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(54) PRINTING METHOD AND DEVICE USING ENERGY-CURABLE INKS FOR A FLEXOGRAPHIC PRINTER

(57) The invention relates to a device and printing method using energy-curable inks for a flexographic printer. The device comprises printing units (21) to wet-on-wet print energy-curable inks on a substrate (23), and at least one energy emission unit (22) for curing the inks printed on the substrate (23) downstream of said printing units (21). Each printing unit (21) comprises an ink application chamber (13) for applying ink to an inking roller (11) arranged for inking a printing roller (12). For each printing unit (21) there are means for periodically adjusting the ink to predetermined values of viscosity, evaporability and temperature, means for supplying ink to the chamber (13), and auxiliary means associated to the chamber (13) for contributing to remove ink remaining in surface pits of the inking roller (11) and to filling them with fresh ink.

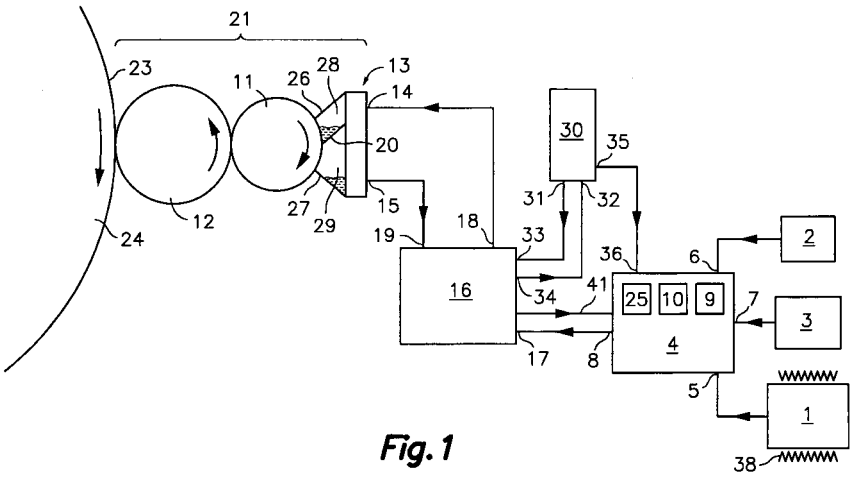

Fig. 1

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Description

Technical Field

[0001] The present invention relates to a printing device and a printing method using energy-curable inks for a flexographic printer.

State of the Prior Art

[0002] Patents US-A-6284816, US-A-6727295 and EP-A-1133533, to Sun Chemical Corporation, disclose energy-curable flexographic printing inks, with a detailed description of the components integrating them. According to another aspect, these patents disclose a printing method combining the use of the mentioned energy-curable ink with two printing process steps, namely: printing the energy-curable ink on a substrate to obtain an image; and subjecting said image to actinic radiation or thermal energy, such as an electron beam or ultraviolet radiation. An essential feature of these energy-curable inks is that they include a low solvent content and therefore have a relatively high viscosity compared to other conventional inks, but sufficiently low to flow suitably, having low odor and good adhesion.

[0003] These features of the energy-curable inks allows implementing a printing technique known as wet-on-wet printing, which consists of consecutively printing with several printing units different colors superimposed on one and the same substrate and subsequently carrying out a single curing operation, for example using an electron beam, downstream of the printing units. As it is not necessary to cure each color before printing the next color, higher printing speeds can be achieved. Energy-curable inks can be water-soluble and the use of an evaporability modifying agent, such as ammonia, to improve the drying capacity of the ink once it has been printed, as well as the capacity to withstand a subsequent wet-on-wet printing without the colors running, is known.

[0004] However, the high viscosity of these inks is a drawback when applying the ink to an inking roller of the printing unit, also known as screen roller or anilox roller. The mentioned screen roller usually comprises a surface provided with pits which must be filled with fresh ink by an ink application chamber in each rotation of the roller. The excess ink from a previous turn remains often housed in the pits, making it difficult to fill them with fresh ink. The viscosity level is furthermore critical for obtaining a good print, which involves the need to have equipment for controlling the viscosity of the ink which is supplied to the ink application chamber.

[0005] For another matter, patent EP-A-0350839 describes a printing system comprising an ink application chamber partly delimited by an upper doctor blade and a lower doctor blade, both of them in contact with the pitted surface of the inking roller, as is conventional. The chamber has an ink inlet and an ink outlet whereby the ink is circulated through the chamber wetting the pitted surface of the inking roller. The chamber includes, as a main feature, a third additional doctor blade located under the chamber between the upper and lower doctor blades. This third additional doctor blade has a longitudinal edge close to the pitted surface of the inking roller but which does not touch it, and the chamber works completely full of ink.

[0006] Patent DE-A-3614582 discloses an ink application device including three doctor blades in contact with the pitted surface of the inking roller, although only two of them form the ink application chamber and the third one is outside, downstream of the chamber.

[0007] For another matter, patent US-A-4552165 describes a method and a device for supplying ink to a printing device and for maintaining the density of a printed color constant. It comprises detecting the light reflected from a printed mark to provide a correction signal which is combined with a viscosity code signal obtained by means of a viscosimeter located at a specific point of a tank containing a mixture of printing solvent and ink to generate control signals for controlling valves of an ink and solvent mixer. The density of the printing ink is thus adjusted according to the density of the printed color.

[0008] Patent US-A-5330576 describes a recirculating coating liquid supply system for a coating apparatus. It includes a tank containing a mixture of coating liquid and a pumping device for circulating the mixture through a main line and a return line. A viscosimeter is connected to measure the viscosity of the mixture flowing through the main line, and viscosity adjustments are made by adding accurate amounts of base coating liquid or thinner to the main line.

[0009] Patent US-A-5772787 describes a method for cleaning and maintaining viscosity and pH measuring devices for water-based flexo inks. The mentioned viscosity and pH measuring devices are introduced in a tank containing the ink for carrying out the corresponding measurements and then they are removed and submersed in a tank of cleaning fluid. The result of the measurements is used to know the ink conditions and determine viscosity and pH adjustments to be carried out manually by the addition of components.

[0010] An objective of the present invention is to a provide a printing device and method for a flexographic printer suitable for the use of energy-curable inks with a relatively high viscosity, including a control of the viscosity and other attributes of the ink mixtures to be supplied to the printing units and an improved mechanical device to assure the application of the ink mixture to the inking roller in each printing unit.

