheets in making masters.

Furthermore, in the present invention, the first and second steps mentioned above may be carried out before the heat-sensitive stencil sheet is wound around the printing drum or after the heat-sensitive stencil sheet has been wound around the printing drum. Since the present printing apparatus employs an ink which reversibly changes in its phase from solid state to liquid state, the printing apparatus is especially useful for carrying out perforation of the heat-sensitive stencil sheet in a state of being wound around the printing drum before heating and fluidizing the ink by a heating means. That is, when the ink in the cylindrical printing drum is in solid state and the ink on the outer circumferential surface of the cylindrical printing drum is still in solid state, an air layer is present between the outer circumferential surface of the cylindrical printing drum and the heat-sensitive stencil sheet wound around the printing drum, and the air layer exhibits a substantial heat insulation effect. Therefore, when the sites to which the photothermal conversion material has been transferred are irradiated with a visible or infrared ray, heat energy generated by photothermal conversion material is accumulated in the thermoplastic film, and, as a result, the thermoplastic film is heated and efficiently molten and perforated.

On the other hand, in a stencil printing machine which uses an ink which is liquid at room temperature, when the heat-sensitive stencil sheet is wound around the cylindrical printing drum, the space between the outer circumferential surface of the printing drum and the heat-sensitive stencil sheet is filled with the liquid ink and no air layer is formed in the space. Therefore, even if the sites to which the photothermal conversion material has been transferred are irradiated with a visible or infrared ray in this state, heat energy generated by the photothermal conversion material diffuses towards the liquid ink from the thermoplastic film, and, as a result, the temperature of the thermoplastic film does not rise, and sometimes melting and perforation are insufficiently performed.

The second feature of the present invention is that the printing apparatus is a printing apparatus which can perform printing in two modes of stencil printing and ink jet printing in which said liquid ejecting means further ejects a photothermal conversion material and/or a colorant contained in a liquid onto a printing sheet in accordance with image information previously transformed to electric signals, whereby images based on the image information can be directly printed on the printing sheet.

In such a printing apparatus, the liquid ejecting means may have a single ejecting head which can turn to different directions of the heat-sensitive stencil sheet and the printing sheet and can eject the photothermal conversion material and/or a colorant onto both the heat-sensitive stencil sheet and the printing sheet selectively, or it may have separately an ejecting head which can eject the photothermal conversion material

onto the heat-sensitive stencil sheet and an ejecting head which can eject the colorant onto the printing sheet. Furthermore, in order to make multicolor printing possible, the liquid ejecting means may have a plurality of ejecting heads each of which ejects each a colorant of a different color onto the printing sheet, or it may have a single ejecting head which can eject a plurality of colorants of different colors onto the printing sheet.

Thus, according to the present printing apparatus, a large number of copies can be printed with stencil printing by ejecting a photothermal conversion material and/or a colorant onto a heat-sensitive stencil sheet from a liquid ejecting means and perforating the stencil sheet by a light irradiation means, and a small number of copies can be simply printed by ejecting the photothermal conversion material and/or colorant directly onto the printing sheet. Therefore, both the printing of a small number of copies and that of a large number of copies can be efficiently performed only by providing one kind of printing sheet and heat-sensitive stencil sheet in the printing apparatus and controlling the liquid ejecting means in the printing appatatus. Moreover, overlay printing and multicolor printing can also be effected by ejecting a photothermal conversion material and/or a colorant in layers onto a printing sheet which has been printed by stencil printing. Furthermore, printing in black, which is frequently demanded, may be effected by stencil printing and printing in red, blue and yellow, which is not frequently demanded, may be effected by printing directly from the liquid ejecting means to increase efficiency of multicolor printing.

Photothermal conversion materials used in the present invention are those which can transform light energy into heat energy, and are preferably those efficient in photothermal conversion, for example, inorganic pigments such as carbon black, silicon carbide, silicon nitride, metal powders, and metal oxides, and, besides, organic pigments and organic dyes. Carbon black includes furnace black, channel black, lampblack, acetylene black and oil black. Among organic dyes, particularly preferred are those having a high light-absorbency within a specific range of wavelength, such as anthraquinone, phthalocyanine, cyanine, squalirium and polymethine dyes.

Colorants used in the present invention may be the same as the photothermal conversion materials if the photothermal conversion materials have colors. Examples of the colorants are organic or inorganic pigments such as carbon black, Phthalocyanine Blue, Victoria Blue, Brilliant Carmine 6B, Permanent Red F5R, Rhodamine Lake B, Benzidine Yellow, Hansa Yellow, Naphthol Yellow, titanium oxide, and calcium carbonate, and azo, anthraquinone, quinacridone, xanthene and acridine dyes.

The liquid in which the photothermal conversion material and the colorant are contained, may be solvents such as aliphatic hydrocarbons, aromatic hydrocarbons, alcohols, ketones, esters, ethers, aldehydes, carboxylic acids, amines, low molecular weight heterocyclic compounds, oxides, and water. Specific examples thereof are hexane, heptane, octane, benzene, toluene, xylene, methyl alcohol, ethyl alcohol, isopropyl alcohol, n-propyl alcohol, butyl alcohol, ethylene glycol, diethylene glycol, propylene glycol, glycerin, acetone, methyl ethyl ketone, ethyl acetate, propyl acetate, ethyl ether, tetrahydrofuran, 1,4-dioxane, formic acid, acetic acid, propionic acid, formaldehyde, acetaldehyde, methylamine, ethylenediamine, dimethylformamide, pyridine, and ethylene oxide. These liquids may be used alone or in combination, and are preferably those which evaporate quickly after having been ejected from the liquid ejecting means onto the heat-sensitive stencil sheet. To the liquid, may be added dyes, pigments, fillers, binders, hardening agents, preservatives, wetting agents, surfactants, pH-adjusting agents, or the like, as required.

