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(54) **PRINTER AND METHOD FOR OPERATING A PRINTER**

(57) The present invention relates to a print method involving a first carriage configured to move in reciprocation in a scanning direction and a second carriage configured to move in reciprocation in a scanning direction. The first carriage carries at least one print head and the

second carriage carries a source of radiation. The speed of movement of the first carriage is increased with regard to the speed of the second carriage to improve the productivity of the print process.

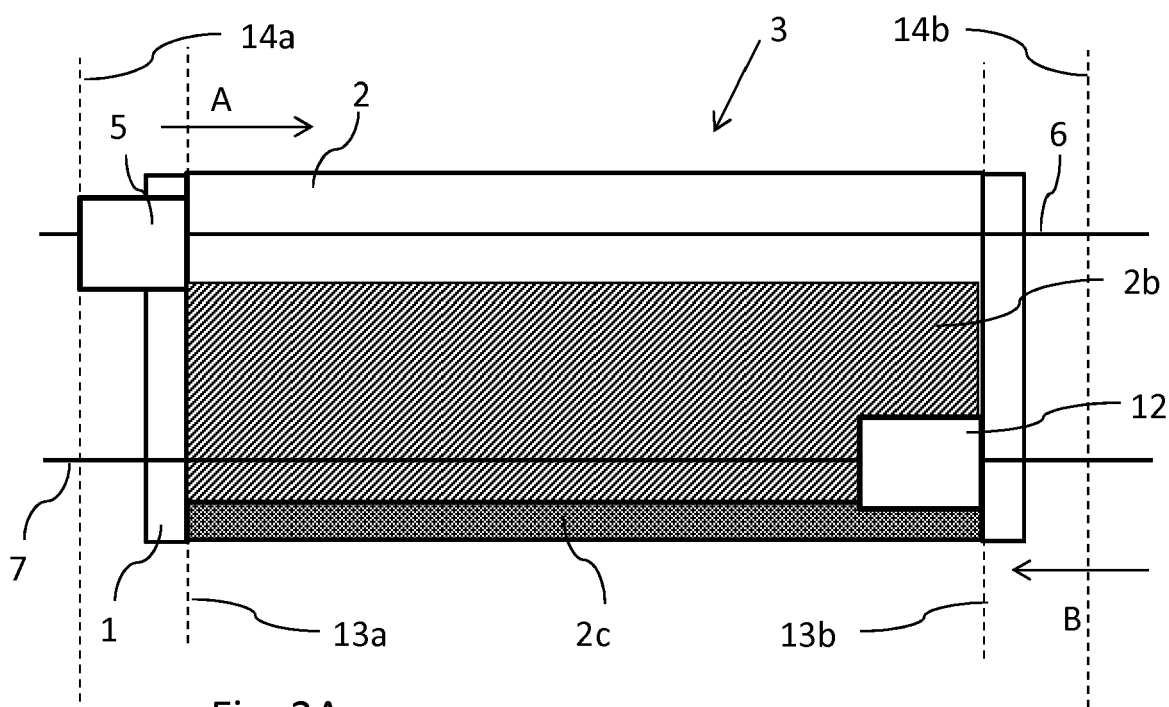


Fig. 2A

Description

[0001] The present invention relates to a method for operating a printer comprising a first carriage and a second carriage. The invention also relates to a printer comprising a first carriage and a second carriage.

Background of the invention

[0002] It is known to form an image on a recording medium in a printer by applying a radiation curable ink onto the medium and subsequently curing the curable ink, deposited on the recording medium, by providing radiation, such as a UV radiation, onto the curable ink. The radiation is provided by a suitable source of radiation, such as a UV lamp, e.g. a UV LED lamp. The radiation curable ink can be applied onto the recording medium by at least one print head.

[0003] A printer that can perform such image forming process may comprise a first carriage and a second carriage. Both the first and second carriage are configured to move in reciprocation in a scanning direction. The first carriage may be e.g. a print head carriage carrying at least one print head for applying droplets of radiation curable ink onto the recording medium. The second carriage may carry a suitable source of radiation for curing the ink. The second carriage may be positioned downstream with regard to the first carriage in a sub scanning direction.

[0004] It is desired that the printer can be operated at high speed. In this way, high productivity can be obtained.

[0005] However, the speed at which the second carriage can be moved may be limited. This limited speed may limit the overall productivity at which the printer can be operated.

[0006] It is therefore an object of the present invention to improve the overall speed at which the printer can be operated.

Summary of the invention

[0007] The object of the present invention is achieved in a method for operating a printer, the printer comprising a first carriage configured to move in reciprocation in a scanning direction, the first carriage comprises a main carriage and a sub-carriage, wherein the sub-carriage is moveable in at least one of the scanning direction and the sub-scanning direction with respect to the main carriage, the sub-carriage carrying at least one print head and a second carriage configured to move in reciprocation in the scanning direction, wherein the second carriage carries at least one source of radiation for curing an ink, wherein the second carriage is positioned downstream of the first carriage in a sub-scanning direction, the sub-scanning direction being essentially perpendicular to the scanning direction, the method comprising the steps of:

a. operating the first carriage to perform a first cycle in a first amount of time, the first cycle comprising:

- i. moving the first carriage in the scanning direction from a first side to a second side at a first speed;
- ii. moving the first carriage and a recording medium relative to one another in the sub scanning direction;
- iii. adjusting the position of the sub-carriage with regard to the main carriage;

b. operating the second carriage to perform a second cycle in a second amount of time, the second cycle comprising:

- i. moving the second carriage and the recording medium relative to one another in the scanning direction from a first one of the first side and the second side to the other one of the first side and the second side at a second speed;
- ii. moving the second carriage and the recording medium relative to one another in the sub scanning direction,

wherein the first speed is higher than the second speed.

[0008] The method according to the present invention may show overall higher productivity. In the method according to the present invention, a printer is operated. The printer may be an ink-jet printer. An ink-jet printer may in operation form an image onto a recording medium by applying a predetermined pattern of droplets onto the recording medium. The droplets may be droplets of a UV curable ink, preferably a UV curable phase change ink, in particular a UV curable gelling ink.

[0009] The printer may comprise a first carriage. The first carriage may be configured to move in reciprocation in a scanning direction. The first carriage may carry at least one print head for applying droplets of ink onto the recording medium. By applying droplets of ink in a predetermined manner, an image may be formed onto the recording medium. Only one color of ink may be applied onto the recording medium, thereby forming a monochrome image. Alternatively, a plurality of different colors of ink may be applied onto the recording medium, thereby forming a polychrome image. For example, a polychrome image may be formed by using Cyan, Magenta, Yellow and black ink.

[0010] The first carriage may comprise a main carriage and a sub-carriage, wherein the sub-carriage is moveable in at least one of the scanning direction and the sub-scanning direction with respect to the main carriage. When moving the first carriage and the recording medium with respect to one another in the sub scanning direction, for example when performing a paper step in between swaths, the movement may be inaccurate. Such inaccuracies in movement may lead to inaccurate stitching of the adjacent swaths. If the movement in the transport

direction is too small, the adjacent swaths will partly overlap, usually resulting in an undesired dark line in the printed image due to a local excess of a number of printed dots. If the movement in the transport direction is too large, a gap between the adjacent swaths results, which may be visible as a line with the color of the recording medium, which is usually white. So, usually, a white line becomes visible.