Disclosure of the Invention

[0011] According to a first aspect, the present invention provides a printing device using energy-curable inks for a flexographic printer, of the type comprising at least one printing unit adapted to print an energy-curable printing ink on a substrate web supported on at least one coun-

terpressure roller, and at least one energy emission unit to direct energy towards said substrate web for the purpose of curing the printing inks printed on said substrate web. The printing unit comprises an ink application chamber adapted to apply the printing ink to a pitted surface of an inking roller arranged to ink in turn a printing roller, supply means for supplying printing ink to the corresponding ink application chamber being included for each printing unit. The device of the present invention is characterized in that it comprises adjustment means for periodically adjusting the printing ink to predetermined values of viscosity, evaporability and temperature before the printing ink is supplied to the ink application chamber; and auxiliary inking means associated to said ink application chamber to contribute to removing printing ink remaining in pits of said pitted surface of the inking roller and to filling them with fresh printing ink.

[0012] The mentioned adjustment means comprise a mixer connected to receive through an inlet the energy-curable ink coming from an ink tank, and to further receive through other respective inlets at least a solvent coming from a solvent tank, and an evaporability modifying agent coming from an evaporability modifying agent tank containing same. The mixer comprises at least a viscosimeter in cooperation with control means and valve means for periodically determining and adding, if necessary, a measured amount of solvent to said printing ink to adjust the viscosity of the printing ink to a predetermined value, an evaporability measuring device in cooperation with control means and valve means for determining and adding if necessary, a measured amount of evaporability modifying agent in the printing ink to adjust the evaporability of the printing ink to a predetermined value, and a thermostat in cooperation with control means and heating-cooling means for heating or cooling, as appropriate, the printing ink until adjusting the temperature of the printing ink to a predetermined value. The mixer is adapted to supply the printing ink, once it has been adjusted, through an outlet.

[0013] The periodicity with which the physical conditions of the printing ink, i.e. viscosity, evaporability and temperature, are controlled and adjusted is short enough to be considered a continuous control, which assures that the physical conditions of the printing ink supplied to the ink application chamber are indeed those stipulated by the manufacturer of the energy-curable ink.

[0014] The ink application chamber is partly delimited, as is conventional, by an upper doctor blade and a lower doctor blade arranged in contact with the pitted surface of the inking roller. The mentioned auxiliary inking means, characteristic of the device of the present invention, comprise at least one additional doctor blade located inside the ink application chamber and arranged between both upper and lower doctor blades mentioned above. This additional doctor blade has a longitudinal edge in contact with the pitted surface of the inking roller and elastically pressed against it. The inking roller is actuated to rotate in a direction such that its pitted surface enters the mixture application chamber through the upper doctor blade and leaves the mixture application chamber through the lower doctor blade. The upper doctor blade and the additional doctor blade are arranged in favor of the mentioned rotating direction of the inking roller, whereas the lower doctor blade is arranged against the rotating direction of the inking roller.

[0015] With this arrangement, the additional doctor blade divides the ink application chamber into an upper cavity communicated with an inlet through which it receives the recirculating printing ink, and a lower cavity communicated with an outlet through which the recirculating printing ink is discharged. Both the upper and lower cavities are communicated with one another through passageways through which the printing ink can pass from the upper cavity to the lower cavity. The openings of the mentioned passageways are located in the upper cavity at a height determining a maximum level of printing ink in the upper cavity. In a similar way, the mentioned outlet has at least one opening in the lower cavity determining a maximum level of printing ink in the lower cavity. The mentioned supply means are further adapted to recirculate the printing ink through the ink application chamber at a suitable flow rate so that the maximum levels of ink in the upper and lower cavities of the ink application chamber do not exceed their maximum levels, such that the upper and lower cavities are only partially filled with printing ink during the operation. The mentioned passageways between the upper and lower cavities have optionally associated thereto valve means which can be selectively actuated to interrupt or allow, or even regulate, the passage of printing ink from the upper cavity to the lower cavity through the passageways, to thus better control the level of ink in the upper and lower cavities of the ink application chamber.

[0016] With this construction, the additional doctor blade acts as a spatula acting to apply the printing ink accumulated in the upper cavity against the pitted surface of the inking roller. Given the relatively high viscosity of the energy-curable printing ink, this spatula action of the additional doctor blade contributes to removing any residue of printing ink remaining in the pits of the pitted surface of the inking roller and to filling them again with fresh printing ink.

[0017] The supply means comprise pumping equipment connected to a recirculation circuit to recirculate the printing ink through the ink application chamber. The recirculation circuit includes a supply line from the pumping equipment to the ink application chamber and a return line from the ink application chamber to the pumping equipment, and the pumping equipment includes at least two pneumatic diaphragm pumps, one pump for driving the ink through the supply line and the other pump for suctioning the ink through the return line. The mixer can be located outside said recirculation circuit, in which case its outlet is connected to an inlet of the pumping equipment through a mixture feed line, or it can be placed in said supply line of the recirculation circuit, in which case

the ink coming from the ink tank is supplied directly to the pumping equipment by means of a feed line and a recirculation outlet of the pumping equipment is connected to the ink inlet of the mixer, and the outlet of the mixer is connected to the inlet of the ink application chamber.

[0018] The device of the present invention can include two or more printing units arranged to consecutively wet-on-wet print on the substrate web, in which case the ink is cured downstream of said printing units. Each printing unit is obviously equipped with its own supply means, adjustment means and auxiliary inking means.

[0019] According to another aspect, the present invention provides a printing method using energy-curable inks for a flexographic printer, of the type comprising the steps of printing an energy-curable printing ink on a substrate web supported on at least one counterpressure roller by means of at least one printing unit, and curing the printing ink printed on said substrate web by means of at least one energy emission unit arranged to direct energy towards said substrate web. The mentioned step of printing comprises supplying by means of supply means said printing ink to a corresponding ink application chamber adapted to apply the printing ink to a pitted surface of an inking roller arranged to ink in turn a corresponding printing roller. The method according to the present invention is characterized in that it comprises the steps of periodically adjusting the printing ink to predetermined values of viscosity, evaporability and temperature before the printing ink is supplied to the ink application chamber, and contributing to remove the printing ink remaining in pits of said pitted surface of the inking roller and to filling them with fresh printing ink by auxiliary inking means associated to the ink application chamber.