Thus, compositions for perforating heat-sensitive stencil sheets or coloring can be prepared by appropriately dispersing or mixing the above photothermal conversion material and/or colorant in the above liquid in a form readily ejectable from the liquid-ejecting means.

The heat-sensitive stencil sheet may be a stencil sheet to at least one side of which the photothermal conversion material can be transferred and which can be molten and perforated by heat emitted by the photothermal conversion material. The stencil sheet may be made of a thermoplastic film only, or may be a thermoplastic film laminated to a porous substrate.

The thermoplastic film includes a film made from polyethylene, polypropylene, polyvinyl chloride, polyvinylidene chloride, polyethylene terephthalate, polybutylene terephthalate, polystyrene, polyurethane, polycarbonate, polyvinyl acetate, acrylic resins, silicone resins, and other resinous compounds. These resinous compounds may be used alone, in combination, or as a copolymer. Suitable thickness of the thermoplastic film is 0.5 - 50 μm, preferably 1 - 20 μm. If the film is less than 0.5μm in thickness, it is inferior in workability and strength. If the film is greater in thickness than 50 μm, it is not economical to be perforated requiring a great amount of heat energy.

The above porous substrate may be a thin paper, a nonwoven fabric, a gauze or the like, which is made from natural fibers such as Manila hemp, pulp, Edgeworthia, paper mulberry and Japanese paper, synthetic fibers such as of polyester, nylon, vinylon and acetate, metallic fibers, or glass fibers, alone or in combination. Basis weight of these porous substrates is preferably 1 - 20 g/m^2, more preferably 5 - 15 g/m^2. If it is less than 1 g/m^2, the stencil sheet is weak in strength. If it is more than 20 g/m^2, the stencil sheet is often inferior in ink permeability upon printing. Thickness of the porous substrate is preferably 5 - 100 μm, more preferably 10 - 50 μm. If the thickness is less than 5 μm, the stencil sheet is weak in strength. If it is more than 100 μm, the stencil sheet is often inferior in ink permeability in printing.

The heat-sensitive stencil sheet used in the present

invention preferably has a liquid absorbing layer laminated to a side of the stencil sheet to which the liquid is ejected, in order to prevent the liquid from blurring on the stencil sheet or to accelerate drying of the liquid on the stencil sheet. In this case, perforations faithful to the image information are obtained when a stencil sheet is irradiated with light, and thus sharp image can be printed.

The liquid absorbing layer is preferably formed on the outermost surface of the heat-sensitive stencil sheet as a resin layer which is molten and perforated similarly to the thermoplastic film upon irradiation with light to obtain a master. The liquid absorbing layer can be made of any materials so long as they can prevent the liquid from spreading in a planar direction and fix the photothermal conversion material on the stencil sheet. Preferably, the liquid absorbing layer is made of a material high in affinity with the liquid used. For example, if the liquid is aqueous, the liquid absorbing layer can be made of polymer compounds such as polyvinyl alcohol, methyl cellulose, carboxymethyl cellulose, hydroxyethyl cellulose, polyvinyl pyrrolidone, ethylene-vinyl alcohol copolymers, polyethylene oxide, polyvinyl ether, polyvinyl acetal, and polyacrylamide. These resinous compounds may be used alone, in combination or as a copolymer. If the liquid is an organic solvent, the liquid absorbing layer can be made of polymer compounds such as polyethylene, polypropylene, polyisobutylene, polystyrene, polyvinyl chloride, polyvinylidene chloride, polyvinyl fluoride, polyvinyl acetate, acrylic resins, polyamide, polyimide, polyester, polycarbonate, and polyurethane. These resinous compounds may be used alone, in combination, or as a copolymer.

Further, organic or inorganic particulates may be added to the liquid absorbing layer. Such particulates include organic particulates such as of polyurethane, polyester, polyethylene, polystyrene, polysiloxane, phenolic resin, acrylic resin, and benzoguanamine resin, and inorganic particulates such as of talc, clay, calcium carbonate, titanium oxide, aluminum oxide, silicon oxide, and kaolin.

The liquid absorbing layer can be obtained by coating a liquid containing the above polymer compound and, if necessary, the above particulates on a heat-sensitive stencil sheet by a coating means such as gravure coater and wire bar coater.

The third feature of the printing apparatus of the present invention is to use an ink which reversibly changes its phase from solid state to liquid state at a certain temperature as a stencil printing ink supplied into a cylindrical printing drum. Since this ink becomes liquid having a certain viscosity by a heating means at the time of stencil printing, it can be passed through perforations of stencil sheets and transferred to printing sheets. Furthermore, the liquid ink that has been transferred to a printing sheet instantaneously changes into a solid ink during conveyance of the printing sheet, and, thus, the ink can be allowed to adhere to the printing sheet and fix thereon in a short time. Accordingly, even if prints obtained by the method of the present invention is touched with hand, the hands are not stained with ink, and besides no set-off of ink occurs even if continuous printing is carried out. Furthermore, the ink used in the present invention does not permeate into printing sheets, and thus no seep-through occurs. Moreover, according to the present invention, since the ink instantaneously changes in its phase from liquid to solid, not only usual printing sheets and postcards which are poor in permeability to ink, but also films or metals can be printed.

