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(71) Applicant: **Comexi Group Industries, S.A.U**
17457 Riudellots de la Selva (Girona) (ES)

(72) Inventors:
- **Puig Vilà, Jordi**
  17162 Bescanó (Girona) (ES)
- **Fortià, Carles**
  17003 Girona (Girona) (ES)

(74) Representative: **Juncosa Miro, Jaime et al**
Torner, Juncosa i Associates, S.L.
Gran Via de les Corts
Catalanes, 669 bis, 1º, 2ª
08013 Barcelona (ES)

(54) CENTRAL IMPRESSION DRUM PRINTING MACHINE FOR PRINTING RADIATION CURABLE INKS

(57) The printing machine (50) comprises a central impression drum (35) supporting a web substrate (S), several printing groups (51-55) arranged around an entry side (35a) and several printing groups (56-60) arranged around an exit side (35b) of the central impression drum for applying radiation-curable inks on the web substrate (S), and at least one curing unit (61-69) arranged between each pair of adjacent printing groups. The first curing unit located in a larger space between the first printing group (51) and the subsequent printing group (53) and/or the last curing unit located in a larger space between the last printing group (60) and the preceding printing group (58) is an extensive curing unit (61, 69) providing an exposure time to ultraviolet radiation longer than the remaining curing units (63-67).

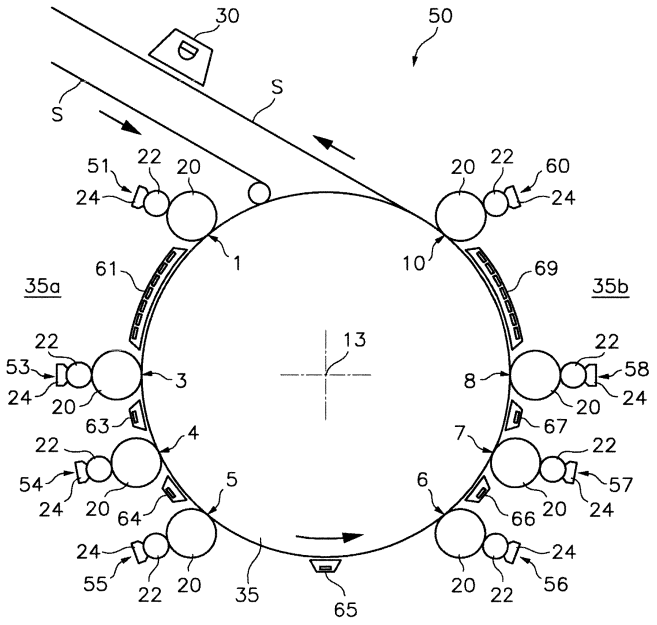

Fig.3

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Description

Technical Field

[0001] The present invention generally relates to a printing machine having a central impression drum for printing radiation-curable inks, and more particularly to a printing machine having several printing groups arranged around a central impression drum for applying radiation-curable inks on a web substrate supported on the central impression drum, and at least one curing unit arranged between each pair of adjacent printing groups, where the curing unit located between the first printing group and a subsequent printing group and/or the curing unit located between the last printing group and a preceding printing group are extensive curing units.

Background of the Invention

[0002] Printing machines are known, such as for example the one described in document US 3528620 A, which have a rotary central impression drum provided with an outer surface suitable for supporting a web substrate between a substrate entry point located on an entry side of said central impression drum and a substrate exit point located on an exit side of the central impression drum. A plurality of printing groups are uniformly distributed along each of said entry and exit sides of the central impression drum, and each printing group has a printing cylinder depositing a respective water-based ink or solvent-based ink at a specific impression point on said web substrate supported on said central impression drum.

[0003] In these and in other known printing machines, there is arranged between each pair of adjacent printing groups at least one drying or curing unit configured for applying a drying agent, such as a drying air stream or infrared radiation or a curing agent such as ultraviolet radiation, to the web substrate supported on the central impression drum and thereby drying or curing the ink deposited on the web substrate by the preceding printing group sufficiently to allow depositing subsequent ink thereon without causing the inks to run, all the drying or curing units being similar or having comparable dimensions.

[0004] After the last printing group and the substrate exit point of the central impression drum, with respect to the forward movement direction of the web substrate, there is arranged a final drying or curing unit generally in the form of a drying tunnel applying a drying or curing agent to the web substrate for final drying of all the inks deposited thereon.

[0005] Drying water-based inks or solvent-based inks involves evaporating water or solvent present in the ink composition by applying an air stream and/or heat. Curing radiation-curable inks involves triggering a chemical reaction between components of the ink by exposure to radiation, whereby the ink goes from a liquid state to a solid state.

[0006] Ultraviolet (UV) radiation-curable inks are known which are widely used, even though in other types of inks curing can be performed using another type of radiation, for example, gamma radiation or electron beam (EB) radiation. Generally, ultraviolet radiation-curable inks are also electron beam-curable, although not all electron beam-curable inks are ultraviolet radiation-curable. Electron beam sources are used less in curing units between printing groups because they are bulkier and more expensive than ultraviolet radiation sources.

[0007] The conventional curing units between printing groups usually use mercury discharge lamps as an ultraviolet radiation source, even though the use of ultraviolet light emitting diodes as an ultraviolet radiation source for curing printed inks in printing machines is also known.

[0008] Document US 20100242763 A1, belonging to Ryobi Ltd., describes a printing machine comprising a supply section for supplying loose sheets of substrate, a printing section provided with a plurality of offset printing units arranged in line for printing inks of different colors on the loose sheets of substrate, and a discharge section for discharging the loose sheets. A drying unit comprising an array of light emitting diodes LEDs emitting ultraviolet radiation for curing at the same time all the inks printed on the sheets of substrate is arranged between the last printing unit and the discharge section.

[0009] International patent application WO 2011154566 A1, belonging to Comexi Group Ind. S.A.U., discloses a printing machine provided with a plurality of flexographic printing units arranged around an impression drum for printing inks of different colors on a web substrate, a plurality of partial drying units, each arranged for drying the ink printed on the substrate by a corresponding printing unit and before the substrate is printed on by the subsequent printing unit, and a final drying tunnel arranged for completely drying all the inks printed on the web substrate. The partial drying units and the final drying tunnel direct an airflow, preferably a hot airflow, towards the inks printed on the substrate in order to dry the inks.