[0020] With the method of the present invention, the printing ink can be effectively supplied to the ink application chamber with the physical conditions stipulated by the manufacturer of the energy-curable ink, and the printing ink can be applied to the pitted surface of the inking roller in a manner according to its relatively high viscosity.

Brief Description of the Drawings

[0021] The previous and other advantages and features will be more fully understood from the following detailed description of some exemplary embodiments with reference to the attached drawings, in which:

Figure 1 is a schematic diagram showing a printing device and method using energy-curable inks for a flexographic printer according to an embodiment of the present invention;

Figure 2 is a schematic cross-sectional view of an ink application chamber of the device of Figure 1 applied to an inking roller;

Figure 3 is a very schematic side view showing a flexographic printer with a central drum with several printing units, to which the device and the method of Figure 1 can be applied; and

Figure 4 is a schematic diagram showing a printing device and method using energy-curable inks for a flexographic printer according to another embodiment of the present invention.

Detailed Description of Exemplary Embodiments

[0022] With reference first to Figure 1, it shows the elements forming the printing device using energy-curable inks for a flexographic printer according to an embodiment of the present invention. The scheme of Figure 1 is also useful for explaining the method of the present invention.

[0023] Figure 3 schematically shows a flexographic printer with a central drum to which the device of Figure 1 is applied by way of example. The mentioned flexographic printer comprises a rotating central drum 24 carrying out the function of a counterpressure roller for a plurality of printing units 21 arranged around it. A substrate web 23 on which the printing is to take place is arranged supported on a part of the outer surface of the central drum 24. The substrate web 23 moves in the direction indicated by arrows in Figure 3 at the same speed as the outer surface of the central drum 24, such that there is no sliding between both. The different printing units 21 are adapted to consecutively wet-on-wet print energy-curable printing inks on the substrate web 23. An energy emission unit 22 to direct energy towards said substrate web 23 is arranged downstream of all the printing units 21 for the purpose of curing the printing inks printed on said substrate web 23. The energy used by said energy emission unit 22 to cure the printing ink is an electron beam, for example.

[0024] The term "wet-on-wet" is used to designate a printing technique which consists of printing by means of a printing unit 21 an ink of one color on the ink of another color previously printed by another printing unit 21 without an intermediate curing operation, a single curing operation being carried out for all the colors superimposed downstream of the printing units 21. This is possible due to the characteristics of energy-curable printing inks allowing a fast partial drying of the ink immediately after being printed as well as a subsequent wet-on-wet printing of another ink without the colors running.

[0025] It must be indicated, for the purposes of the present invention, that the flexographic printer is not limited to a flexographic printer with a central drum, but can be any other type of flexographic printer, for example, in-line or stack flexographic printers, in which each printing unit includes its own counterpressure roller 24. Furthermore, for the purposes of the present invention, at least one printing unit 21 is sufficient, the possibility of wet-on-wet printing several inks by means of two or more printing units being optional.

[0026] Returning to Figure 1, each printing unit 21 comprises an ink application chamber 13 adapted to apply the printing ink to a pitted surface of an inking roller 11, which is arranged to ink in turn a printing plate arranged

on the surface of a printing roller 12 rotating in contact with the substrate supported on the counterpressure roller 24 so as to print an image with the printing ink. Supply means for supplying printing ink to the corresponding ink application chamber 13 are included for each printing unit 21. In one embodiment, these supply means comprise pumping equipment 16 connected to receive printing ink through an inlet 17 and also connected to a recirculation circuit for recirculating the printing ink through the ink application chamber 13. The mentioned recirculation circuit comprises a supply line from a recirculation outlet 18 of the pumping equipment 16 to an inlet 14 of the ink application chamber 13, and a return line from an outlet 15 of the ink application chamber 13 to a recirculation inlet 19 of the pumping equipment 16. The pumping equipment 16 comprises a first pneumatic diaphragm pump connected to drive printing ink through said supply line of the recirculation circuit and a second pneumatic diaphragm pump connected to aspirate printing ink through said return line of the recirculation circuit.

[0027] For each printing unit 21, the device comprises adjustment means for periodically adjusting the printing ink to predetermined values of viscosity, evaporability and temperature before the printing ink is supplied to the ink application chamber 13. In one embodiment, these adjustment means comprise, a mixer 4 having an ink inlet 5 connected to an outlet of an ink tank 1 to receive the energy-curable printing ink, a solvent inlet 6 connected to an outlet of a solvent tank 2 to receive a solvent, and an evaporability modifying agent inlet 7 connected to the outlet of an evaporability modifying agent tank 3 to receive an evaporability modifying agent. The mixer 4 is adapted to adjust the printing ink by means of adding, if necessary, measured amounts of said solvent and/or of said evaporability modifying agent to the printing ink, and/or by means of heating or cooling, as appropriate, the printing ink. The adjusted printing ink is supplied through an outlet 8 of the mixer which is connected to the mentioned inlet 17 of the pumping equipment 16. Thus, in the embodiment of Figure 1, the printing ink supplied to the pumping equipment 16 is already adjusted. It will be observed that, with this arrangement, the mixer 4 is located outside said recirculation circuit. The recirculation circuit can optionally include a line 41 from the pumping equipment 16 to the mixer 4, therefore the recirculated ink passes through the mixer 4 to be adjusted in each cycle.

[0028] The mixer 4 essentially includes a viscosimeter 9 and an evaporability measuring device 10 in cooperation with control means and valve means for controlling the flow of printing ink and adding measured amounts of solvent and of an evaporability modifying agent thereto, if considered necessary. The mixer also includes a thermostat 25 in cooperation with control means and heating-cooling means for heating or cooling the printing ink once it has been adjusted. The operation of the mixer 4 comprises periodically evaluating the viscosity of the printing ink by means of said viscosimeter 9 and comparing the evaluated value with a predetermined value of viscosity stipulated by the manufacturer of the energy-curable ink. If considered necessary, said valve means are actuated by a command of the control means for adding a measured amount of solvent to the printing ink that is suitable for adjusting the viscosity of the printing ink to said predetermined value of viscosity. Similarly, the evaporability of the printing ink is periodically evaluated by means of said evaporability measuring device 10 of the mixer 4 and, if it is considered necessary as a result of the comparison of the obtained value with a predetermined value of evaporability stipulated by the manufacturer, the valve means are actuated by a command of the control means for adding a measured amount of evaporability modifying agent to said printing ink that is suitable for adjusting the evaporability of the printing ink to said predetermined value of evaporability. The operation of the mixer 4 also comprises periodically evaluating the temperature of the printing ink by means of said thermostat 25 and, if considered necessary, said heating-cooling means are actuated by a command of the control means for heating or cooling, as appropriate, the printing ink until adjusting the temperature of the printing ink to a predetermined value.