Stencil printing inks used in the present invention are desirably printing inks having a phase-change temperature of 30 - 150°C, preferably 40 - 120°C. The solid state here means a state of ink which loses fluidity to such an extent that the ink does not stick to materials which touch the ink. The liquid state means a state of ink higher in fluidity than in the solid state, preferably, a state of ink having a viscosity of such an extent that the ink can flow through perforations of stencil sheets. The phase-change temperature of ink means a maximum temperature at which the ink can keep the above-mentioned solid state. If the phase-change temperature is too low, when the inside temperature of the printing apparatus or environmental temperature becomes lower than 30°C, the ink is fluidized to cause staining of a printing apparatus or occurrence of so-called side or end leakage. If the phase-change temperature is higher than 150°C, a heating means of large scale is needed for changing the ink from solid to liquid to often cause loss of heat energy, and a long time is required for changing the ink from solid to ink to prolong the waiting period before starting of printing.

The stencil printing ink used in the present invention can be obtained by mixing a colorant and a reversibly phase-changeable component which reversibly changes in phase from solid state to liquid state at a temperature in the range of 30 - 150° C, preferably 40 - 120°C. For example, it can be obtained by melting the reversibly phase-changeable component and mixing this component with a colorant and, if necessary, a dispersing agent.

As the reversibly phase-changeable component, mention may be made of, for example, waxes, fatty acid amides, fatty acid esters, and resins, such as carnauba wax, microcrystalline wax, polyethylene wax, montan wax, paraffin wax, candellila wax, shellac wax, oxidized wax, ester wax, beeswax, Japan wax, spermaceti, stearic acid amide, lauric acid amide, behenic acid amide, caproic acid amide, palmitic acid amide, low molecular polyethylene, polystyrene, α-methylstyrene polymer, vinyltoluene, indene, polyamide, polypropylene, acrylic resin, alkyd resin, polyvinyl acetate, ethylene-vinyl acetate copolymer, and vinyl chloride-vinyl acetate copolymer.

The colorants include, for example, organic or inorganic piqments such as furnace carbon black, lamp-

black, Cyanine Blue, Lake Red, Cyanine Green, titanium oxide, and calcium carbonate and dyes such as of azo, anthraquinone and quinacridone.

As the dispersing agents, anionic, cationic and non-ionic ones can be used, and examples of them are sorbitan fatty acid esters, fatty acid monoglycerides and quaternary ammonium salts.

The stencil printing ink used in the present invention may be in a form of oil ink and W/O type emulsion. The oil ink can be prepared by dissolving and mixing the reversibly phase-changeable component, the colorant, and, if necessary, the dispersing agent. The W/O type emulsion ink can be prepared by by dissolving and mixing the reversibly phase-changeable component, the colorant, and, if necessary, the dispersing agent and emulsifying the mixture with addition of an aqueous phase component under stirring, and when the emulsion is cooled, a solid ink of W/O type is obtained. The colorant may be contained in the aqueous phase component.

The stencil printing ink is rendered liquid by heating to higher than the phase-change temperature at the time of printing, and the ink is preferably heated to such an extent that the ink has a viscosity in a range of 10 - 1,000,000 cps, preferably 100 - 100,000 cps. If viscosity of the ink at the time of printing is lower than 10 cps, this is too low and the ink is apt to leak from between the printing apparatus and an edge of a stencil sheet to cause so-called side leakage or end leakage of the ink, and, besides, the ink rapidly permeates a printing sheet from the surface to the inside to cause seep-through. If the viscosity is higher than 1,000,000 cps, the ink passes through the perforations of the perforated stencil sheet with difficulty to result in decrease of printing density and uneven printing.

The cylindrical printing drum used in the present invention may be a printing drum conventionally used for rotary stencil printing apparatuses, such as a metallic drum having pores on the circumferential surface through which inks are passed. The circumferential surface of the drum may be formed of porous members used for conventional stencil printing apparatuses, such as metallic fibers, synthetic fibers, metallic porous bodies, and polymeric porous bodies.

Furthermore, the printing apparatus of the present invention is provided with a heating means which heats the stencil printing ink fed into the printing drum and a squeeze means which internally contacts with the inner circumferential surface of the printing drum and feeds the ink to the circumferential surface of the printing drum.

The heating means may be such as directly heating the stencil printing ink or heating the squeeze means to generate heat by which the ink is heated. The heating means may be either a contact type or a non-contact type. Examples of the heating means are a nichrome wire heater, plate heater, ceramics heater, electrically conductive carbon heater, magnetic induction heater, infrared heater, halogen lamp, xenon lamp, and microwave heater.

Preferably, the heating means is arranged so as to heat the squeeze means preferentially to the ink in order to improve heating efficiency for the stencil printing ink and attain high speed printing. For example, the heating means may be provided near the squeeze means or in contact with the squeeze means, or may be housed in the squeeze means, or may be integrated with the squeeze means.

The squeeze means is provided internally contacting with the inner circumferential surface of the printing drum and acts to squeeze out of the drum the ink which has been changed in phase from solid to liquid by the heating means. Therefore, the squeeze means must be sufficiently heated at the time of printing. The squeeze means may be formed of heat resistant members comprising rigid body or elastic body, such as metallic roller, metallic pipe, plastic blade and plastic belt.

Thus, according to the present invention, a perforated heat-sensitive stencil sheet is wound around the outer circumferential surface of an ink-permeable cylindrical printing drum rotated about its axis as in the case of conventional rotary stencil printing apparatuses, and the stencil printing ink is molten by the heating means. Then, in such a state that the printing sheet is moving synchronously with rotation of the printing drum, the printing ink fed to the inner circumferential surface of the printing plate is allowed to pass through perforations of the stencil sheet and transferred to the printing sheet by the squeeze means with the assistance of a pressing means which presses at least one of the printing drum and the printing sheet to bring them into close contact. Thus, stencil printing is attained.