[0010] Throughout this description, the term "ink" is generically used to designate inks, varnishes, adhesives, coatings and other radiation-curable compounds that can be applied to a substrate by means of a printing machine.

[0011] In printing machines having a central impression drum that use radiation-curable inks, a problem arises when the first ink applied by the first printing group, with respect to the forward movement direction of the web substrate, is a base ink having a relatively high viscosity, generally white in color, applied as a relatively thick layer, completely covering the surface of the web substrate or a significantly large area thereof, on which the rest of the inks will be successively applied, because the ultraviolet radiation applied by the first curing unit in combination with a high speed of movement of the web substrate is insufficient to perform a curing or even a partial curing of said base ink which would allows the subsequent ink to be applied on the base ink without

causing the inks to run.

[0012] A similar problem occurs when the ink applied by the last printing group is a transparent coating varnish or ink, generally having a shiny finish, applied as a layer completely covering the surface of the web substrate or a significantly large area thereof over the previously deposited inks, because the ultraviolet radiation applied successively by all the curing units in combination with a high speed of movement of the web substrate is insufficient to perform a partial curing of the superimposed inks allowing the coating varnish or ink to be subsequently applied thereon without causing the inks to run.

[0013] An objective of the present invention is to provide a printing machine having a central impression drum for printing radiation-curable inks provided with at least one extensive curing unit arranged between the first printing group and a subsequent printing group, with respect to the movement direction of the web substrate, which allows using a base ink applied by the first printing group and/or at least one extensive curing unit arranged between the last printing group and a preceding printing group, with respect to the movement direction of the web substrate, which allows using a coating varnish or ink applied by the last printing group.

Disclosure of the Invention

[0014] The present invention contributes to achieving the foregoing and other objectives by providing a printing machine having a central impression drum for printing radiation-curable inks, comprising a rotary central impression drum which has an outer surface suitable for supporting a web substrate between a substrate entry point located on an entry side of said central impression drum and a substrate exit point located on an exit side of the central impression drum, with respect to a vertical plane containing the axis of rotation of the central impression drum.

[0015] The printing machine of the present invention further comprises a plurality of printing groups distributed along said entry side and said exit side of the central impression drum. Each printing group has a printing cylinder depositing a respective radiation-curable ink at a corresponding impression point on said web substrate supported on said central impression drum. Said printing groups include a first printing group adjacent to said substrate entry point and a last printing group adjacent to said substrate exit point, with respect to the forward movement direction of the web substrate.

[0016] The printing machine of the present invention further comprises a plurality of curing units configured and arranged for applying radiation to the web substrate supported on the central impression drum and thereby curing the ink deposited on the web substrate. At least one of said curing units is arranged between each pair of adjacent printing groups

[0017] Between the impression point of the first printing group and the impression point of a subsequent printing group and/or between the impression point of the last printing group and the impression point of a preceding printing group, there is an angular distance with respect to the circumference of the central impression drum at least one and a half times greater, and preferably at least two times greater than an angular distance between the impression points of each remaining pair of adjacent printing groups located on said entry side of the central impression drum and than an angular distance between the impression points of each remaining pair of adjacent printing groups located on said exit side of the central impression drum.

[0018] In a space provided by said angular distance between the impression point of the first printing group and the impression point of said subsequent printing group and/or between the impression point of the last printing group and the impression point of said preceding printing group, there is installed at least one of the curing units which is at least an extensive curing unit dimensioned for providing an exposure time of the web substrate to the ultraviolet radiation applied by said at least one extensive curing unit at least one and a half times longer, preferably at least two times longer, and more preferably at least three times longer than an exposure time of the web substrate to the ultraviolet radiation applied by each of the remaining curing units.

[0019] Thus, the extensive curing unit located between the first printing group and the subsequent printing group allows using a base ink applied by the first printing group without causing the inks to run, and the extensive curing unit located between the last printing group and the preceding printing group allows using a coating varnish or ink applied by the last printing group without causing the inks to run.

[0020] The curing units preferably use at least one ultraviolet radiation source as a radiation source. In one embodiment, said ultraviolet radiation source of each curing unit comprises an array of ultraviolet light emitting diodes arranged for emitting ultraviolet radiation towards the web substrate covering a maximum allowable substrate width for the web substrate. In another alternative embodiment, the ultraviolet radiation source of each curing unit comprises one or more mercury discharge lamps.

[0021] When said array of ultraviolet light emitting diodes is used as the ultraviolet radiation source, the printing machine comprises control means selectively activating the operation of said ultraviolet light emitting diodes of said array according to one or more impression data relating to a printing job that is being performed by the printing machine. These control means preferably include data acquisition means acquiring said impression data which include, for example, a substrate width of the web substrate on which said printing job is performed and/or one or more characteristics of the ink deposited on the web substrate and/or a location of ink areas deposited on the web substrate. Optionally, the control means adapt one or more operation parameters of the ultraviolet light emitting diodes, such as radiation power

and/or radiation wavelength, to one or more of said impression data.

[0022] The printing machine preferably comprises a final curing unit configured and arranged for applying radiation to the web substrate after the substrate exit point of the central impression drum, with respect to the forward movement direction of the web substrate, to perform final curing of all the inks successively deposited on the web substrate by all the printing groups. The final curing unit can be a conventional type including at least one ultraviolet radiation source, such as one or more mercury discharge lamps, or an electron beam source. Nevertheless, the possibility of the final curing unit including an array of ultraviolet light emitting diodes is not ruled out.

[0023] The printing groups of the printing machine of the present invention can be flexographic printing groups, rotogravure printing groups, offset printing groups, or a combination of flexographic printing groups and/or rotogravure printing groups and/or offset printing groups.