[0029] It can be advantageous, especially in cold environments, to preheat the printing ink before the printing ink is supplied to said mixer 4. To that end, a heating device 38 is arranged to preheat the printing ink when it is inside said ink tank 1.

[0030] In a preferred embodiment, the energy-curable printing ink is a water-soluble printing ink that can be cured by an electron beam. As a result, said solvent is treated water. With this type of printing ink, ammonia can be used as an evaporability modifying agent, modifying the pH of the printing ink, among other parameters. In this case a pH meter is used as the evaporability measuring device 10 because the evaporability will be related to the pH. Furthermore, the mixer 4 is not limited to adjusting the viscosity, evaporability and temperature of the printing ink, and it can optionally adjust other parameters by means of adding other additives with the aid of suitable measuring and control equipment.

[0031] For each printing unit 21, the device of the present invention further comprises auxiliary inking means associated to said ink application chamber 13, which means are adapted to contribute to removing any residue of printing ink that may remain in pits existing in said pitted surface of the inking roller 11 after the inking of said printing roller 12 and to filling them again with fresh printing ink inside the ink application chamber.

[0032] Figure 2 shows with more detail the mentioned auxiliary inking means. The ink application chamber 13 is delimited, as is conventional, by a body 40, an upper doctor blade 26, a lower doctor blade 27 and a portion of the inking roller 11. At the side ends, the ink application chamber 13 is closed in a known manner by lids that are not shown. The upper and lower doctor blades 26, 27 are logically in contact with the pitted surface of the inking

roller 11. The auxiliary inking means comprise at least an intermediate doctor blade 20 located inside the ink application chamber 13 and arranged between said upper and lower doctor blades 26, 27, such that a longitudinal edge of the mentioned intermediate doctor blade 20 is in contact with the pitted surface of the inking roller 11, and elastically pressed against it. As a result, the intermediate doctor blade 20 divides the ink application chamber 13 into an upper cavity 28 and a lower cavity 29. The mentioned inlet 14 of the ink application chamber 13 communicates with said upper cavity 28, whereas said outlet 15 of the ink application chamber 13 communicates with said lower cavity 29. Passageways 37 communicate the upper and lower cavities 28, 29 with one another to allow the passage of printing ink from the upper cavity 28 to the lower cavity 29.

[0033] The mentioned passageways 37 have openings in the upper cavity 28 located at a height determining a maximum level of printing ink in the upper cavity 28. Similarly, the outlet 15 has at least one opening in the lower cavity 29 located at a height determining a maximum level of printing ink in the lower cavity 29. The supply means described above are furthermore adapted to supply the printing ink to the ink application chamber 13 at a suitable rate so that the upper and lower cavities 28, 29 of the ink application chamber 13 are only partially filled with printing ink during operation. The passageways 37 have associated thereto valve means 39 which can be actuated to interrupt or allow, or to regulate, the passage of printing ink from the upper cavity 28 to the lower cavity 29 through the passageways 37.

[0034] The inking roller 11 is actuated to rotate in a direction indicated by means of a curved arrow in Figure 2. This rotating direction is selected such that the pitted surface of the inking roller 11 enters the mixture application chamber 13 through the upper doctor blade 26 and leaves the mixture application chamber 13 through the lower doctor blade 27. As can be observed, the upper doctor blade 26 and the intermediate doctor blade 20 are arranged in favor of the rotating direction of the inking roller 11, whereas the lower doctor blade 27 is arranged against the rotating direction of the inking roller 11. As a result, the printing ink recirculating through the recirculation circuit enters the upper cavity of the mixture application chamber 13 through the inlet 14 and is accumulated on the intermediate doctor blade 20, wetting the pitted surface of the inking roller 11 as the latter rotates. The elastic pressure exerted by the intermediate doctor blade 20 against the pitted surface of the inking roller makes the intermediate doctor blade 20 act as a polishing spatula, contributing to remove any residue of printing ink remaining in the pits of the pitted surface of the inking roller and forcing the fresh printing ink to fill the pits again.

[0035] In relation now to Figure 4, another embodiment of the device of the present invention is described below, essentially comprising, for each printing unit 21, the same elements described above in relation to the device of Figure 1. The main difference is that here, the mixer 4 is placed in said supply line of the recirculation circuit. To that end, the recirculation outlet 18 of the pumping equipment 16 is connected to the ink inlet 5 of the mixer 4 and the outlet 8 of the mixer 4 is connected to the inlet 14 of the ink application chamber 13. In this case, the printing ink coming from the ink tank 1 is directly supplied to the pumping equipment 16 by means of a line from the ink tank 1 to the feed inlet 17 of the pumping equipment 16 and which reaches the mixer 4 through a first section of the supply line of the recirculation circuit. The recirculation circuit optionally includes a line 42 from the ink application chamber 13 to the mixer 4 and another line 43 from the mixer 4 to the pumping equipment 16.

[0036] The device of the present invention can advantageously include a self-cleaning device comprising a cleaning fluid tank 30 containing a cleaning fluid and connections with the pumping equipment 16 to circulate said cleaning fluid through the ink application chamber 13 and through the mixer 4 during periods in which the circulation of printing ink is interrupted. In the embodiment shown in the diagram of Figure 1, said cleaning fluid tank 30 has a first outlet 31 and an inlet 32 respectively connected to cleaning inlet and outlet 33, 34 of said pumping equipment 16, whereas a second outlet 35 of the cleaning fluid tank 30 is connected to an inlet 36 of the mixer 4. With this arrangement, the pumping equipment 16, in cooperation with control means and valve means, can circulate the cleaning fluid through the recirculation circuit including the ink application chamber 13, through the mixer 4, or through both at the same time. In the embodiment shown in the diagram of Figure 4, the cleaning fluid tank 30 has an outlet 31 connected to a cleaning inlet 33 of the pumping equipment 16, and the pumping equipment 16 has a cleaning outlet 34 connected to an inlet 32 of the cleaning fluid tank 30. The pumping equipment 16, in cooperation with control means and valve means, can thus circulate the cleaning fluid through the mixer 4 and through the ink application chamber 13.