The pressing means is provided, for example, outside and opposite to the printing drum, and may be a press roller which presses the outer circumferential surface or may be a squeeze roller or blade which internally contacts with a flexible circumferential surface of a printing drum and expands the wall of the printing drum outwardly thereby to press the printing drum to another drum provided outside and opposite to the printing drum. This squeeze roller or blade may also serve as the squeeze means mentioned above. When an ink in liquid state is passed through perforations of a perforated stencil sheet to transfer the ink to a printing sheet by the pressing means, the stencil sheet and the printing sheet are pressed together under a pressure of 0.01 - 10 kg/cm^2, preferably 0.05 - 5 kg/cm^2 and printing is carried out for 0.001 - 10 seconds, preferably 0.005 - 5 seconds. If the pressure is lower and the time is shorter, the ink in liquid state is difficult to pass through the perforated stencil sheet, and, hence, amount of the ink transferred to the printing sheet is small to result in low printing density and uneven printing. On the other hand, if the pressure is higher and the time is longer, amount of the ink passing through the stencil sheet is large and amount of the ink transferred to the printing sheet is

increased to result in indistinct prints having blotting or blurring and to cause seep through or set-off of ink. Therefore, in the present printing apparatus, when the pressure is low, the printing time should be prolonged, and when the pressure is high, the printing time should be shortened for obtaining good prints. Hereinafter, the present invention will be explained in more detail by way of the following examples with reference to the accompanying drawings in which:

Fig. 1(a) is a sectional side view which diagrammatically shows a state in which a liquid containing a photothermal conversion material is ejected from a liquid ejecting means to a liquid absorbing layer of a heat-sensitive stencil sheet,

Fig. 1(b) is a sectional side view which diagrammatically shows a state in which a photothermal conversion material is transferred onto a heat-sensitive stencil sheet,

Fig. 1(c) is a sectional side view which diagrammatically shows a state in which a heat-sensitive stencil sheet onto which a photothermal conversion material has been transferred is irradiated with light,

Fig. 1(d) is a sectional side view which diagrammatically shows a state in which a heat-sensitive stencil sheet is perforated by irradiation with light,

Fig. 2 is a side view which schematically shows the printing drum of the printing apparatus of the present invention with circumferential devices, and

Fig. 3 is a side view which schematically shows an internal structure of an example of the printing apparatus of the present invention.

It should be construed that the following examples are presented for only illustrative purpose, and the present invention is not limited to the examples.

A mechanism of perforating a heat-sensitive stencil sheet to make a master by the apparatus of the present invention will be explained, referring to Fig. 1. Fig. 1(a) shows a heat-sensitive stencil sheet 13 of three-layer structure comprising a liquid absorbing layer 21, a thermoplastic film 22 and a porous substrate 23. Droplets of liquid 26 containing a photothermal conversion material is ejected from an ejecting head 25 of the liquid ejecting means onto the liquid absorbing layer 21 of the heat-sensitive stencil sheet 13 in a form of letter images so that the photothermal conversion material 28 is transferred onto the heat-sensitive stencil sheet 13 as shown in Fig. 1(b).

Then, when the image portions on the stencil sheet which comprise the photothermal conversion material 28 transferred and fixed are irradiated with a visible or infrared ray 31 by a light irradiation means 30 with a reflector 29 as shown in Fig. 1(c), only the fixed photothermal conversion material 28 generates heat to melt the liquid absorbing layer 21 and the thermoplastic film 22, thereby forming perforations 32 as shown in Fig. 1(d). Thus, a master is formed.

Next, a mechanism of stencil printing in the printing apparatus of the present invention will be explained, referring to an example illustrated in Fig. 2. In Fig. 2, numeral 5 indicates a cylindrical printing drum of the present invention, the outer circumferential surface of which is constituted of a porous member. The heat-sensitive stencil sheet 13 perforated as shown in Fig. 1 is wound around the outer circumferential surface of the printing drum 5 by a known method. Inside the cylindrical printing drum 5, squeeze means 51 comprising a metallic pipe is provided in contact with the inner surface of the printing drum 5 so that it can be rotated about its axis parallel to the central axis of the printing drum 5, and the squeeze means 51 is rotated in the same direction as the rotation of the printing drum at the time of rotating the drum. Heating means 52 of a halogen lamp is provided in the squeeze means 51 so as to positively heat the metallic pipe, whereby the metallic pipe can be efficiently heated with light 53. When the temperature of the outer circumference of the squeeze means 51 reaches the phase-change temperature of ink 54 used for printing, the ink 54 changes from solid state to liquid state, and the ink 54 in liquid state is forced out of the inner surface of the printing drum 5 to the outside by the squeeze means 51 at the time of rotation of the printing drum 5.

Printing sheet 14 fed synchronously with the rotation of the printing drum 5 is pressed to the heat-sensitive stencil sheet 13 on the outer circumferential surface of the printing drum 5 by press roller 6 provided outside the printing drum 5 and opposite to the squeeze means 51, whereby ink 54 is transferred onto the printing sheet 14 through the perforations of the heat-sensitive stencil sheet 13. Temperature of the transferred ink instantaneously becomes lower than the phase-change temperature, and the ink is fixed as a solid ink 55.