[0011] In order to increase the stitching accuracy, a sub-carriage is provided on the carriage, wherein the sub-carriage is moveable relative to the carriage. An inaccuracy in the relative movement in the transport direction of the carriage and the recording medium is then compensable by translating and/or rotating the sub-carriage relative to the carriage in the transport direction.

[0012] The printer may comprise a second carriage. The second carriage may be configured to move in reciprocation in a scanning direction. The second carriage may carry at least one source of radiation. The second carriage is positioned downstream of the first carriage in a sub-scanning direction, the sub-scanning direction being essentially perpendicular to the scanning direction. The sub-scanning direction may be the paper transport direction, i.e. the direction in which the recording medium is transported through the printer.

[0013] In the method according to the present invention, the first carriage is operated to perform a first cycle in a first amount of time. In step i the first carriage is moved in the scanning direction from a first side to a second side at a first speed. A print surface may be present underneath the first carriage. The print surface may extend to an area underneath the second carriage. The print surface may be limited in the scanning direction. The print surface may be limited in the scanning direction at a first side and a second side. The print surface may be configured to hold a recording medium in printing operation. The print surface may be provided with holes for providing an underpressure for fixing the recording medium onto the print surface. The width of the recording medium, i.e. the length of the recording medium in the scanning direction, may match the length of the print surface in the scanning direction. Alternatively, the length of the recording medium in the scanning direction, may be smaller than the length of the print surface in the scanning direction. The carriage is moved from a first side to a second side in the scanning direction. The first side may be the position at which the first carriage starts the scanning movement, the second end may be the position at which the first carriage stops the scanning movement. The position of the first end and second end may be selected such that the first carriage traverses the entire length of the recording medium, to allow the print head mounted on the first carriage to apply droplets of ink over the length of the recording medium, thereby forming an image. The first carriage may be moved at a first speed.

[0014] In step i, part of an image is formed on an area of the recording medium. The width of the part of the image may correspond to the length of the at least one

print head in a direction substantially perpendicular to the scanning direction, and is also referred to as swath width.

[0015] In step ii, the first carriage and a recording medium are moved relative to one another in the sub scanning direction. In step i. in a first swath a first part of the image was applied. To further form the image onto the recording medium, the at least one print head, carried by the first carriage and the recording medium have to be moved with respect to one another to allow the formation of another part of the image on another part of the recording medium. Therefore, the first carriage and the recording medium are moved relative to one another in the sub scanning direction. The first carriage may be moved in the sub scanning direction or the recording medium may be moved in the sub scanning direction. Alternatively, both the first carriage and the recording medium may be moved in the sub scanning direction. The first carriage and the recording medium may be moved relative to one another in a second amount of time.

[0016] In a further embodiment, the first cycle comprises the step of:

In step iii., the position of the sub-carriage with regard to the main carriage is adjusted. By adjusting the position of the sub-carriage with regard to the main carriage, inaccuracies in the movement of the first carriage and the recording medium may be compensated. Further, adjusting the position of the sub-carriage carrying at least one print head, with respect to the main carriage may result in adjusting the position of the at least one print head carried by the sub-carriage. This may result in accurate positioning of the print heads with respect to the recording medium, which may result in better stitching accuracy, thereby improving print quality.

[0017] In the second cycle, in step i, the second carriage and the recording medium are moved relative to one another in the scanning direction from the second side to the first side at a second speed. Preferably, the second carriage is moved, while the recording medium is in a substantially fixed position during step i. In step i., the at least one source of radiation irradiates the ink, thereby curing the ink to obtain a robust ink layer. The ink applied onto the recording medium may be uncured before it is irradiated by the source of radiation carried by the second carriage. Alternatively, the ink may be already partially cured ("pinned") before it is irradiated by the source of radiation carried by the second carriage. By moving the second carriage and the recording medium relative to one another in the scanning direction, a part of the image printed may be cured. The speed at which the second carriage can be moved may be limited. To suitably cure the radiation curable ink present on the recording medium, a sufficient amount of radiation has to be supplied to the ink. The amount of radiation supplied to the ink depends e.g. on the amount of time that the source of radiation locally irradiates the ink. Hence, the amount of radiation supplied depends on the speed of the carriage. Therefore, the speed of the second carriage

with respect to the recording medium may not be too high, because then the ink may not be fully cured. Therefore, the speed of the second carriage may be lower than the speed of the first carriage.

[0018] In step ii of the second cycle, the second carriage is moved in the sub scanning direction. In step i, a first image received radiation from the source of radiation and may consequently have been cured. In a subsequent swath of the second carriage, a second image may receive radiation from the source of radiation and may consequently be cured. However, the second carriage and the recording medium need to be moved with regard to one another in the sub scanning direction. The second carriage may be moved in the sub scanning direction or the recording medium may be moved in the sub scanning direction. Alternatively, both the second carriage and the recording medium may be moved in the sub scanning direction.

[0019] In the method according to the present invention, when moving in the scanning direction, the first carriage may move at a higher speed than the second carriage. As a consequence, the first carriage needs less time to travel from one side to the other than the second carriage. The first carriage may have to wait for the second carriage. However, during this period, the position of the first carriage with respect to the recording medium may be calibrated. Thus, when using the present invention, the speed of the printer can be increased without mitigating the print quality.

[0020] In an embodiment, the first amount of time equals the second amount of time. The at least one print head mounted on the first carriage is configured to apply droplets onto the recording medium, thereby forming an image. The image is built by printing a plurality of swaths. The swaths may be printed adjacent to one another or may partially overlap. The printed image is cured in a plurality of swaths.

[0021] In this embodiment, the number of swaths performed by the first carriage in a certain time interval may equal the number of swaths performed by the second carriage in that time interval. In this way, the time between printing and curing may be kept essentially constant, which may prevent decrease of print quality.

[0022] In an embodiment, step ii of the first cycle and step ii of the second cycle are performed simultaneously. When operating the printer having two scanning carriages; the first carriage and the second carriages, both carriages have to be moved with regard to the recording medium in the sub-scanning direction to perform a subsequent swath. It is preferred that the first carriage and the second carriage are moved in the sub-scanning direction with regard to the recording medium simultaneously. This can be done e.g. by moving the recording medium in the sub scanning direction. Alternatively and/or additionally, a frame, to which both the first carriage and the second carriage are connected, may be moved in the sub-scanning direction.

[0023] In an embodiment, step iii of the first cycle is

performed during step i of the second cycle.

[0024] Step iii of the first cycle may be finished before step i of the second cycle is finished. When step iii of the first cycle is finished, the first cycle may be restarted and step i of the first cycle may be performed. Preferably, step i of the first cycle and step i of the second cycle finish at about the same time.

[0025] By performing the adjustment the position of the sub-carriage with regard to the main carriage while the second carriage moves with regard to the recording medium, the printer may be operated in a productive way.

[0026] In an embodiment, the first cycle further comprises:

iv. pausing the first carriage.

[0027] In step iii, there may be no substantive movement of the first carriage in the scanning direction; i.e. the first carriage does not yet start a subsequent swath. In step iii, the first carriage may wait to compensate for the higher speed of the first carriage in step i of the first cycle, compared to the speed of the second carriage in step i of the second cycle. Optionally, in step iii, the position of the first carriage with regard to the recording medium may be calibrated. When moving the recording medium and first carriage with respect to one another, inaccuracies may occur. It is important that the print head is accurately positioned with respect to the recording medium, because inaccurate positioning may result in poor print quality. In step iii, the relative position of the print head carried by the first carriage and the recording medium is checked and if necessary, adjusted. Optionally, a number of dots may be printed for use in the calibration process.