[0037] A person skilled in the art will be able to introduce variations and modifications in the shown and described embodiments without departing from the scope of the present invention as defined in the attached claims.

Claims

1. A printing device using energy-curable inks for a flexographic printer of the type comprising at least a printing unit (21) adapted to print an energy-curable printing ink on a substrate web (23) supported on at least one counterpressure roller (24), and an energy emission unit (22) to direct energy towards said substrate web (23) for the purpose of curing said printing ink printed on said substrate web (23), wherein said printing unit (21) comprises an ink application chamber (13) adapted to apply the printing ink to a pitted surface of an inking roller (11) arranged to ink in turn a printing roller (12), supply means for supplying

printing ink to the corresponding ink application chamber (13) being included, **characterized in that** it comprises:

- adjustment means for periodically adjusting the printing ink to predetermined values of viscosity, evaporability and temperature before the printing ink is supplied to the ink application chamber (13); and
- auxiliary inking means associated to said ink application chamber (13) for contributing to remove printing ink remaining in pits of said pitted surface of the inking roller (11) and to filling them with fresh printing ink.

2. A device according to claim 1, **characterized in that** said adjustment means comprise a mixer (4) connected to receive through respective inlets (5, 6, 7) at least the energy-curable printing ink coming from an ink tank (1), a solvent coming from a solvent tank (2) and an evaporability modifying agent coming from an evaporability modifying agent tank (3), said mixer (4) being adapted to adjust the printing ink by adding, if necessary, measured amounts of said solvent and/or of said evaporability modifying agent to the printing ink, and/or heating or cooling, as appropriate, the printing ink, and to supply the adjusted printing ink through an outlet (8).

3. A device according to claim 2, **characterized in that** the mixer (4) comprises at least:

- a viscosimeter (9) in cooperation with control means and valve means for determining and adding amounts of solvent to said printing ink to adjust the viscosity of the printing ink to a predetermined value;
- an evaporability measuring device (10) in cooperation with control means and valve means for determining and adding amounts of evaporability modifying agent to the printing ink to adjust the evaporability of the printing ink to a predetermined value; and
- a thermostat (25) in cooperation with control means and heating-cooling means to adjust the temperature of the printing ink to a predetermined value.

4. A device according to claim 2 or 3, **characterized in that** it comprises a heating device (38) for preheating said printing ink in said ink tank (1) before the printing ink is supplied to said mixer (4).

5. A device according to claim 1, **characterized in that** the ink application chamber (13) is partly delimited by upper and lower doctor blades (26, 27) in contact with the inking roller (11), and **in that** said auxiliary inking means comprise at least one additional doctor blade (20) located inside the ink application chamber (13) and arranged between said upper and lower doctor blades (26, 27), said additional doctor blade (20) comprising a longitudinal edge in contact with the pitted surface of the inking roller (11) and elastically pressed against it.

6. A device according to claim 5, **characterized in that** said additional doctor blade (20) divides the ink application chamber (13) into an upper cavity (28), adapted to receive the printing ink through an inlet (14), and a lower cavity (29), adapted to discharge the printing ink through an outlet (15), said upper and lower cavities (28, 29) being communicated with one another through passageways (37) for the passage of printing ink from the upper cavity (28) to the lower cavity (29).

7. A device according to claim 6, **characterized in that** said passageways (37) have openings in the upper cavity (28) located at a height determining a maximum level of printing ink in the upper cavity (28), and **in that** said outlet (15) has at least one opening in the lower cavity (29) determining a maximum level of printing ink in the lower cavity (29), said supply means being adapted to supply the printing ink to the ink application chamber (13) at a rate such that the upper and lower cavities (28, 29) of the ink application chamber (13) are only partially filled with printing ink during the operation.

8. A device according to claim 7, **characterized in that** comprises valve means (39) associated to said passageways (37) suitable for being actuated to interrupt or allow the passage of printing ink from the upper cavity (28) to the lower cavity (29) through the passageways (37).

9. A device according to any of claims 5 to 8, **characterized in that** the inking roller (11) is actuated to rotate in a direction such that its pitted surface enters the mixture application chamber (13) through the upper doctor blade (26) and leaves the mixture application chamber (13) through the lower doctor blade (27), the upper doctor blade (26) and said additional doctor blade (20) being arranged in favor of said rotating direction of the inking roller (11) and the lower doctor blade (27) being arranged against the rotating direction of the inking roller (11).

10. A device according to any of claims 2 to 9, **characterized in that** said supply means comprise pumping equipment (16) connected to a recirculation circuit for recirculating the printing ink through the ink application chamber (13), said recirculation circuit including a supply line from a recirculation outlet (18) of the pumping equipment (16) to an inlet (14) of the ink application chamber (13) and a return line from

an outlet (15) of the ink application chamber (13) to a recirculation inlet (19) of the pumping equipment (16).

11. A device according to claim 10, **characterized in that** the pumping equipment (16) comprises a first pneumatic diaphragm pump associated to said supply line of the recirculation circuit and a second pneumatic diaphragm pump associated to said return line of the recirculation circuit.

12. A device according to claim 10 or 11, **characterized in that** the mixer (4) is located outside said recirculation circuit, with said outlet (8) of the mixer (4) connected to a feed inlet (17) of the pumping equipment (16).

13. A device according to claim 10 or 11, **characterized in that** the mixer (4) is placed in said supply line of the recirculation circuit, with said recirculation outlet (18) of the pumping equipment (16) connected to said ink inlet (5) of the mixer (4) and said outlet (8) of the mixer (4) connected to said inlet (14) of the ink application chamber (13), a feed inlet (17) of the pumping equipment (16) being connected to directly receive the printing ink from said ink tank (1).