Next, the printing apparatus of the present invention will be explained, referring to an example illustrated in Fig. 3. Fig. 3 is a schematic side view which shows the internal structure of the printing apparatus of the present invention, and printing drum 5 is placed inside the casing C. The printing drum 5 has the same construction as shown in Fig. 2, and a rotatable metallic pipe which contacts with the inner surface of the drum is provided inside the drum as squeeze means 51. The squeeze means 51 is provided with a heating means 52 comprising a halogen lamp and is positively heated by the lamp. The heated squeeze means 51 heats and fluidizes the phase-changeable ink in the printing drum 5 and simultaneously squeezes the ink out of the printing drum 5 at the time of rotation of the printing drum 5. Furthermore, a press roller 6 which can move up and down so as to touch to or be detached from the outer surface

of the printing drum 5 is provided just below the printing drum 5 at the position opposite to the metallic pipe of the squeeze means 51. A clamping means 55 which clamps one end portion of the stencil sheet wound around the outer circumferential surface of printing drum 5 and which can be opened and closed is provided at a part of the outer circumferential surface of the printing drum 5.

The printing drum 5 is rotated counterclockwise as shown in Fig. 3, and a paper feeding tray 8 for printing sheets 14 is provided on the left side of the casing C. A paper feeding means 11 which comprises a pair of rollers between which an endless belt is stretched and which feeds one by one printing sheets 14 on the paper feeding tray 8 towards the printing drum 5 is provided above the paper feeding tray 8. Adjacent to the paper feeding means 11, there is provided a paper feeding timing rollers 12a comprising a pair of the upper and lower rollers which feed printing sheets 14 delivered from the paper feeding means 11 to between printing drum 5 and press roller 6 with timing to the rotation of printing drum at printing. On the right side of the printing drum 5, there are provided paper discharging rollers 12b comprising a pair of the upper and lower rollers which carry printed sheets 15 delivered after printed between the printing drum 5 and the press roller 6 to paper discharging tray 9 disposed on the right side of casing C.

In Fig. 3, a cover S is provided above the casing C, and an image sensor 1 is provided on the back side of the cover S. An original feeding roller 19 is provided opposite to the image sensor 1 and on the upper surface of the casing C, so that an original is fed between the original feeding roller 19 and the image sensor 1 from the outside of the cover S to scan the images on the original and transform them into image information of electric signals. In the casing C, a roll of heat-sensitive stencil sheet 13 is placed below the original feeding roller 19 and supported in a state of being rotatable about an axis by a suitable stencil sheet holding means. In order to carry the heat-sensitive stencil sheet therefrom toward the printing drum 5, there are provided stencil sheet feeding rollers 10 comprising a pair of the upper and lower opposing rollers. On the opposite side of the printing drum 5, a stencil sheet disposal box 7 is provided for disposal of the stencil sheet after use. Furthermore, a cutter 20 which cuts the heat-sensitive stencil sheet upon completion of carrying of the heat-sensitive stencil sheet for one printing to the printing drum 5 is provided between the printing drum 5 and the stencil sheet feeding roller 10.

According to the present invention, in the printing apparatus of Fig. 3, in order to eject the photothermal conversion material onto the heat-sensitive stencil sheet, for example, an ejecting head as shown by 2a of the liquid ejecting means can be provided being directed to the stencil sheet 13 and near the stencil sheet carrying route A on which the stencil sheet 13 is carried to the printing drum 5, and, besides, the ejecting head as shown by 2b can be provided being directed to the printing drum 5.

Furthermore, in order to perforate a stencil sheet to make a master by the printing apparatus shown in Fig. 3, for example, a light irradiation means as shown by 4a can be provided being directed to the stencil sheet and near the stencil sheet carrying route A on which the stencil sheet 13 is carried to the printing drum 5. Alternatively, the light irradiation means as shown by 4b can be provided being directed to the printing drum 5.

Moreover, in order to directly print the image on the printing sheet 14 by the printing apparatus shown in Fig. 3, an ejecting head as shown by 3a of the liquid ejecting means can be provided downstream the printing drum 5 and being directed to the printing sheet on the printing sheet carrying route B. Alternatively, an ejecting head as shown by 3b can be provided upstream the printing drum 5 and being directed to the printing sheet on the printing sheet carrying route B.

In the printing apparatus shown in Fig. 3, the liquid ejecting means may have one or both of the ejecting heads 2a and 2b for the perforation of the heat-sensitive stencil sheet, and may have one or both of the ejecting heads 3a and 3b for the direct printing on the printing sheet. Furthermore, for example, if the direction of the ejecting head 2b can be turned to the printing drum and the printing sheet, and both the perforation of the heat-sensitive stencil sheet and the direct printing on the printing sheet can be performed only by a single ejecting head 2b.

In order to directly duplicate an original by the printing apparatus of Fig. 3, the original is inserted below the cover S, and while the original is being fed by the original feeding roller 19, images on the original are scanned by the image sensor 1 and transformed into image information of electric signals, and movement of the ejecting head and ejection of the liquid are controlled based on the image information, whereby the images can be reproduced on the stencil sheet or the printing sheet. It is also possible to reproduce the images by controlling the operation of the ejecting head directly by a personal computer (not shown) based on the image information stored therein.

Printing of a small number of copies on printing sheet 14 is carried out in the following manner. Printing drum 5 and press roller 6 are detached from each other, and during the printing sheet 14 on the paper feeding tray 8 being carried by the paper feeding means 11 and the paper feeding timing roller 12a and the paper discharging roller 12b, the liquid ejecting means is controlled so that a liquid containing a colorant and/or a photothermal conversion material is directly ejected onto the printing sheet 14 from the ejecting head 3a or 3b to reproduce images. The printed sheets 15 are stocked on the paper discharging tray 14.

In order to carry out color printing on printing sheet 14, the liquid ejecting means is provided with a plurality

of ejecting heads, and the ejecting means is controlled so that colorants of different colors are ejected from the respective ejecting heads onto the printing sheet 14. For example, two-color printing can be performed by ejecting colorants of different colors from ejecting heads 3a and 3b, respectively.