[0028] In an embodiment, the first cycle further comprises:

v. moving the first carriage in the scanning direction from the second side to the first side at the first speed;
vi. moving the first carriage and a recording medium relative to one another in the sub scanning direction.

[0029] A print may be built in a plurality of swaths. Thus, after performing a first swath and moving the first and second carriage with regard to the recording medium in the sub scanning direction, a subsequent swath may be performed. Preferably, in a second swath, the first carriage moves in an opposite direction in the scanning direction, with regard to the first swath. Analogously, in a second swath, the second carriage preferably moves in an opposite direction in the scanning direction, with regard to the first swath.

[0030] In an embodiment, in step i of the first cycle, position markers are applied onto the recording medium. In addition to printing ink droplets for forming an image, additional droplets may be applied. Such droplets may form position markers. The position markers may be detected by suitable detection means. Based on the detect-

ed position of the position markers, the relative position of the position markers and the first carriage may be determined. Known suitable position markers are markers provided with yellow ink in thin lines. Such yellow thin lines are essentially invisible to the human vision when normally viewing the printed image due to the limited contrast to a white recording medium. Of course, if the recording medium is not white, a different color may be selected such that a contrast with the recording medium is limited. A commonly known sensor unit may be applied in the inkjet printing assembly for optically detecting such a position marker, wherein the contrast between recording medium and position marker may be enhanced either by the optical system or in image processing. Of course, any other kind of position marker may be employed instead. For example, a part of the second swath may be already printed in the first swath and its position may be detected during printing of the complete second swath. Other suitable methods and markers are well known in the art and it is deemed within the ambit of the skilled person to select such a method and marker for detecting a position of the first swath.

[0031] In a further embodiment, the position of the sub-carriage is adjusted based on the position of the position markers.

[0032] The position of the position markers may be detected by suitable detection means, such as a sensor unit, for example an optical sensor. The detection means may be positioned on the sub-carriage. By detecting the position of the position markers, the relative position of the position markers with regard to the sub-carriage may be determined. Based on the determined position, the position of the sub-carriage with respect to the main carriage may be adjusted. Thus, stitching accuracy may be improved.

[0033] In an embodiment, in step i of the second cycle, the second carriage is moved from the second side to the first side. In this embodiment, if the first carriage and the second carriage are both moving in the scanning direction, then they are moving in opposite direction. Both the first carriage and the second carriage have a certain weight. By moving the first and second carriage in opposite directions, the forces acting on the printer due to movement of the carriages is better distributed, which improves the stability of the printer.

[0034] In an embodiment, the at least one print head is configured to eject droplets of a radiation-curable gelling ink onto a recording medium. Radiation-curable gelling inks, such as UV-curable gelling inks, can be suitably applied in the present invention. Gelling ink may be kept in a reservoir of the print head at elevated temperature. At elevated temperatures, the UV-curable gelling inks are liquid and can be suitably jetted. When applied onto the recording medium, the ink droplets may cool down. Due to the decrease in temperature, the viscosity of the ink droplets may increase, thereby preventing color bleed. There may be a certain time interval between applying the ink onto the recording medium and curing the

ink onto the recording medium. When using a gelling ink, the uncured ink droplets may be sufficiently stable to allow formation of an image having good image quality.

[0035] In an embodiment, the first carriage carries a plurality of print heads. By applying more print heads, the productivity can be improved. Further, in practice often one type of ink (color of ink) is applied by a single print head. Therefore, by providing a plurality of print heads, multi colored images can be formed. Further, also print heads configured to apply a primer composition, an overcoat composition and/or a metallic ink may be provided.

[0036] In an aspect of the invention, a printer is provided, the printer comprising a first carriage configured to move in reciprocation in a scanning direction and a second carriage configured to move in reciprocation in the scanning direction, wherein the second carriage is positioned downstream of the first carriage in a sub-scanning direction, the sub-scanning direction being essentially perpendicular to the scanning direction, the printer further comprising a control unit configured to control the first carriage and the second carriage in accordance with the method according to the present invention. The printer is thus configured to perform the method according to the present invention.

Brief Description of the Drawings

[0037] The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying schematical drawings which are given by way of illustration only, and thus are not limitative of the present invention, and wherein:

Fig. 1A shows a schematic representation of an inkjet printing system.

Fig. 1B shows a schematic representation of an inkjet print head.

Fig. 2A-2E show a schematic representation of a first example of the method according to the invention.

Fig. 3A-3C show a schematic representation of a second example of the method according to the invention.

Fig. 4 shows a schematic representation of a third example of a method according to the invention.

Fig. 5 shows a schematic representation of an aspect of a fourth example of the method according to the present invention.

Fig. 6 shows a schematic representation of an aspect of a fifth example of the method according to the present invention.

Fig. 7A and Fig. 7B show a schematic representation of an aspect of a sixth example of the method according to the present invention.

[0038] In the drawings, same reference numerals refer to same elements.

Detailed description of the Drawings

[0039] The present invention will now be described with reference to the accompanying drawings, wherein the same reference numerals have been used to identify the same or similar elements throughout the several views.

[0040] Fig. 1A shows an ink jet printing assembly 3. The ink jet printing assembly 3 comprises supporting means for supporting an image receiving medium 2. The supporting means are shown in Fig. 1A as a flat surface 1, but alternatively, the supporting means may be a platen, for example a rotatable drum that is rotatable around an axis. The supporting means may be optionally provided with suction holes for holding the image receiving medium in a fixed position with respect to the supporting means. The ink jet printing assembly 3 comprises print heads 4a - 4d, mounted on a scanning print carriage 5. The scanning print carriage 5 is guided by suitable guiding means 6 to move in reciprocation in the main scanning direction X. Each print head 4a - 4d comprises an orifice surface 9, which orifice surface 9 is provided with at least one orifice 8, as is shown in Fig. 1B. The print heads 4a - 4d are configured to eject droplets of marking material onto the image receiving medium 2.

[0041] The image receiving medium 2 may be a medium in web or in sheet form and may be composed of e.g. paper, cardboard, label stock, coated paper, plastic or textile. Alternatively, the image receiving medium 2 may also be an intermediate member, endless or not. Examples of endless members, which may be moved cyclically, are a belt or a drum. The image receiving medium 2 is moved in the sub-scanning direction Y over the flat surface 1 along four print heads 4a - 4d provided with a fluid marking material.

[0042] The image receiving medium 2, as depicted in Fig. 1A is locally heated or cooled in the temperature control region 2a. In the temperature control region 2A, temperature control means (not shown), such as heating and/or cooling means may be provided to control the temperature of the receiving medium 2. Optionally, the temperature control means may be integrated in the supporting means for supporting an image receiving medium 2. The temperature control means may be electrical temperature control means. The temperature control means may use a cooling and/or heating liquid to control the temperature of the image receiving medium 2. The temperature control means may further comprise a sensor (not shown) for monitoring the temperature of the image receiving medium 2.