Brief Description of the Drawings

[0024] The foregoing and other features and advantages will become more evident from the following detailed description of exemplary embodiments with reference to the accompanying drawings, in which:

Fig. 1 is a schematic front view of a printing machine having a central impression drum for printing radiation-curable inks according to a first embodiment of the present invention;

Fig. 2 is a schematic front view of a printing machine having a central impression drum for printing radiation-curable inks according to a second embodiment of the present invention;

Fig. 3 is a schematic front view of a printing machine having a central impression drum for printing radiation-curable inks according to a third embodiment of the present invention;

Fig. 4 is a schematic top view of an ultraviolet radiation curing unit of the ink curing device of the printing machine of any of Figs. 1, 2 or 3 during a printing job;

Fig. 5 is a schematic side view of the ultraviolet radiation curing unit of Fig. 4;

Fig. 6 is a schematic front view of the ultraviolet radiation curing unit of Fig. 4

Detailed Description of several Embodiments

[0025] First referring to Fig. 1, the reference sign 50 designates a printing machine having a central impression drum for printing radiation-curable inks according to a first embodiment of the present invention, which comprises a rotary central impression drum 35 rotating about an axis of rotation 13. Said central impression drum 35 has an outer surface suitable for supporting a web substrate S. Guide means guide the web substrate S from an unwinding device (not shown) to the central impression drum 35 and from the central impression drum 35 to a rewinding device (not shown). These guide means provide a substrate entry point 11 located on an entry side 35a of the central impression drum 35 and a substrate exit point 12 located on an exit side 35b of the central impression drum 35 with respect to a forward movement direction of the web substrate S indicated by means of arrows.

[0026] Thus, the web substrate S is supported on the outer surface of the central impression drum 35 from said substrate entry point 11 to said substrate exit point 12 while the central impression drum 35 rotates. The mentioned entry side 35a and exit side 35b of the central impression drum 35 are demarcated by a vertical geometric plane containing the axis of rotation 13 of the central impression drum.

[0027] The printing machine further comprises four printing groups 51, 53, 54, 55 distributed along the entry side 35a and other five printing groups 56, 57, 58, 59, 60 distributed along the exit side 35b of the central impression drum 35. Each printing group 51, 53, 54, 55, 56, 57, 58, 59, 60 has a printing cylinder 20 depositing a respective radiation-curable ink at a corresponding impression point 1, 3, 4, 5, 6, 7, 8, 9, 10 on the web substrate S supported on the central impression drum 35. The mentioned impression points 1, 3, 4, 5, 6, 7, 8, 9, 10 correspond to nip lines between the printing cylinders 20 and the web substrate S supported on the central impression drum 35.

[0028] It will be understood that the number of printing groups located on the entry side 35a and the number of printing groups located on the exit side 35b of the central impression drum 35 is variable, and that any number of printing groups equal to or greater than two is within the scope of the present invention.

[0029] The printing groups 51, 53, 54, 55, 56, 57, 58, 59, 60 include a first printing group 51 adjacent to said substrate entry point 11 on the entry side 35a and a last printing group 60 adjacent to said substrate exit point 12 on the exit side 35b.

[0030] In the embodiments shown in Figs. 1, 2 and 3, the printing groups are flexographic printing groups in which said printing cylinder 20 is a plate cylinder, which cooperates with an anilox cylinder 22 which in turn cooperates with a conventional inking device 24 having a doctor blade and a closed chamber. Nevertheless, in alternative embodiments the printing groups can be rotogravure printing groups or offset printing groups, or a combination of flexographic printing groups and/or rotogravure printing groups and/or offset printing groups without departing from the scope of the present invention.

[0031] Returning to the first embodiment shown in Fig. 1, between each pair of adjacent printing groups 51, 53; 53, 54; 54, 55; 55, 56; 56, 57; 57, 58; 58, 59; 59, 60 there is arranged a curing unit 61, 63, 64, 65, 66, 67, 68, 69 applying ultraviolet radiation to the web substrate S supported on the central impression drum 35 for curing the ink deposited on the web substrate S by the preceding

printing group through a chemical reaction between components included in the ink.

[0032] Between the impression point 1 corresponding to the first printing group 51 and the impression point 3 corresponding to the subsequent printing group 53 there is an angular distance, with respect to the circumference of the central impression drum 35, which is at least one and a half times greater, and preferably at least two times greater than the angular distance existing between the impression points 3, 4; 4, 5 corresponding to each remaining pair of adjacent printing groups 53, 54; 54, 55 located on the entry side 35a of the central impression drum 35 and than an angular distance between the impression points 6, 7; 7, 8; 8, 9; 9, 10 corresponding to each remaining pair of adjacent printing groups 56, 57; 57, 58; 58, 59; 59, 60 located on the exit side 35b of the central impression drum 35.

[0033] The mentioned angular distance between the impression point 1 corresponding to the first printing group 51 and the impression point 3 corresponding to the subsequent printing group 53 provides a free space in which the first curing unit, which is an extensive curing unit 61, is installed. This extensive curing unit 61 is dimensioned for providing an exposure time of the web substrate S to the ultraviolet radiation applied by said extensive curing unit 61 which is at least one and a half times longer, preferably at least two times longer, and more preferably at least three times longer than an exposure time of the web substrate S to the ultraviolet radiation applied by each of the remaining curing units 63, 64, 65, 66, 67, 68, 69.

[0034] Longer exposure time of the web substrate S to the ultraviolet radiation applied by said extensive curing unit 61 entails the possibility of a greater curing capacity for curing the ink applied by the first printing group 51 in relation to the curing capacity of the remaining curing units 63, 64, 65, 66, 67, 68, 69.

[0035] Thus, the extensive curing unit 61 located between the first printing group 51 and the subsequent printing group 53 allows using a base ink having a relatively high viscosity, generally white in color, applied by the first printing group 51 as a relatively thick layer completely covering the surface of the web substrate S or a significantly large area thereof, because it assures a curing of said base ink sufficient to allow applying successive inks deposited onto the base ink by the remaining printing groups 53, 54, 55, 56, 57, 58, 59, 60 without causing the inks to run, even with a high speed of movement of the web substrate S.

[0036] Fig. 4 shows one of the curing units 63 which, for the purpose of the following description, is representative of any of the curing units 61-69, including the extensive curing unit 61, although this extensive curing unit 61 has greater dimensions.