When a large number of copies are printed on printing sheets 14, while the heat-sensitive stencil sheet 13 is fed to printing drum 5 by feeding rollers 10, the liquid ejecting means is controlled so that the liquid containing the photothermal conversion material is ejected from ejecting head 2a onto the stencil sheet 13 to reproduce images, and then the stencil sheet is irradiated with a visible or infrared ray by a light irradiation means 4a to perforate the stencil sheet 13 and the perforated stencil sheet is wound around the printing drum 5. This perforation may be carried out by the irradiation with a visible or infrared ray from a light irradiation means 4b after the stencil sheet 13 is wound around the printing drum 5. Furthermore, since the heat-sensitive stencil sheet of the present invention can be perforated in the non-contact state, the perforation may be carried out in the following manner. For example, after the heat-sensitive stencil sheet 13 is wound around the printing drum 5, the liquid ejecting means is controlled so that the liquid containing the photothermal conversion material is ejected onto the stencil sheet 13 wound around the printing drum 5 to reproduce images before the phase-changeable ink in the printing drum 5 changes from solid state to liquid state by heating, and then the stencil sheet 13 is irradiated with a visible or infrared ray by the light irradiation means 4b to perforate the stencil sheet.

The printing drum 5 having the stencil sheet 13 wound around the outer circumferential surface thereof is rotated counterclockwise about its axis as shown, and simultaneously a stencil printing ink changed from solid to liquid in its phase by squeeze means 51 heated by a heating apparatus 52 is fed to the inner circumferential surface of the printing drum. Printing sheet 14 which is carried by the paper feeding means 11 and timing rollers 12a synchronously with the rotation of the printing drum is pressed against the printing drum 5 by the press roller 6, whereby the stencil printing ink which passes through the perforations of the stencil sheet 13 is transferred to the printing sheet 14 to complete printing. Then, the printing paper 14 is carried to the paper discharging tray 9 by the paper discharging rollers 12b, where it is stocked as printed paper 15 on which the ink has been dried.

In order to obtain a piece of paper which is printed by both the stencil printing and the direct printing with a liquid containing a colorant, the direct printing on the printing paper 14 is carried out by ejecting means 3a or 3b in addition to the above-mentioned stencil printing carried out by pressing the printing paper 14 against printing drum 5 by press roller 6. In this case, the liquid ejecting means may have a single ejecting head which can move to the position of the ejecting head 2a in the stencil printing and to the position of the ejecting head 3a in the direct printing, or may have a rotatable single ejecting head which can turn to the ejecting head 2b in the stencil printing and to the ejecting head 3b in the direct printing. However, it is advantageous for obtaining multicolor prints to provide a plurality of the ejecting heads. In this case, the order of printing is, for example, as follows. First, either one of the direct printing or the stencil printing is carried out on printing paper 14, the printed paper is stocked on the paper discharging tray 9 as printed paper 15, this paper 15 is again placed on the paper feeding tray 8, and then another printing is carried out on the paper 15. If the direct printing is carried out by ejecting heads 3a and/or 3b before and/or after printing paper 14 is stencil-printed by the printing drum 5, both the stencil printing and the direct printing can be performed during one step of the printing paper 14 being carried from the paper feeding tray 8 to the paper discharging tray 9.

According to the present invention, there is no need to allow the heat-sensitive stencil sheet to contact with any matters such as originals and thermal heads, and the heat-sensitive stencil sheet can be merely irradiated with a visible or infrared ray. Therefore, no wrinkling of the stencil sheet occurs and no failure in conveyance of the stencil sheet is caused.

Moreover, since printing of a large number of copies can be carried out by stencil printing and that of a small number of copies can be carried out by direct printing on printing paper, it is sufficient to provide only one kind of printing paper and a heat-sensitive stencil sheets in the printing apparatus as in conventional rotary stencil printing apparatuses, and, thus, an efficient printing can be performed by one small printing apparatus at a low running cost.

Furthermore, since an ink which can reversibly change in its phase from solid to liquid by heating is used, clear prints with neither set-off of ink nor seep through can be obtained. In addition, because the ink spontaneously changes from liquid to solid on the prints, not only usual printing paper, but also plastic films or metal sheets can be printed.

Furthermore, overlay printing and multicolor printing can also be performed by carrying out direct printing on printing paper which has been stencil-printed. The present invention can also be applied to color printing.

Claims

1. A printing apparatus comprising

   a liquid ejecting means for ejecting a photothermal conversion material contained in a liquid onto a heat-sensitive stencil sheet in accordance with image information, so that the photothermal conversion material is transferred to the stencil sheet to reproduce thereon an image based on the image information;

a light irradiation means for irradiating the heat-sensitive stencil sheet to which the photothermal conversion material has been transferred, with a visible or infrared ray to perforate the stencil sheet;

a cylindrical printing drum having an ink-permeable circumferential surface, which is rotated about a central axis thereof with the heat-sensitive stencil sheet wound around the circumferential surface;

a heating means for heating a stencil printing ink which reversibly changes in its phase from solid state to liquid state in said printing drum;

a squeeze means for internally contacting with the circumferential surface of said printing drum and feeds the ink to the surface; and

a pressing means for pressing at least one of said printing drum and a printing sheet which moves synchronously with the rotation of said printing drum, thereby to bring them into close contact with each other, so that the stencil printing ink in liquid state which is fed to the circumferential surface of said printing drum is transferred to the printing sheet through the perforated heat-sensitive stencil sheet;

wherein said liquid ejecting means further ejects a photothermal conversion material and/or a colorant contained in a liquid onto the printing sheet in accordance with image information, whereby an image based on the image information can be directly printed on the printing sheet.