[0043] A scanning print carriage 5 carries the four print heads 4a - 4d and may be moved in reciprocation in the main scanning direction X parallel to the platen 1, such as to enable scanning of the image receiving medium 2 in the main scanning direction X. Only four print heads 4a - 4d are depicted for demonstrating the invention. In practice an arbitrary number of print heads may be employed. In any case, at least one print head 4a - 4d per

color of marking material is placed on the scanning print carriage 5. For example, for a black-and-white printer, at least one print head 4a - 4d, usually containing black marking material is present. Alternatively, a black-and-white printer may comprise a white marking material, which is to be applied on a black image-receiving medium 2. For a full-color printer, containing multiple colors, at least one print head 4a - 4d for each of the colors, usually black, cyan, magenta and yellow is present. Often, in a full-color printer, black marking material is used more frequently in comparison to differently colored marking material. Therefore, more print heads 4a - 4d containing black marking material may be provided on the scanning print carriage 5 compared to print heads 4a - 4d containing marking material in any of the other colors. Alternatively, the print head 4a - 4d containing black marking material may be larger than any of the print heads 4a - 4d, containing a differently colored marking material.

[0044] The carriage 5 is guided by guiding means 6. These guiding means 6 may be a rod as depicted in Fig. 1A. Although only one rod 6 is depicted in Fig. 1A, a plurality of rods may be used to guide the carriage 5 carrying the print heads 4. The rod may be driven by suitable driving means (not shown). Alternatively, the carriage 5 may be guided by other guiding means, such as an arm being able to move the carriage 5. Another alternative is to move the image receiving material 2 in the main scanning direction X.

[0045] Each print head 4a - 4d comprises an orifice surface 9 having at least one orifice 8, in fluid communication with a pressure chamber containing fluid marking material provided in the print head 4a - 4d. On the orifice surface 9, a number of orifices 8 are arranged in a single linear array parallel to the sub-scanning direction Y, as is shown in Fig. 1B. Alternatively, the nozzles may be arranged in the main scanning direction X. Eight orifices 8 per print head 4a - 4d are depicted in Fig. 1B, however obviously in a practical embodiment several hundreds of orifices 8 may be provided per print head 4a - 4d, optionally arranged in multiple arrays.

[0046] As depicted in Fig. 1A, the respective print heads 4a - 4d are placed parallel to each other. The print heads 4a - 4d may be placed such that corresponding orifices 8 of the respective print heads 4a - 4d are positioned in-line in the main scanning direction X. This means that a line of image dots in the main scanning direction X may be formed by selectively activating up to four orifices 8, each of them being part of a different print head 4a - 4d. This parallel positioning of the print heads 4a - 4d with corresponding in-line placement of the orifices 8 is advantageous to increase productivity and/or improve print quality. Alternatively multiple print heads 4a - 4d may be placed on the print carriage adjacent to each other such that the orifices 8 of the respective print heads 4a - 4d are positioned in a staggered configuration instead of in-line. For instance, this may be done to increase the print resolution or to enlarge the effective print area, which may be addressed in a single scan in the

main scanning direction X. The image dots are formed by ejecting droplets of marking material from the orifices 8.

[0047] The ink jet printing assembly 3 may further comprise curing means 11a, 11b. As shown in Fig. 1A, a scanning print carriage 12 carries the two curing means 11a, 11b and may be moved in reciprocation in the main scanning direction X parallel to the platen 1, such as to enable scanning of the image receiving medium 2 in the main scanning direction X. Alternatively, more than two curing means may be applied. The first curing means 11a may emit a first beam of UV radiation, the first beam having a first intensity. The first curing means 11a may be configured to provide the radiation for the pre-curing step. The second curing means 11b may emit a second beam of radiation, the second beam of radiation having a second intensity. The second curing means 11b may be configured to provide the radiation for the post-curing step.

[0048] The carriage 12 is guided by guiding means 7. These guiding means 7 may be a rod as depicted in Fig. 1A. Although only one rod 7 is depicted in Fig. 1A, a plurality of rods may be used to guide the carriage 12 carrying the print heads 11. The rod 7 may be driven by suitable driving means (not shown). Alternatively, the carriage 12 may be guided by other guiding means, such as an arm being able to move the carriage 12. The curing means may be energy sources, such as actinic radiation sources, accelerated particle sources or heaters. Examples of actinic radiation sources are UV radiation sources or visible light sources. UV radiation sources are preferred, because they are particularly suited to cure UV curable inks by inducing a polymerization reaction in such inks. Examples of suitable sources of such radiation are lamps, such as mercury lamps, xenon lamps, carbon arc lamps, tungsten filaments lamps, light emitting diodes (LED's) and lasers. In the embodiment shown in Fig. 1A, the first curing means 11a and the second curing means 11b are positioned parallel to one another in the sub scanning direction Y. The first curing means 11a and the second curing means 11b may be the same type of energy source or may be different type of energy source. For example, when the first and second curing means 11a, 11b, respectively both emit actinic radiation, the wavelength of the radiated emitted by the two respective curing means 11a, 11b may differ or may be the same. The first and second curing means are depicted as distinct devices. However, alternatively, only one source of UV radiation emitting a spectrum of radiation may be used, together with at least two distinct filters. Each filter may absorb a part of the spectrum, thereby providing two beams of radiation, each one having intensity different from the other.

[0049] The flat surface 1, the temperature control means, the carriage 5, the print heads 4a - 4d, the carriage 12 and the first and second curing means 11a, 11b are controlled by suitable controlling means 10.

[0050] Fig. 2 shows a schematic representation of a

first example of the method according to the invention. A printer 3 is provided. The printer 3 comprises a flat surface 1 that carries a recording medium 2. The printer further comprises a first carriage 5 that carries a number of print heads (not shown). The carriage 5 is connected to guide rail 6. The printer further comprises the second carriage 12. The second carriage 12 carries a source of radiation for curing the ink (not shown). The second carriage 12 is connected to guide rail 7.

[0051] In Fig. 2A, the second carriage is positioned above the recording medium 2. The recording medium comprises a printed part 2b. On the printed part 2b, ink has been applied by the print heads carried by the first carriage 5. On printed part 2b, the ink has not yet been cured. The recording medium further comprises a cured part 2c. On the cured part 2c of the recording medium the ink has been applied and has been cured. The recording medium has a first edge 13a and a second edge 13b. The image is formed onto the recording medium 2 by applying ink onto the recording medium in between the first edge 13a and the second edge 13b.

[0052] The second carriage 12 is positioned above the printed part of the medium 2b. The source of radiation irradiates the ink, thereby curing the ink. The second carriage is moving in direction B towards the first side 14a. The first carriage 5 is positioned at first side 14a. The first carriage 5 has not yet moved in direction A.

[0053] In Fig. 2B, the first carriage and the second carriage 12 have moved compared to the situation shown in Fig. 2A. The first carriage has moved in direction A and is positioned at the second end 14b. The second carriage 12 has moved in direction B, which is opposite to direction A, and is positioned at the first end 14a. When comparing the situation shown in Fig. 2A and the situation shown in Fig. 2B, the first carriage 5 has travelled a greater distance than the second carriage 12. As shown in Fig. 2B, both the first 5 and second carriage 12 have finished the swath.

[0054] Next, as shown in Fig. 2C, the first carriage 5 and the second carriage 12 are moved with regard to the recording medium. In the example shown in Fig. 2C, this is done by moving the recording medium in direction C, which is essentially perpendicular to both directions A and B.

[0055] In Fig. 2D, the first carriage 5 is in the same position as in the situation shown in Fig. 2C. The second carriage 12 is moving in the direction B'. This is a direction opposite the direction B, in which the second carriage 12 moved in the situation shown in Fig. 2A. The cured portion 2c of the recording medium extends over an area downstream of the second carriage 12 with regard to the recording medium transport direction (direction C) and the area of the present swath of the second carriage 12 that was already traversed by the second carriage 12.