[0037] Thus, as shown in Fig. 4, the curing unit 63 (i.e., any of the curing units 61-69) comprises an array 71 of ultraviolet light emitting diodes 72 arranged for emitting ultraviolet radiation towards the web substrate S covering at least a maximum allowable substrate width Asm for the web substrate S. In the curing units 63-69 located between the second printing group 53 and the last printing group 60, said array 71 comprises two staggered rows of ultraviolet light emitting diodes 72 such that the ultraviolet light emitting diodes 72 of one row covers the spaces between ultraviolet light emitting diodes 72 of the other row. However, it must be indicated that alternatively the rows could be only one or more than two in number, or that the array 71 could have the ultraviolet light emitting diodes 72 arranged in any other suitable manner.

[0038] In the extensive curing unit 61 located between the first printing group 51 and the second printing group 53, the array (not shown in this case) includes a higher number of staggered rows of ultraviolet light emitting diodes 72. It must be indicated that the number of rows in the extensive curing unit 61 is variable and that alternatively, the array 71 can have the ultraviolet light emitting diodes 72 arranged in any suitable manner other than in rows.

[0039] Now in relation to Figs. 5 and 6, the curing unit 63 (i.e., any of the curing units 61-69) comprises an enclosure 75 surrounding a support 73 on which said array 71 of ultraviolet light emitting diodes 72 is installed. There is a control circuit, preferably a printed circuit, in said support 73. Said enclosure 75 has an opening 75a facing and adjacent to said support surface of the central impression drum 35, such that the ultraviolet radiation emitted by the ultraviolet light emitting diodes 72 is projected on the support surface of the central impression drum 35 and on the web substrate S through said opening 75a. Therefore, the ink deposited on the web substrate S is exposed to the ultraviolet radiation and the ultraviolet radiation cures the ink.

[0040] The inside of the enclosure 75 is in communication with an inert gas supply source 78 (Fig. 5), preferably a nitrogen supply source, through a conduit 78a. When performing a printing job, the inert gas supply source 78 fills a space demarcated by inner surfaces of the enclosure 75, the support surface of the central impression drum 35 and the web substrate S supported thereon with an inert gas. The inert gas, preferably nitrogen, displaces the air inside the enclosure 75 and prevents or reduces the possibility of the ink being oxidized while curing.

[0041] The enclosure 75 also prevents the ultraviolet radiation emitted by the ultraviolet light emitting diodes 72 from disturbing the sight of the personnel responsible for the printing machine or close to it.

[0042] The curing device comprises control means 80 connected through wiring 80a to said control circuit included in the support 73 of the array 71 of ultraviolet light emitting diodes 72. The control means 80 include data acquisition means acquiring impression data relating to a printing job to be performed by the printing machine. These data acquisition means can comprise, for example, a digital reader reading the impression data contained in a digital file or a user interface through which a

user enters the impression data.

[0043] These impression data comprise for example a width As of the web substrate S and/or one or more characteristics of the ink deposited on the web substrate S and/or a location of ink areas At deposited on the web substrate S (see Fig. 4).

[0044] When performing a printing job, the control means 80 selectively activate the operation of the ultraviolet light emitting diodes 72 of the array 71 according to one or more of the impression data relating to the printing job that is being performed by the printing machine.

[0045] In the printing job example illustrated in Fig. 4, the reference sign Asm indicates a maximum allowable substrate width that the central impression drum 35 can allow for the web substrate S. Nevertheless, the web substrate S that is being used in the illustrated printing job has a substrate width As less than the maximum allowable substrate width Asm, and furthermore the ink deposited on the web substrate S by the printing unit located immediately upstream from the curing unit 63 is inscribed in two ink areas At (shaded areas in Fig. 4) along the web substrate S. Therefore, only the ultraviolet light emitting diodes 72 covering the ink areas At (non-shaded diodes in Fig. 4) are activated by the control means 80.

[0046] In another printing job example (not shown), the ink deposited on the web substrate S is not inscribed in well-defined ink areas but rather is dispersed over the entire surface of the web substrate S or continuously covers the entire surface of the web substrate S. In such case, the control means activate the operation of those ultraviolet light emitting diodes 72 of the array 71 covering the substrate width As, or all the ultraviolet light emitting diodes 72 of the array 71 if the width of the web substrate S is equal to the maximum allowable substrate width Asm.

[0047] Optionally, the control means 80 adapt one or more operation parameters of the ultraviolet light emitting diodes 72, such as for example the radiation power and/or the radiation wavelength, to one or more of said impression data, such as the one or more characteristics of the ink deposited on the web substrate S.

[0048] It will be understood that, alternatively, instead of the single extensive curing unit 61 shown in Fig. 1, two or more extensive curing units 61 could be installed with the same result in said free space provided by the angular distance between the impression point 1 corresponding to the first printing group 51 and the impression point 3 corresponding to the subsequent printing group 53.

[0049] The printing machine of the first embodiment shown in Fig. 1 further includes a conventional final curing unit 30, configured and arranged for applying radiation to the web substrate S after the substrate exit point 12 of the central impression drum 35, with respect to the forward movement direction of the web substrate S. This final curing unit 30 performs final curing of all the inks successively deposited on the web substrate S by the different printing groups 51, 53, 54, 55, 56, 57, 58, 59, 60. In the illustrated embodiment, the final curing unit 30 comprises an electron beam source 76. In an alternative embodiment (not shown), the final curing unit 30 comprises one or more ultraviolet radiation sources, such as one or more mercury discharge lamps, or an array of ultraviolet light emitting diodes.

[0050] Fig. 2 shows a second embodiment of the printing machine having a central impression drum for printing radiation-curable inks of the present invention, which is similar to the first embodiment described above in relation to Fig. 1, except that in this second embodiment the printing machine comprises five printing groups 51, 52, 53, 54, 55 distributed along the entry side 35a and other four printing groups 56, 57, 58, 60 distributed along the exit side 35b of the central impression drum 35. The printing groups 51, 52 53, 54, 55, 56, 57, 58, 60 deposit respective radiation-curable inks at corresponding impression points 1, 2, 3, 4, 5, 6, 7, 8, 10 on the web substrate S supported on the central impression drum 35.

[0051] The printing groups 51, 52, 53, 54, 55, 56, 57, 58, 60 include a first printing group 51 adjacent to said substrate entry point 11 on the entry side 35a and a last printing group 60 adjacent to said substrate exit point 12 on the exit side 35b.