2. A printing apparatus according to claim 1, wherein said liquid ejecting means has a single ejecting head which can turn to a direction of the heat-sensitive stencil sheet and a direction of the printing sheet to eject the photothermal conversion material and/or the colorant onto the heat-sensitive stencil sheet and the printing sheet selectively.

3. A printing apparatus according to claim 1, wherein said liquid ejecting means has a plurality of ejecting heads which eject colorants of colors different from one another onto the printing sheet to perform multicolor printing.

4. A printing apparatus according to claim 1, wherein the heat-sensitive stencil sheet comprises a thermoplastic film and a liquid absorbing layer provided thereon, the photothermal conversion material is ejected onto the liquid absorbing layer, and the heat-sensitive stencil sheet is irradiated with light by the light irradiation means to perforate the thermoplastic film.

5. A printing apparatus according to claim 1, wherein said heating means heats said squeeze means and the ink is heated with heat generated by said squeeze means.

6. A printing apparatus according to claim 1, wherein the stencil printing ink reversibly changes in its phase from solid state to liquid state at a temperature of 30-150°C.

7. A printing apparatus according to claim 1, wherein the stencil printing ink reversibly changes in its phase from solid state to liquid state at a temperature of 40-120°C.

FIG. 1A

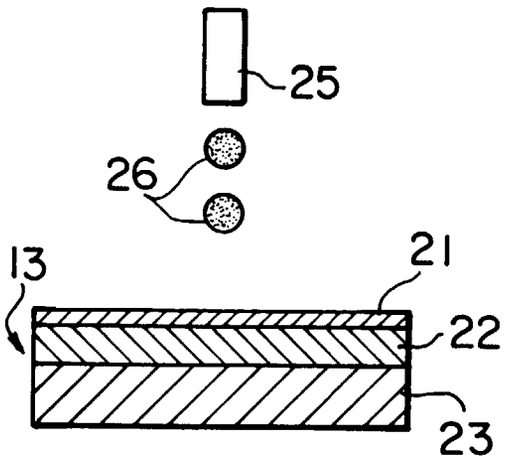