[0056] In Fig. 2E, the first carriage 5 is positioned at the first end 14a; the second carriage 12 is positioned at the second end 14b. When comparing the situation shown in Fig. 2E with the situation shown in Fig. 2D, the

first carriage 5 has travelled a greater distance in the same amount of time as the second carriage 12. Thus, the first carriage 5 has travelled at a speed that is larger than the speed of the first carriage 12.

[0057] Fig. 3 shows a schematic representation of a second example of the method according to the invention.

[0058] In Fig. 3A, a printer comprising a flat surface 1 that carries a recording medium 2. In the second example, the relative width of the recording medium 2 with regard to the flat surface 1 is smaller than the relative width of the recording medium 2 with regard to the flat surface 1 shown in the first example (Fig. 2A-2E).

[0059] In the situation shown in Fig. 3A, the second carriage 12 is positioned above the printed part of the recording medium 2b. The first carriage 5 is positioned at the first side 14a.

[0060] In Fig. 3B, the second carriage 12 is positioned at the first side 14a, the first carriage 5 is positioned at the second side 14b. Part of the recording medium 2 has been provided with ink and has become part of the printed part of the recording medium 2b. Part of the printed part of the recording medium 2b has been cured and has become part of the cured part of the image 2c. The first carriage 5 has travelled a greater distance than the second carriage 12. Thus, the first carriage 5 has travelled at higher speed than the second carriage 12.

[0061] In Fig. 3C, the recording medium 3 has been moved in the recording medium transport direction C and the second carriage 12 has moved in direction B'. The first carriage 5 is still positioned at the second side 14b.

[0062] Fig. 4 shows a schematic representation of a third example according to the present invention. In Fig. 4, both the first carriage 5 and the second carriage 12 are positioned at the second end 14b. When starting a subsequent swath, first carriage 5, as well as the second carriage 12 will move in direction A. However, the first carriage 5 may start moving in direction A only after the second carriage 12 has started moving in direction A. In a subsequent swath, the first carriage 5 and the second carriage 12 may move in a direction opposite to direction A.

[0063] Fig. 5 illustrates a part of a scanning inkjet printing assembly. In particular, the embodiment of Fig. 5 comprises a medium support surface 1, also referred to herein as the print surface 1, on which an image receiving member, herein also referred to as a recording medium, may be arranged. The guide beam 6 extends over the print surface 1 and the first carriage 5 is moveably supported thereon. The carriage 5 supports a sub-carriage 51 and the sub-carriage 51 supports - in the illustrated embodiment - eight print heads 4, but the present invention is in no way limited to a specific number of print heads. The part of the first carriage excluding the sub-carriage may be referred to as main-carriage. Further, the sub-carriage 51 supports - in this embodiment - two optical sensor units 40, one on either side of the array of print heads such that at least one optical sensor unit 40

is available upstream of the array of print heads 4 during printing. Hence, if the scanning printing assembly is configured to print only when the carriage 5 is moving in one direction, it suffices to have a single optical sensor unit 40 upstream of the print heads 4. Further, only one, or more optical sensor units 40 may be provided as well, for example in order to improve a detection accuracy. It is noted that, in another embodiment, the optical sensor units may be arranged on the carriage 5 or a sensor unit 40 may be supported directly on the guide beam 16. In the latter embodiment, the sensor unit 40 may be moveably supported or a sensor unit 40 extending over the full width of the guide beam 16 (in particular in the Y-axis direction as defined in Fig. 1C) may be statically arranged thereon. An advantage of providing the sensor units 40 on the sub-carriage 51 is the fact that a position of the sensor units 40 is directly coupled to a position of the print heads 4, which ensures that a detection of a position of a first swath by the sensor units 40 is easily coupled and related to the position of the print heads 4. Further, it is noted that the sensor units 40 are not restricted to optical sensor units, although optical sensor units 40 may be deemed most apparently suitable kind of sensor units. However, any other kind of sensor capable of detecting a position of a previous swath is contemplated as well.

[0064] The guide beam 6 is moveably supported and may be controlled to move either in a first beam direction X1 or a second beam direction X2. The carriage 5 is arranged to be moveable in a first carriage direction A and a second carriage direction A'. The sub-carriage 51 is moveably supported such to be controllably moved in a first sub-carriage direction X3 or a second sub-carriage direction X4 and such to be controllably moved in a sub-carriage rotation direction Rz1 around a rotation axis Rz (also referred to herein as a center of rotation) extending in the Z-direction, wherein the Z direction is essentially perpendicular to both direction A and X1. Although the center of rotation Rz is illustrated in a geometric center of the sub-carriage 51, a center of rotation in another embodiment may be selected to be arranged on any other suitable location.

[0065] Two adjacent swaths, a first swath 101 and a second swath 102, are depicted by three dashed lines: a first swath trailing edge 101a, a first swath leading edge 101b and a second swath leading edge 102b. A second swath trailing edge coincides with the first swath leading edge 101b and is thus not separately indicated in Fig. 5.

[0066] In the embodiment of Fig. 5, the first swath 101 may be presumed to have been printed in a previous scanning movement of the carriage 5. The second swath 102 is being printed adjacent to the first swath 101. A swath width corresponds to a width of the print heads 4 and in this example perfectly straight swaths 101 and 102 are printed accurately adjacent to each other.

[0067] The sensor units 40 may be employed to detect the first swath leading edge 101b after the guide beam 6 has stepped in the first beam direction X1 (or the second beam direction X2, *mutatis mutandis*). Based on the de-

tected first swath leading edge 101b, the sub-carriage 51 may be moved in the first sub-carriage direction X3 or the second sub-carriage direction X4 to correct for any inaccuracy of the step-wise movement of the guide beam 6. This method is shown in Figs. 7A and 7B in more detail.

[0068] In the embodiment of Fig. 6, it is presumed that the first swath 101 has been applied. For ease of illustration, the first swath 101 is shown as straight, while in practice the first swath 101 may be slanted and/or curved. While the first swath 101 of printed dots was being applied, the print heads 4 applied also an array of position markers 60 just next to the first swath leading edge 101b. While scanning movement of the carriage 5 to apply the dots of the second swath 102, the sensor unit 40 optically senses the area next to the first swath leading edge 101b to detect the position of the position markers 60. Thereto, an image signal may be generated by the sensor unit 40 and the image signal may be supplied to an image processor, which may be incorporated in a control unit (not shown). With each detection of a subsequent position marker 60, the control unit may determine a suitable amount of translation and a suitable amount of rotation which amounts are deemed to minimize any print artifacts. Numerous (mathematical) methods are available and known to the skilled person for determining (e.g. calculating) such suitable amounts. Such method may be relatively simple. For example, a difference in position between the just detected position marker 60 and a previously detected position marker 60 may be used to determine the amounts. Alternatively, more complex methods may be applied. For example, a number of previously detected position markers 60 may be taken into account. For example, if the sub-carriage 51 has a width (dimension of the sub-carriage 51 in the scanning direction 52) and the width of the sub-carriage 51 extends over e.g. a hundred position markers 60, the method may take the position of such one hundred position markers 60 into account.