[0052] Between each pair of adjacent printing groups 51, 52; 52, 53; 53, 54; 54, 55; 55, 56; 56, 57; 57, 58; 58, 60, there is arranged a curing unit 61, 62 63, 64, 65, 66, 67, 69 applying ultraviolet radiation to the web substrate S supported on the central impression drum 35 for curing the ink deposited on the web substrate S by the preceding printing group through a chemical reaction between components included in the ink.

[0053] Between the impression point 10 corresponding to said last printing group 60 and the impression point 8 corresponding to a preceding printing group 58, there is an angular distance, with respect to the circumference of the central impression drum 35, which is at least one and a half times greater, and preferably at least two times greater than the angular distance existing between the impression points 1, 2; 2, 3; 3, 4; 4, 5 corresponding to each remaining pair of adjacent printing groups 51, 52; 52, 53; 53, 54; 54, 55 located on the entry side 35a of the central impression drum 35 and than an angular distance between the impression points 6, 7; 7, 8 corresponding to each remaining pair of adjacent printing groups 56, 57; 57, 58 located on the exit side 35b of the central impression drum 35.

[0054] Said angular distance between the impression point 10 corresponding to the last printing group 60 and the impression point 8 corresponding to said preceding printing group 58 provides a free space in which the last curing unit, which is an extensive curing unit 69, is installed. This extensive curing unit 69 is dimensioned for providing an exposure time of the web substrate S to the ultraviolet radiation applied by said extensive curing unit 69 which is at least one and a half times longer, preferably at least two times longer, and more preferably at least three times longer than an exposure time of the web substrate S to the ultraviolet radiation applied by each of the

remaining curing units 61, 62, 63, 64, 65, 66, 67.

[0055] Longer exposure time of the web substrate S to the ultraviolet radiation applied by said extensive curing unit 69 entails the possibility of a greater curing capacity for curing the inks successively applied by all the preceding printing groups 51, 52, 53, 54, 55, 56, 57, 58 in relation to the curing capacity of the remaining curing units 61, 62, 63, 64, 65, 66, 67.

[0056] Thus, the extensive curing unit 69 located between the last printing group 60 and the preceding printing group 58 allows using a transparent coating varnish or ink, generally having a shiny finish, applied by the last printing group 60 as a layer on top of the inks previously deposited by the remaining printing groups 51, 52, 53, 54, 55, 56, 57, 58, completely covering the surface of the web substrate or a significantly large area thereof, because it assures a curing of these previously deposited inks sufficient to allow depositing the coating varnish or ink thereon without causing the inks to run, even with a high speed of movement of the web substrate S.

[0057] The features of curing units 61, 62, 63, 64, 65, 66, 67, 69, including the extensive curing unit 69 and associated control means, are similar to those described for curing units 61, 63, 64, 65, 66, 67, 68, 69, including the extensive curing unit 61, and associated control means, of the first embodiment.

[0058] The printing machine of the second embodiment shown in Fig. 2 includes a final curing unit 30 having features similar to those described above in relation to the first embodiment.

[0059] Fig. 3 shows a third embodiment of the printing machine having a central impression drum for printing radiation-curable inks of the present invention, which comprises a rotary central impression drum 35 similar to that described above in relation to the first and second embodiments, with four printing groups 51, 53, 54, 55 arranged along the entry side 35a of the central impression drum 35 in a manner similar to that described in relation to the first embodiment illustrated in Fig. 1, and other four printing groups 56, 57, 58, 60 arranged along the exit side 35b of the central impression drum 35 in a manner similar to that described in relation to the second embodiment illustrated in Fig. 2.

[0060] The printing machine of this third embodiment comprises a first extensive curing unit 61 located between the first printing group 51 and the subsequent printing group 53 in a manner similar to that described in relation to the first embodiment illustrated in Fig. 1, a second intensive curing unit 69 located between the last printing group 60 and the preceding printing group 58 in a manner similar to that described in relation to the second embodiment illustrated in Fig. 2, and other five curing units 63, 64, 65, 66, 67 located between each remaining pair of adjacent printing groups 53, 54; 54, 55; 55, 56; 56, 57; 57, 58.

[0061] Thus, the first extensive curing unit 61 located between the first printing group 51 and the subsequent printing group 53 allows using a base ink applied by the first printing group 51 as explained above in relation to the first embodiment, and the second extensive curing unit 69 located between the last printing group 60 and the preceding printing group 58 allows using a coating varnish or ink applied by the last printing group 60 as explained above in relation to the second embodiment.

[0062] The printing machine of the third embodiment shown in Fig. 3 includes a final curing unit 30 having features similar to those described above in relation to the first embodiment.

[0063] The scope of the present invention is defined in the attached claims.

Claims

1. A printing machine having a central impression drum for printing radiation-curable inks, comprising:

a rotary central impression drum (35) having an outer surface suitable for supporting a web substrate (S) between a substrate entry point (11) located on an entry side (35a) of said central impression drum (35) and a substrate exit point (12) located on an exit side (35b) of the central impression drum (35);

a plurality of printing groups (51-60) distributed along said entry side and said exit side of the central impression drum (35), each printing group (51-60) having a printing cylinder (20) depositing a respective radiation-curable ink at a corresponding impression point (1-10) on said web substrate (S) supported on said central impression drum (35), said printing groups (51-60) including a first printing group (51) adjacent to said substrate entry point (11) and a last printing group (60) adjacent to said substrate exit point (12) with respect to the forward movement direction of the web substrate (S);

and a plurality of curing units (61-69) configured and arranged for applying radiation to the web substrate (S) supported on the central impression drum (35) for curing the ink deposited on the web substrate (S), at least one of said curing units (61-69) being arranged between each pair of adjacent printing groups (51-60), **characterized in that**:

between the impression point (1) corresponding to said first printing group (51) and the impression point (3) corresponding to a subsequent printing group (53) and/or between the impression point (10) corresponding to said last printing group (60) and the impression point (8) corresponding to a preceding printing group (58) there is an angular distance with respect to the circumference of the central impression drum (35) at

least one and a half times greater than an angular distance between the impression points (3-5) corresponding to each remaining pair of adjacent printing groups (53-55) located on said entry side (35a) of the central impression drum (35) and than an angular distance between the impression points (6-8) corresponding to each remaining pair of adjacent printing groups (56-58) located on said exit side (35b) of the central impression drum (35); and

in a space provided by said angular distance between the impression point (1) corresponding to the first printing group (51) and the impression point (3) corresponding to said subsequent printing group (53) and/or between the impression point (10) corresponding to the last printing group (60) and the impression point (8) corresponding to said preceding printing group (58), there is installed at least one extensive curing unit (61, 69) dimensioned for providing an exposure time of the web substrate (S) to the radiation applied by said at least one extensive curing unit (61, 69) at least one and a half times longer than an exposure time of the web substrate (S) to the radiation applied by each of the remaining curing units (63-67).