FIG. 1B

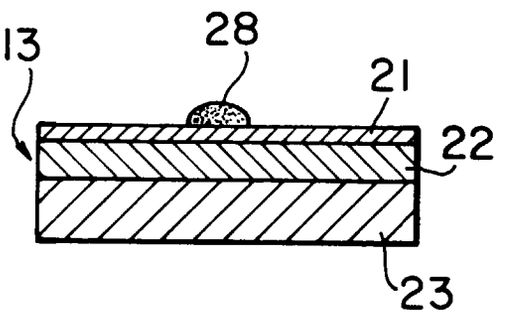


FIG. 1C

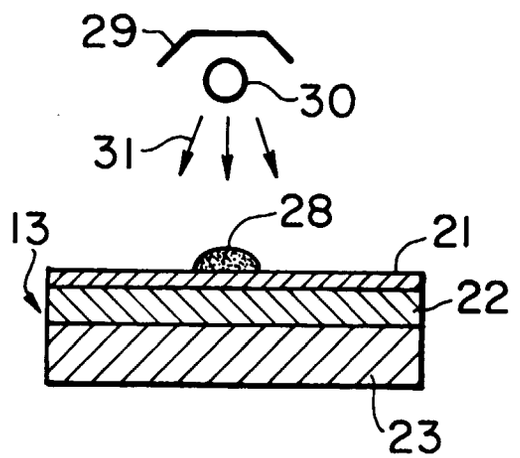


FIG. 1D

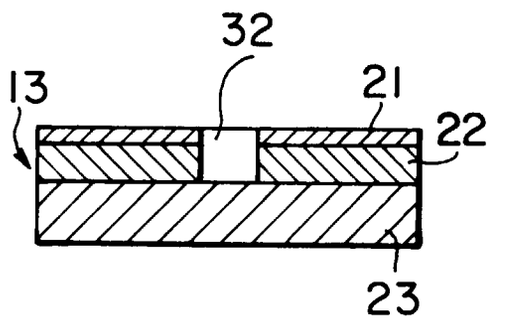


FIG. 2

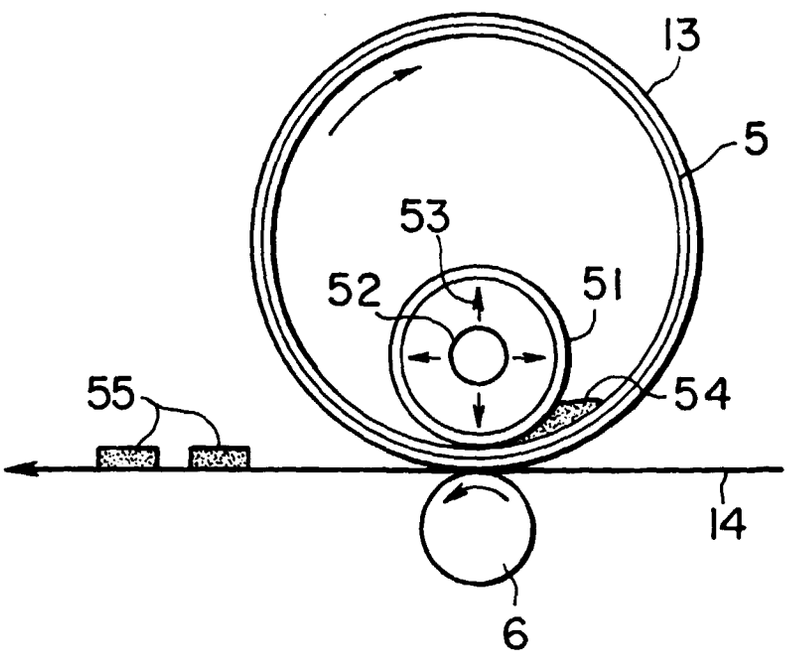
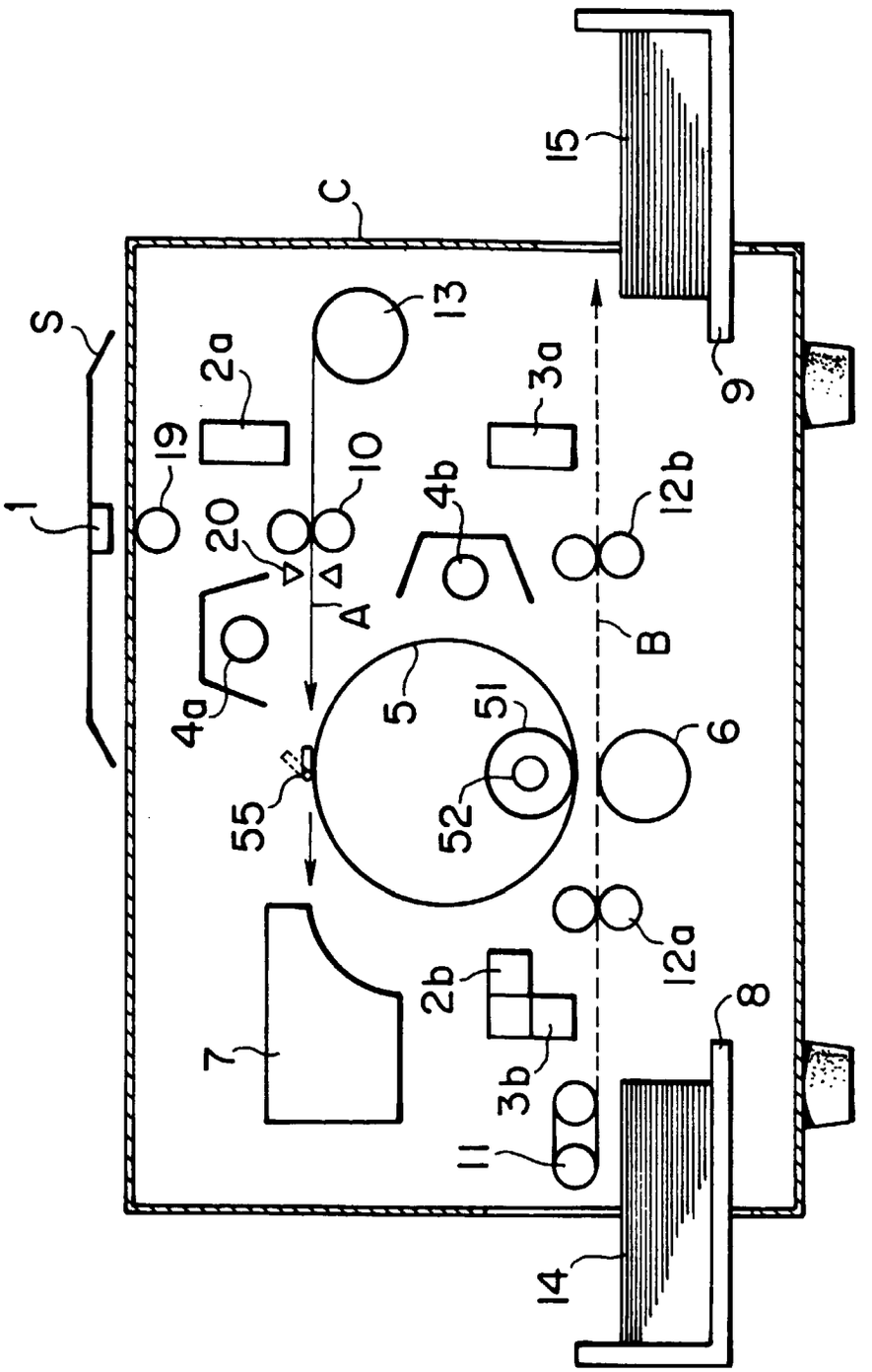


FIG. 3



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 10 5246

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	FR 2 206 704 A (AGFA-GEVAERT AKTIENGESELLSCHAFT) 7 June 1974 * page 2, line 6 - line 34 * * claims 1-6; examples 1-4 *	1-7	B41L13/06 B41C1/14
A	EP 0 635 362 A (RISO KAGAKU CORPORATION) 25 January 1995 * page 2, line 45 - page 4, line 15 * * claims 1-6; examples 1-9 * * figures 1-7 *	1-7	
A	EP 0 710 552 A (RISO KAGAKU CORPORATION) 8 May 1996 * column 2, line 13 - line 45 * * column 3, line 34 - column 6, line 29 * * claims 1-7; figures 2,3 *	1-7	
P,X	EP 0 771 647 A (RISO KAGAKU CORPORATION) 7 May 1997 * column 1, line 56 - column 3, line 9 * * column 3, line 30 - line 44 * * column 7, line 1 - line 22 * * column 8, line 2 - column 11, line 47 * * claims 1-8; figures 1,2 *	1-7	TECHNICAL FIELDS SEARCHED (Int.Cl.6) B41C B41L B41M
P,A	EP 0 767 053 A (RISO KAGAKU CORPORATION) 9 April 1997 * column 1, line 53 - column 2, line 46 * * column 3, line 15 - line 37 * * column 5, line 33 - column 6, line 9 * * claims 1-13; figure 1; example 1 *	1-7	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	10 June 1998	Bacon, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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