[0069] When scanning and determining the translation and rotation amounts, it is considered that the center of rotation R_z is offset from the sensor unit 40, although the sensor unit 40 detects the position of the position markers 60 and thus the amount of correction needed is determined at the location of the sensor unit 40. When applying an amount of rotation around the center of rotation R_z , the rotation introduces an amount of translation at the location of the sensor unit 40. In order to enable correction of such translation, it is advantage to first determine the amount of rotation and then determining an amount of translation, thereby taking into account/correcting the amount of translation introduced by the amount of rotation.

[0070] Further, it is contemplated that any selected method is preferably adapted to ensure smooth transitions at the positions where the sub-carriage is translated and/or rotated by any amount. Exception to this preference is envisaged at the start of the scanning movement for the second swath. When detecting a first position

marker 60 at the start of the scanning movement, any deviation from an expected position may be directly compensated by a translation, since such a deviation may be deemed attributable to an inaccurate step-wise movement of the guide beam 16 or recording medium transport step. Such inaccurate step may be directly and immediately compensated by a corrective translation without rotation, provided that the detection is performed before any dots of the second swath 102 have been applied otherwise the sudden stepping of the sub-carriage 51 may become visible as a print artifact.

[0071] A number of position markers 60 along the scanning direction or in other words a number of position markers 60 per unit length in the scanning direction may be selected depending on different requirements. For example, it may be contemplated that a high number of position markers 60 will increase the accuracy. On the other hand, a lower number of position markers 60 will reduce the required computation power. Further, the more position markers are actually printed, the higher the chance that the position markers 60 may become visible in the resulting printed image.

[0072] Fig. 7A shows the sub-carriage 51 in a centered position with respect to the carriage 5. In other words, it is presumed that the sub-carriage 51 has not yet been moved relative to the carriage 5 and is scanning in a scanning direction A' for applying the second swath 102. The first carriage 5 and the recording medium 2 have been moved relative to one another in direction C (step b). It is presumed that the step made was larger than intended. Consequently, the print heads 4 are positioned such that a second swath trailing edge 102a does not coincide with the first swath leading edge 101b. A gap remains between the first swath 101 and the second swath 102. If the recording medium 2 is white, the gap will appear as a white stripe in the resulting printed image and hence will be considered a print artifact. Please note that a shorter step of the guide beam 6 would have resulted in the first swath 101 and the second swath 102 partly overlapping (not shown), which will be visible as a dark stripe, which is likewise considered to be a print artifact.

[0073] With reference to Fig. 7B, the sub-carriage 51 is moved in the second sub-carriage direction X4 - compared to the situation as illustrated in Fig. 3A - with an amount suitable to let the second swath trailing edge 102a and the first swath leading 101b coincide such that the first swath 101 and the second swath 102 are adjacent and no stripe will become visible in the resulting printed image. In this example, the sub carriage 51 is moved with regard to the main carriage in a direction X3,. However, alternatively and or additionally, the sub-carriage may be translated in a direction perpendicular to direction X3 and or rotated.

[0074] Detailed embodiments of the present invention are disclosed herein; however, it is to be understood that the disclosed embodiments are merely exemplary of the invention, which can be embodied in various forms.

Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a basis for the claims and as a representative basis for teaching one skilled in the art to variously employ the present invention in virtually and appropriately detailed structure. In particular, features presented and described in separate dependent claims may be applied in combination and any combination of such claims are herewith disclosed. Further, the terms and phrases used herein are not intended to be limiting; but rather, to provide an understandable description of the invention. The terms "a" or "an", as used herein, are defined as one or more than one. The term plurality, as used herein, is defined as two or more than two. The term another, as used herein, is defined as at least a second or more. The terms including and/or having, as used herein, are defined as comprising (i.e., open language). The term coupled, as used herein, is defined as connected, although not necessarily directly.

Claims

1. Method for operating a printer, the printer comprising a first carriage configured to move in reciprocation in a scanning direction, the first carriage comprises a main carriage and a sub-carriage, wherein the sub-carriage is moveable in at least one of the scanning direction and the sub-scanning direction with respect to the main carriage, the sub-carriage carrying at least one print head and a second carriage configured to move in reciprocation in the scanning direction, wherein the second carriage carries at least one source of radiation for curing an ink, wherein the second carriage is positioned downstream of the first carriage in a sub-scanning direction, the sub-scanning direction being essentially perpendicular to the scanning direction, the method comprising the steps of:
 - a. operating the first carriage to perform a first cycle in a first amount of time, the first cycle comprising:
 - i. moving the first carriage in the scanning direction from a first side to a second side at a first speed;
 - ii. moving the first carriage and a recording medium relative to one another in the sub scanning direction;
 - iii. adjusting the position of the sub-carriage with regard to the main carriage;
 - b. operating the second carriage to perform a second cycle in a second amount of time, the second cycle comprising:
 - i. moving the second carriage and the re-
2. Method according to claim 1, wherein the first amount of time equals the second amount of time.
3. Method according to claim 1 or 2, wherein step ii of the first cycle and step ii of the second cycle are performed simultaneously.
4. Method according to any of the preceding claims, wherein step iii of the first cycle is performed during step i of the second cycle.
5. Method according to any of the preceding claims, wherein the first cycle further comprises :
 - iv. pausing the first carriage.
6. Method according to any of the preceding claims, wherein the first cycle further comprises:
 - v. moving the first carriage in the scanning direction from the second side to the first side at the first speed;
 - vi. moving the first carriage and a recording medium relative to one another in the sub scanning direction.
7. Method according to any of the preceding claims, wherein in step i of the first cycle position markers are applied onto the recording medium.
8. Method according to claim 7, wherein the position of the sub-carriage is adjusted based on the position of the position markers.
9. Method according to any of the preceding claims, wherein in step i of the second cycle, the second carriage is moved from the second side to the first side.
10. Method according to any of the preceding claims, wherein the at least one print head is configured to eject droplets of a radiation-curable gelling ink onto a recording medium.
11. Method according to any of the preceding claims, wherein the first carriage carries a plurality of print

heads.

12. Printer comprising a first carriage configured to move in reciprocation in a scanning direction and a second carriage configured to move in reciprocation in the scanning direction, wherein the second carriage is positioned downstream of the first carriage in a sub-scanning direction, the sub-scanning direction being essentially perpendicular to the scanning direction, the printer further comprising a control unit configured to control the first carriage and the second carriage in accordance with the method according to claim 1.