2. The printing machine according to claim 1, **characterized in that** said exposure time during which the web substrate (S) is exposed to the radiation applied by said extensive curing unit (61, 69) is preferably at least two times longer, and more preferably three times longer than said exposure time of the web substrate (S) to the radiation applied by each of the remaining curing units (63-67).

3. The printing machine according to claim 1 or 2, **characterized in that** said curing unit (61-69) comprises at least one ultraviolet radiation source.

4. The printing machine according to claim 3, **characterized in that** said ultraviolet radiation source comprises an array (71) of ultraviolet light emitting diodes (72) arranged for emitting ultraviolet radiation towards the web substrate (S) covering a maximum allowable substrate width (Asm) for the web substrate (S).

5. The printing machine according to claim 4, **characterized in that** the printing machine (50) comprises control means (80) selectively activating the operation of said ultraviolet light emitting diodes (72) of said array (71) according to one or more impression data relating to a printing job that is being performed by the printing machine.

6. The printing machine according to claim 5, **characterized in that** said control means (80) include data acquisition means acquiring said impression data

7. The printing machine according to claim 6, **characterized in that** the impression data comprise a substrate width (As) of the web substrate (S) on which said printing job is performed and/or one or more characteristics of the ink deposited on the web substrate (S) and/or a location of ink areas (At) deposited on the web substrate (S).

8. The printing machine according to claim 6 or 7, **characterized in that** said control means (80) adapt one or more operation parameters of the ultraviolet light emitting diodes (72) to one or more of said impression data.

9. The printing machine according to claim 8, **characterized in that** said one or more operation parameters of the ultraviolet light emitting diodes (72) comprise radiation power and/or radiation wavelength.

10. The printing machine according to claim 3, **characterized in that** said ultraviolet radiation source comprises one or more mercury discharge lamps.

11. The printing machine according to claim 1, 2 or 3, **characterized in that** the printing machine (50) comprises a final curing unit (30) configured and arranged for applying radiation to the web substrate (S) after the substrate exit point (12) of the central impression drum (35) with respect to the forward movement direction of the web substrate (S).

12. The printing machine according to claim 11, **characterized in that** said final curing unit (30) comprises at least one ultraviolet radiation source or at least one electron beam source (76).

13. The printing machine according to claim 12, **characterized in that** said ultraviolet radiation source comprises one or more mercury discharge lamps.

14. The printing machine according to claim 1, **characterized in that** said printing groups (51-60) are flexographic printing groups, rotogravure printing groups, offset printing groups, or a combination of flexographic printing groups and/or rotogravure printing groups and/or offset printing groups.

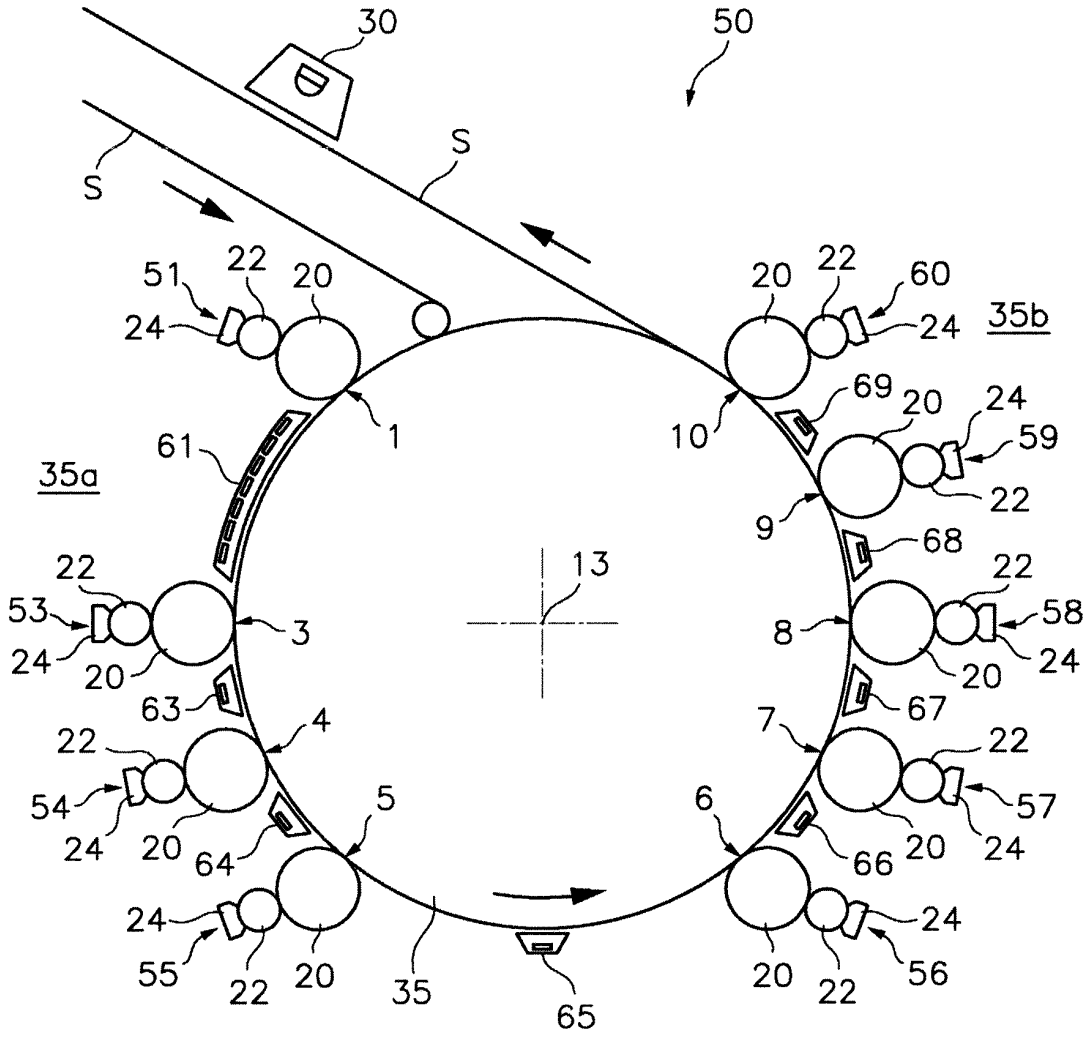
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Fig. 1