14. A device according to claim 12, **characterized in that** it includes a self-cleaning device comprising a cleaning fluid tank (30) containing a cleaning fluid, a first outlet (31) and an inlet (32) of said cleaning fluid tank (30) being respectively connected to a cleaning inlet and outlet (33, 34) of said pumping equipment (16) and a second outlet (35) of the cleaning fluid tank (30) being connected to an inlet (36) of the mixer (4), whereby the pumping equipment (16) in cooperation with control means and valve means can circulate the cleaning fluid through the ink application chamber (13) and/or through the mixer (4).

15. A device according to claim 13, **characterized in that** it includes a self-cleaning device comprising a cleaning fluid tank (30) containing a cleaning fluid, an outlet (31) and an inlet (32) of said cleaning fluid tank (30) being respectively connected to a cleaning inlet and outlet (33, 34) of said pumping equipment (16), whereby the pumping equipment (16) in cooperation with control means and valve means can circulate the cleaning fluid through the mixer (4) and through the ink application chamber (13).

16. A device according to claim 3, **characterized in that** said evaporability measuring device (10) comprises a pH meter.

17. A device according to any of the previous claims, **characterized in that** it comprises two or more of said printing units (21) adapted to consecutively wet-on-wet print energy-curable printing inks on said substrate web (23), said energy emission unit (22) being arranged downstream of said printing units (21), and ones of said supply means, ones of said adjustment means, and ones of said auxiliary inking means being included for each printing unit (21).

18. A printing method using energy-curable inks for a flexographic printer, of the type comprising the steps of printing an energy-curable printing ink on a substrate web (23) supported on a counterpressure roller (24) by means of at least one printing unit (21), and curing the printing ink printed on said substrate web (23) by means of an energy emission unit (22) arranged to direct energy towards said substrate web (23), wherein said step of printing comprises, for each printing unit (21), supplying by means of supply means said printing ink to a corresponding ink application chamber (13) adapted to apply the printing ink to a pitted surface of an inking roller (11) arranged to ink in turn a corresponding printing roller (12), **characterized in that** it comprises the steps of:

- periodically adjusting the printing ink to predetermined values of viscosity, evaporability and temperature before the printing ink is supplied to the ink application chamber (13); and
- contributing to remove printing ink remaining in pits of said pitted surface of the inking roller (11) and to filling them with fresh printing ink by means of auxiliary inking means associated to the ink application chamber (13).

19. A method according to claim 18, **characterized in that** said step of periodically adjusting the printing ink comprises:

- receiving in a mixer (4) at least the energy-curable printing ink coming from an ink tank (1), a solvent coming from a solvent tank (2) and an evaporability modifying agent coming from an evaporability modifying agent tank (3) through respective inlets (5, 6, 7) of said mixer (4);
- evaluating if the printing ink needs to be adjusted with regard to viscosity and/or evaporability and/or temperature;
- in the affirmative case, adjusting the printing ink by adding, as appropriate, measured amounts of said solvent and/or of said evaporability modifying agent to the printing ink, and/or heating or cooling, as appropriate, the printing ink; and
- supplying the adjusted printing ink through an outlet (8) of said mixer (4).

20. A method according to claim 19, **characterized in that** it comprises carrying out in the mixer (4) the steps of:

- periodically evaluating the viscosity of the printing ink by means of a viscosimeter (9) and, if necessary, actuating valve means in cooperation with control means for adding a measured amount of solvent to said printing ink that is suitable for adjusting the viscosity of the printing ink to a predetermined value of viscosity;
- periodically evaluating the evaporability of the printing ink by means of an evaporability measuring device (10) and, if necessary, actuating valve means in cooperation with control means for adding a measured amount of evaporability modifying agent to said printing ink that is suitable for adjusting the evaporability of the printing ink to a predetermined value of evaporability;
- periodically evaluating the temperature of the printing ink by means of a thermostat (25) and, if necessary, actuating heating-cooling means in cooperation with control means for heating or cooling the printing ink until adjusting the temperature of the printing ink to a predetermined value.

21. A method according to claim 19 or 20, **characterized in that** it comprises preheating said printing ink in said ink tank (1) before the printing ink is supplied to said mixer (4).

22. A method according to claim 18, **characterized in that** said step of contributing to remove printing ink remaining in pits of said pitted surface of the inking roller (11) and to filling them with fresh printing ink is carried out by means of an additional doctor blade (20) arranged between upper and lower doctor blades (26, 27) in contact with the inking roller (11) and cooperating in the partial delimiting of the ink application chamber (13), wherein a longitudinal edge of said additional doctor blade (20) is in contact with the pitted surface of the inking roller (11) and elastically pressed with it in favor of the rotating direction of the inking roller (11).

23. A method according to claim 22, **characterized in that** it comprises maintaining an upper cavity (28) of the ink application chamber (13) comprised between the upper doctor blade (26) and the additional doctor blade (20) and communicated with a printing ink inlet (14), and a lower cavity (29) comprised between the additional doctor blade (20) and the lower doctor blade (27) and communicated with a printing ink outlet (15), only partially filled with printing ink during the operation.

24. A method according to any one of claims 18 to 23, **characterized in that** said energy-curable printing ink is water-soluble printing ink which can be cured by an electron beam and said solvent is treated water.

25. A method according to claim 24, **characterized in that** said evaporability modifying agent is ammonia and said evaporability measuring device (10) comprises a pH meter.

26. A method according to any of the previous claims, **characterized in that** it comprises consecutively wet-on-wet printing energy-curable printing inks on a substrate web (23) by means of two or more of said printing units (21), and curing the printing ink printed on said substrate web (23) by means of said energy emission unit (22) arranged downstream of said printing units (21), and carrying out said steps of supplying, adjusting and contributing by means of ones of said supply means, ones of said adjustment means, and ones of said auxiliary inking means for each printing unit (21).