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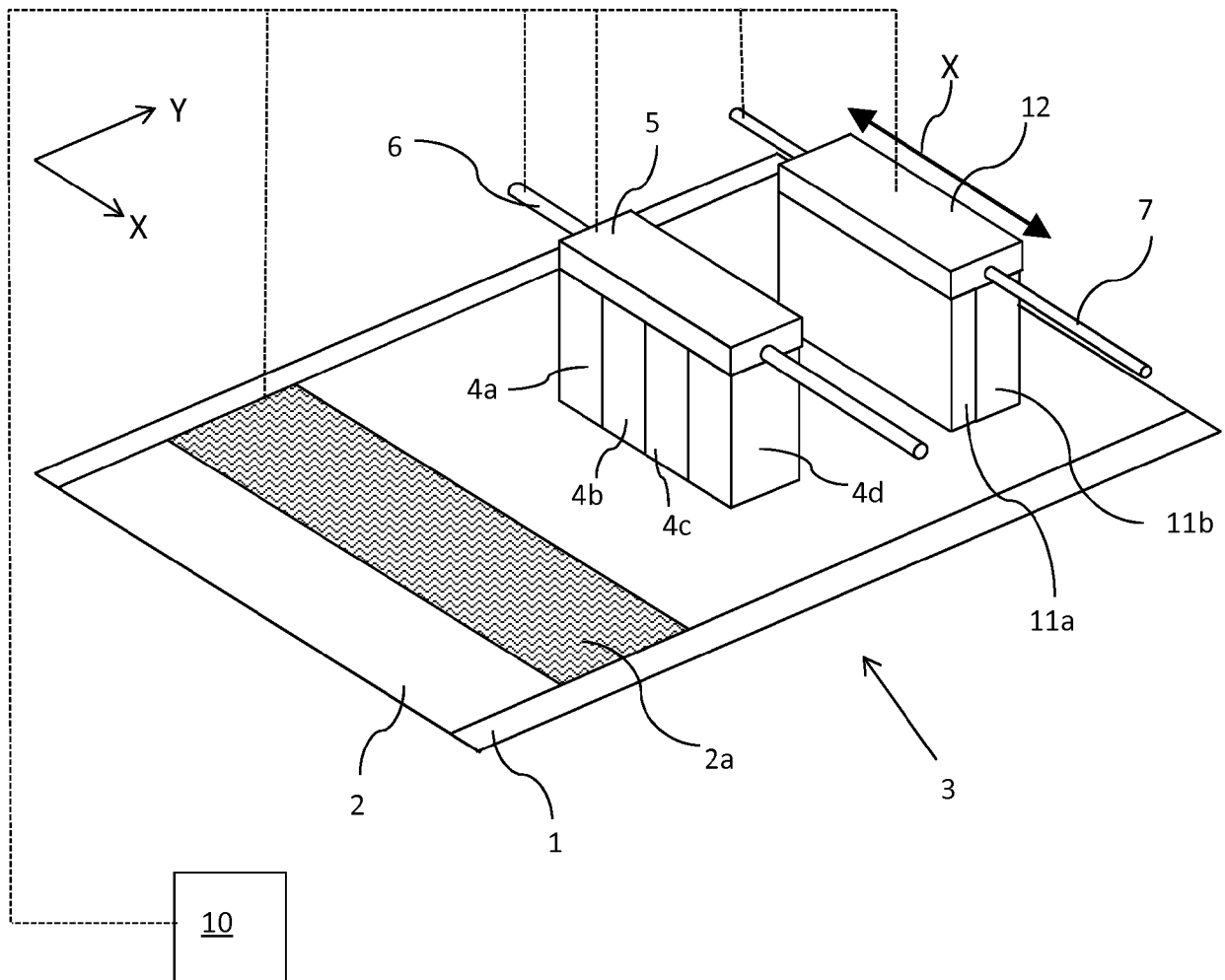