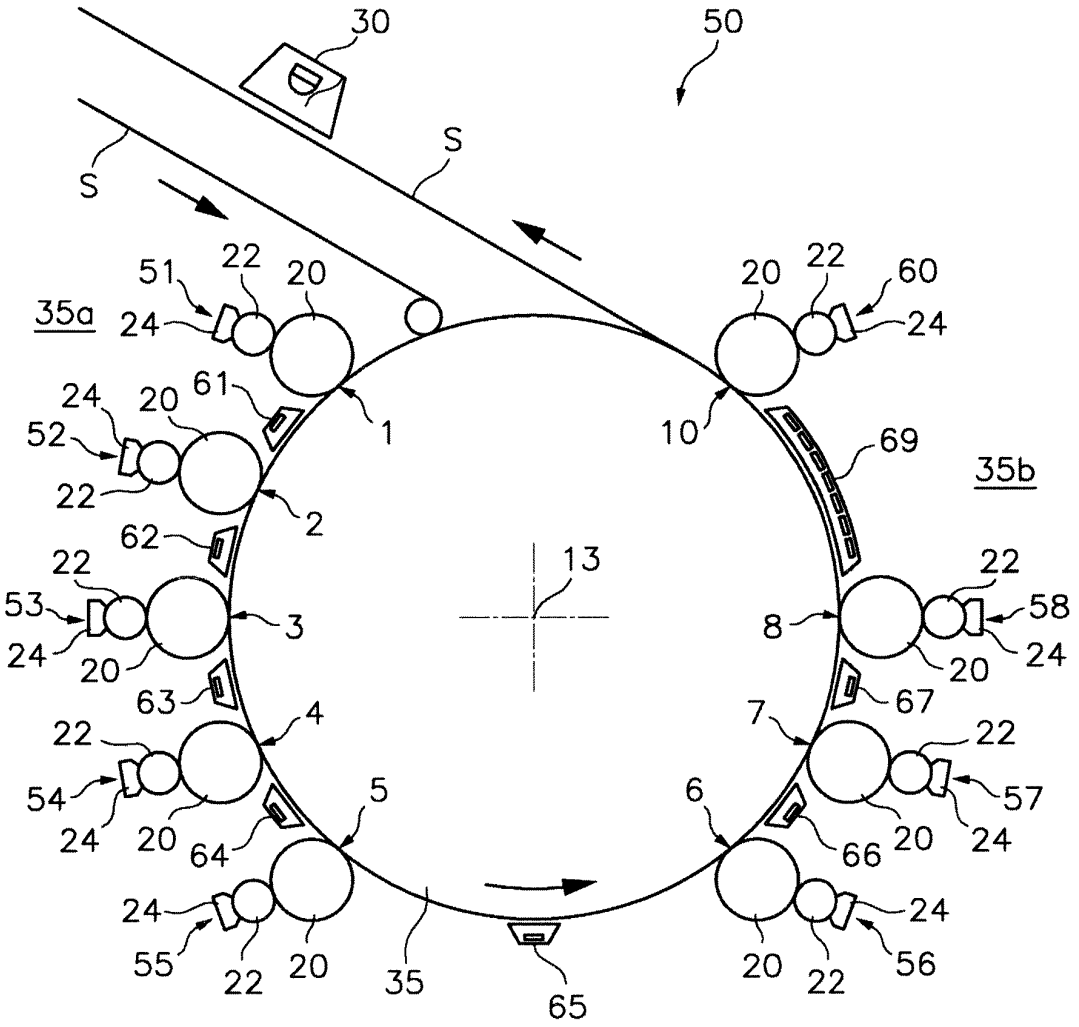
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Fig.2