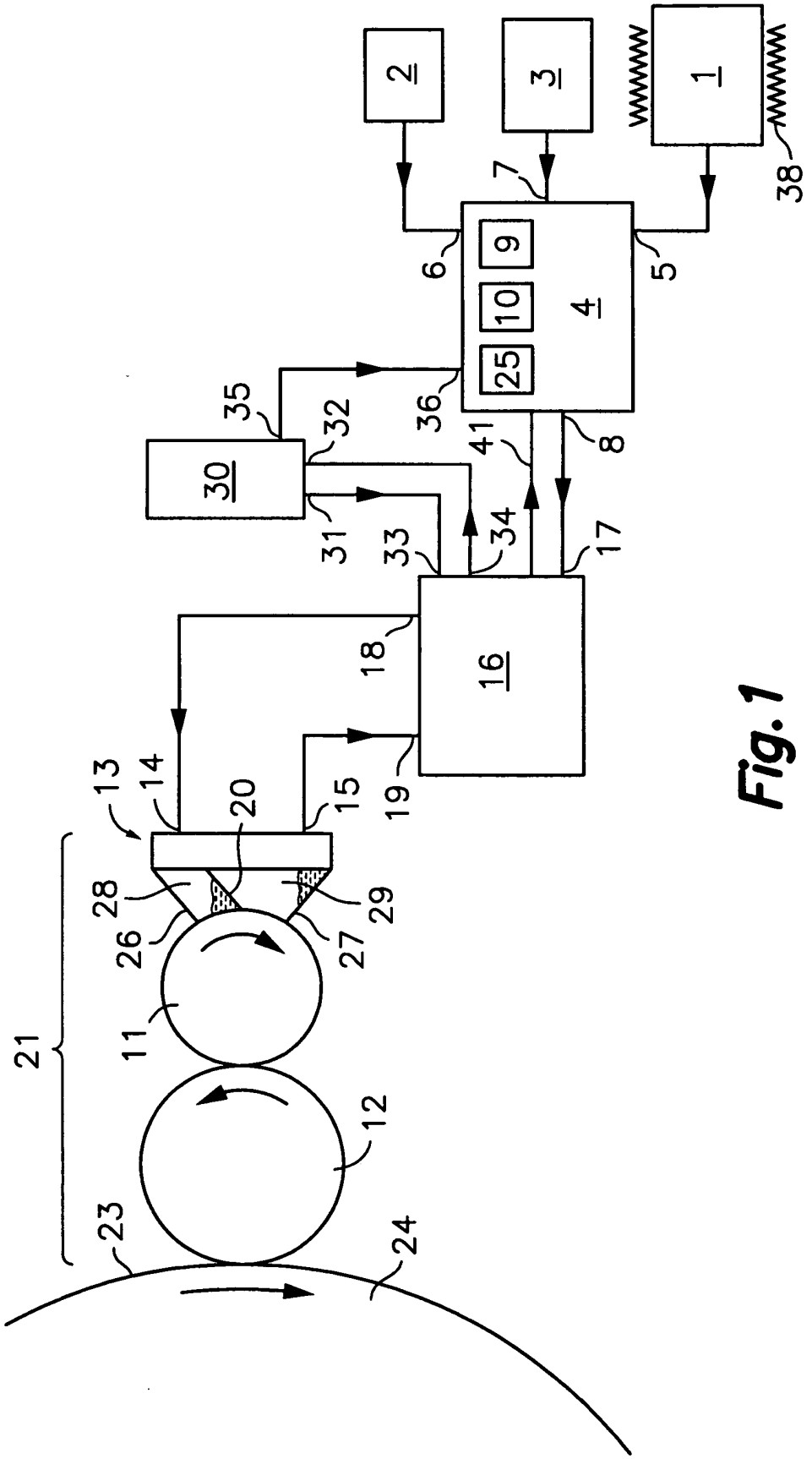
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Fig. 1

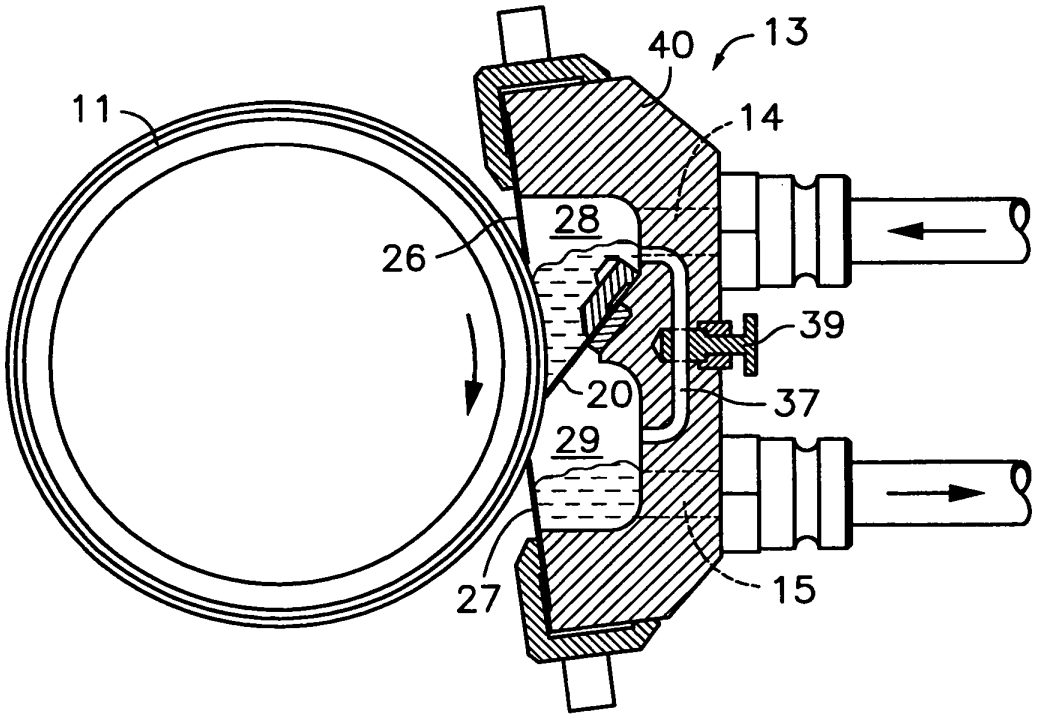
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Fig.2

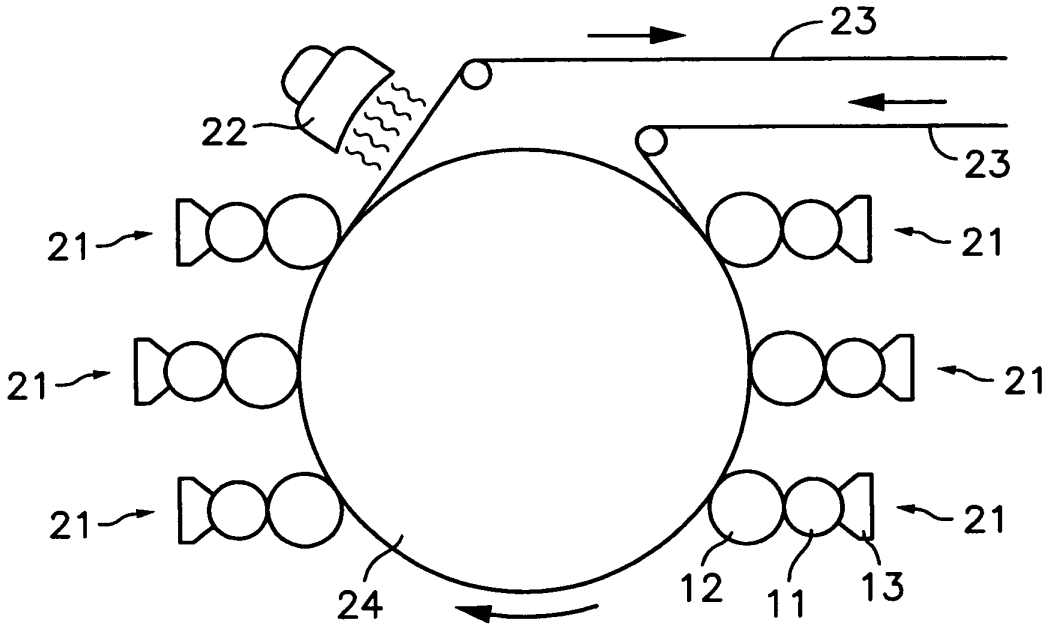
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Fig.3

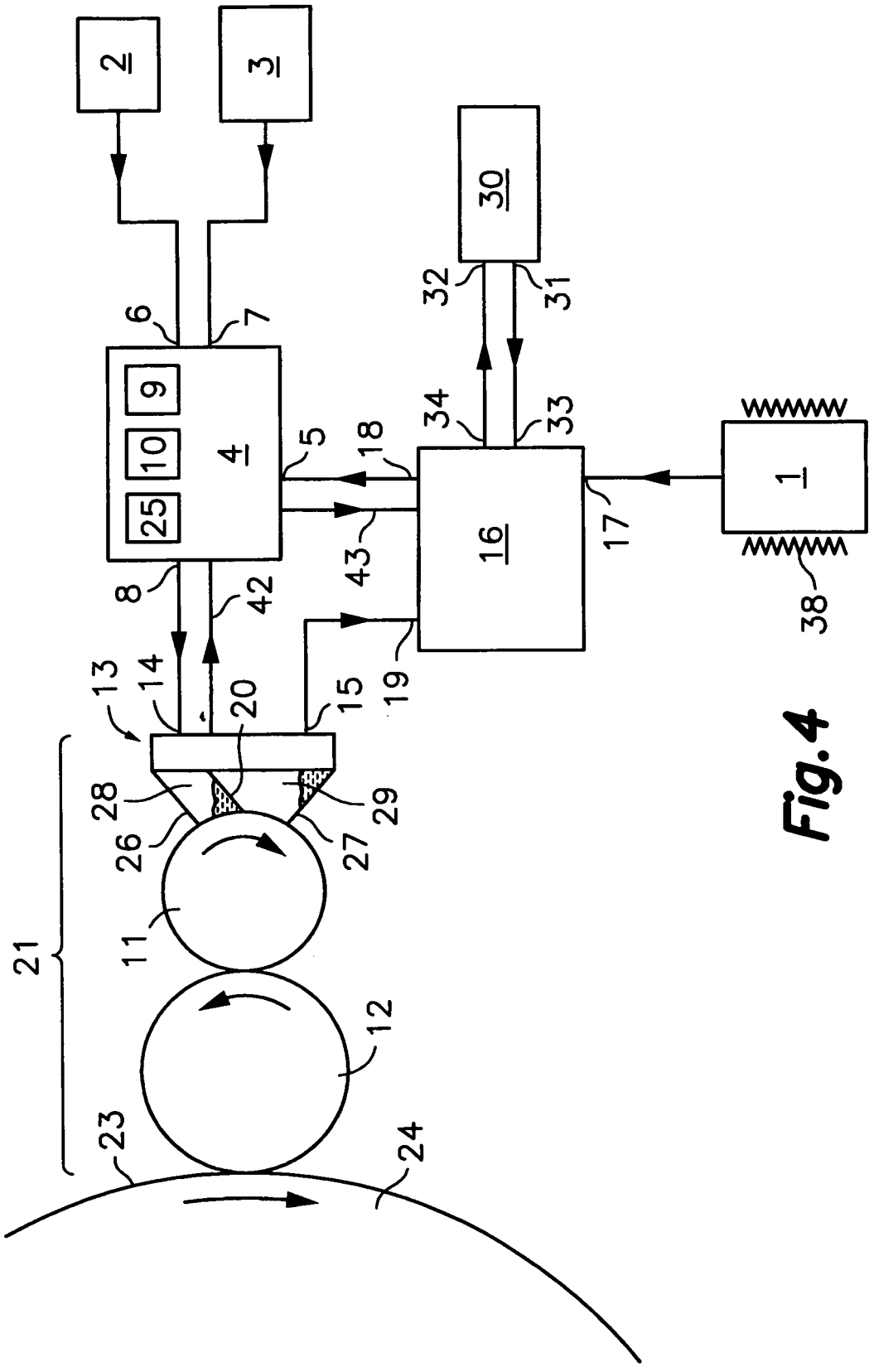
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Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/ ES 2006/000298

A. CLASSIFICATION OF SUBJECT MATTER

see extra sheet
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B41F+

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

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☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15.September.2006 (15.09.2006)	(28-09-2006)
Name and mailing address of the ISA/ O.E.P.M. Paseo de la Castellana, 75 28071 Madrid, España. Facsimile No. 34 91 3495304	Authorized officer A. Ezcurra Martínez Telephone No. + 34 91 3496866

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INTERNATIONAL SEARCH REPORT

International application No.
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International application No.
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/ ES 2006/000298

CLASSIFICATION OF SUBJECT MATTER

B41F 31/00 (2006.01)
B41F 31/02 (2006.01)

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