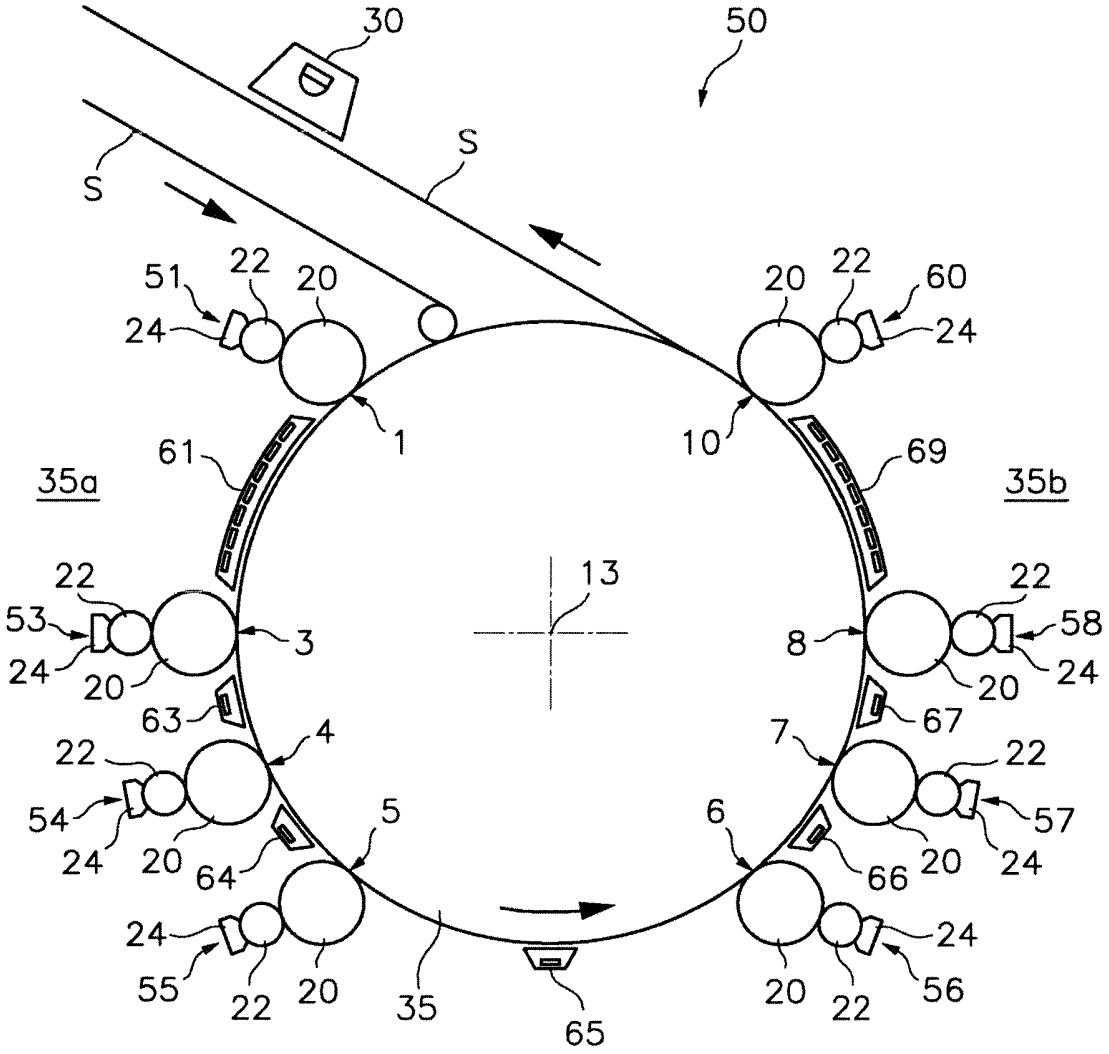
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Fig.3

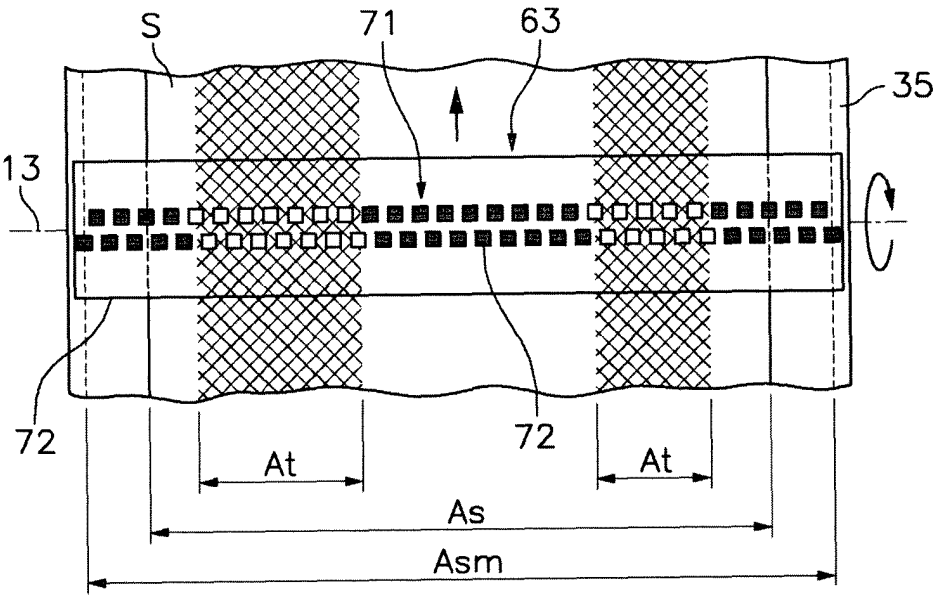

Fig.4

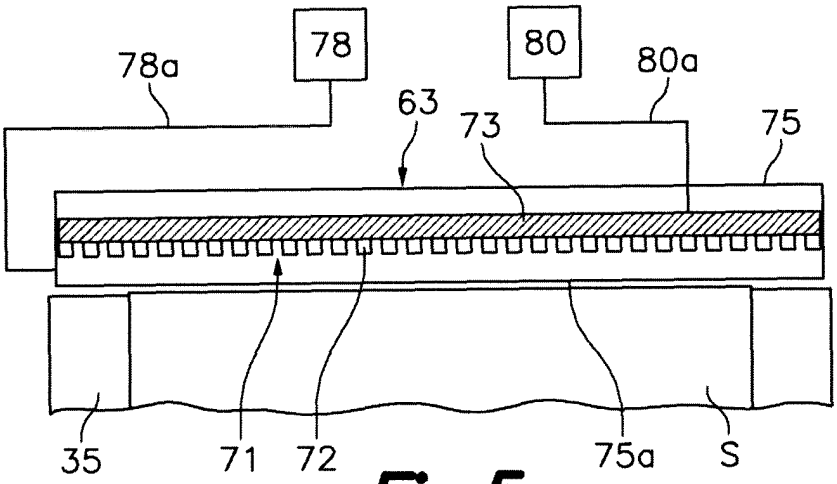

Fig.5

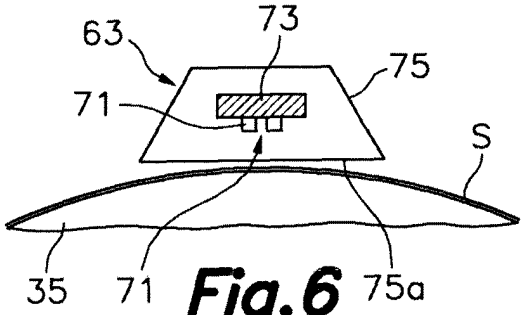

Fig.6

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EUROPEAN SEARCH REPORT

Application Number
EP 13 38 0045

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	8 May 2014	Fox, Thomas

CATEGORY OF CITED DOCUMENTS

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