Fig. 1A

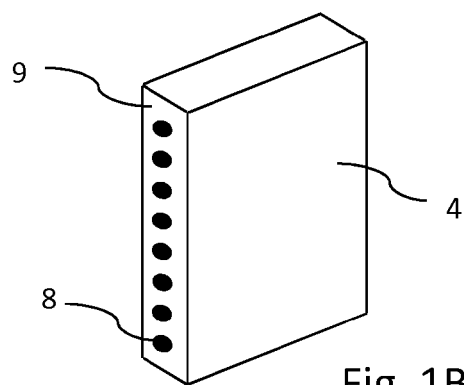


Fig. 1B

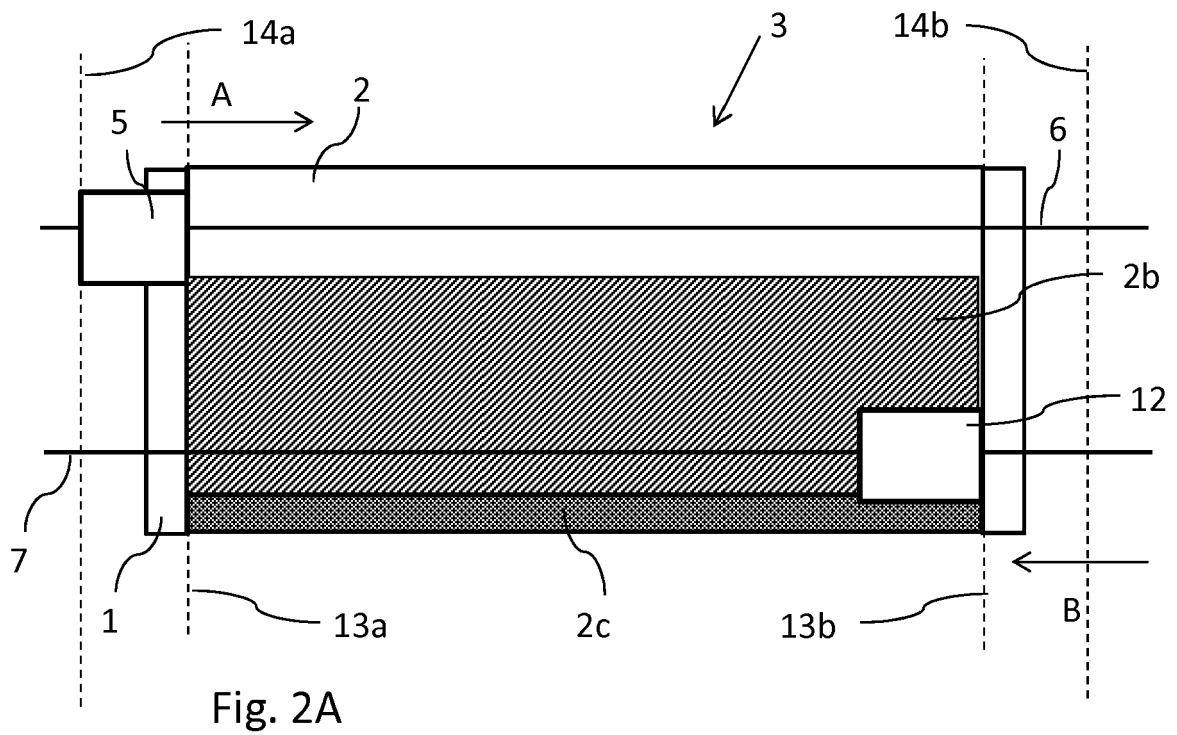


Fig. 2A

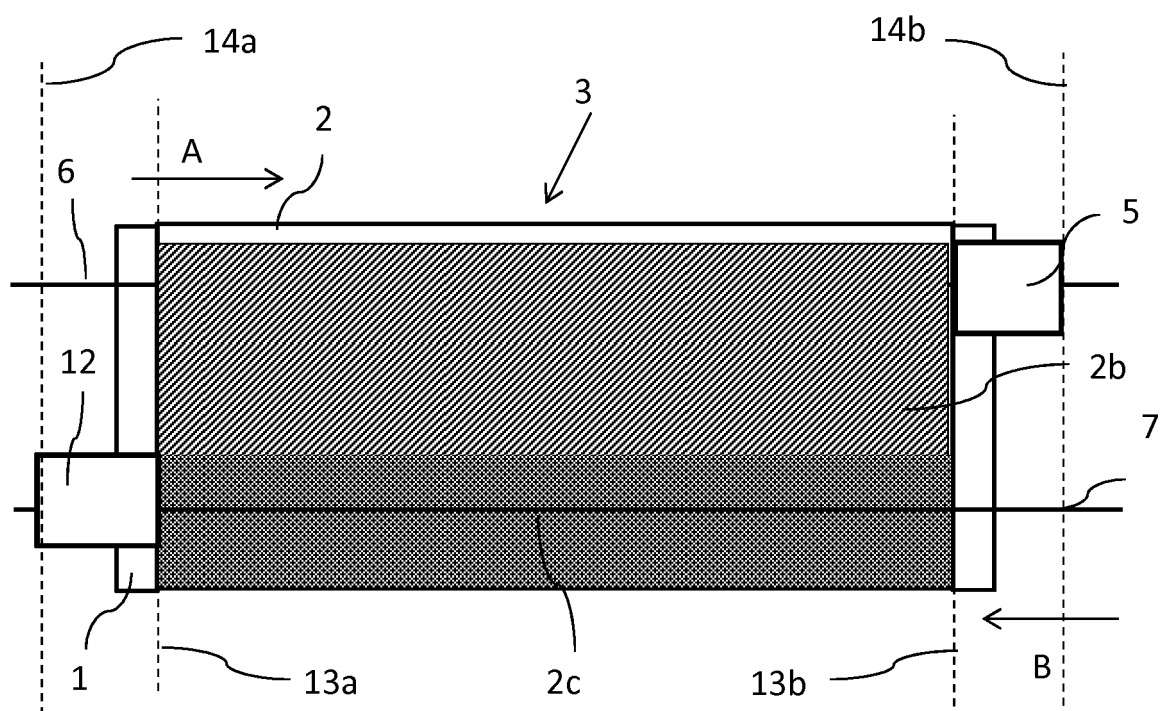


Fig. 2B

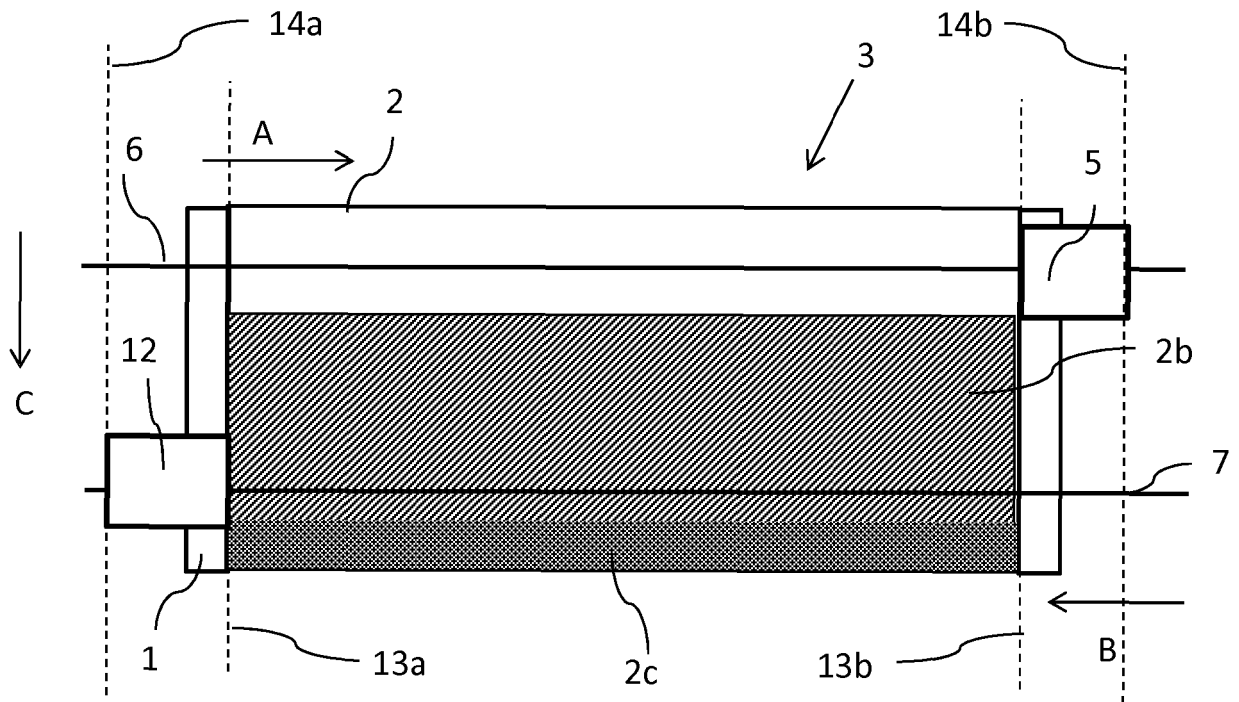


Fig. 2C

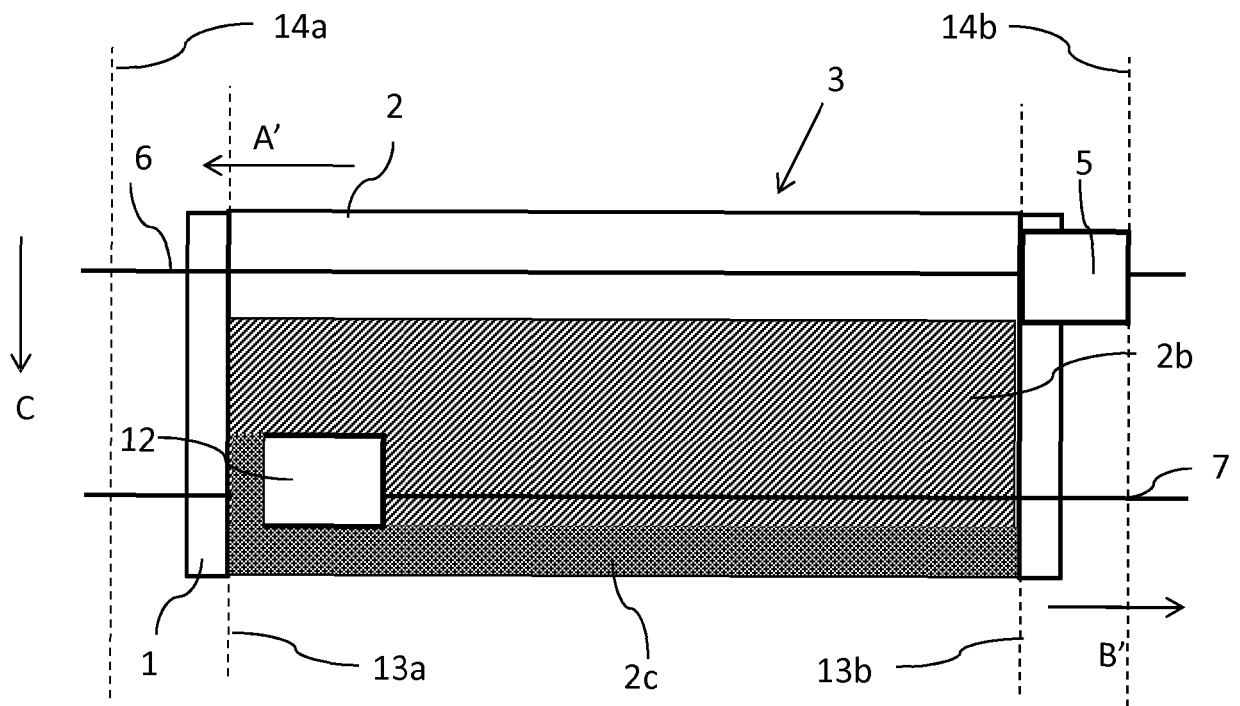


Fig. 2D

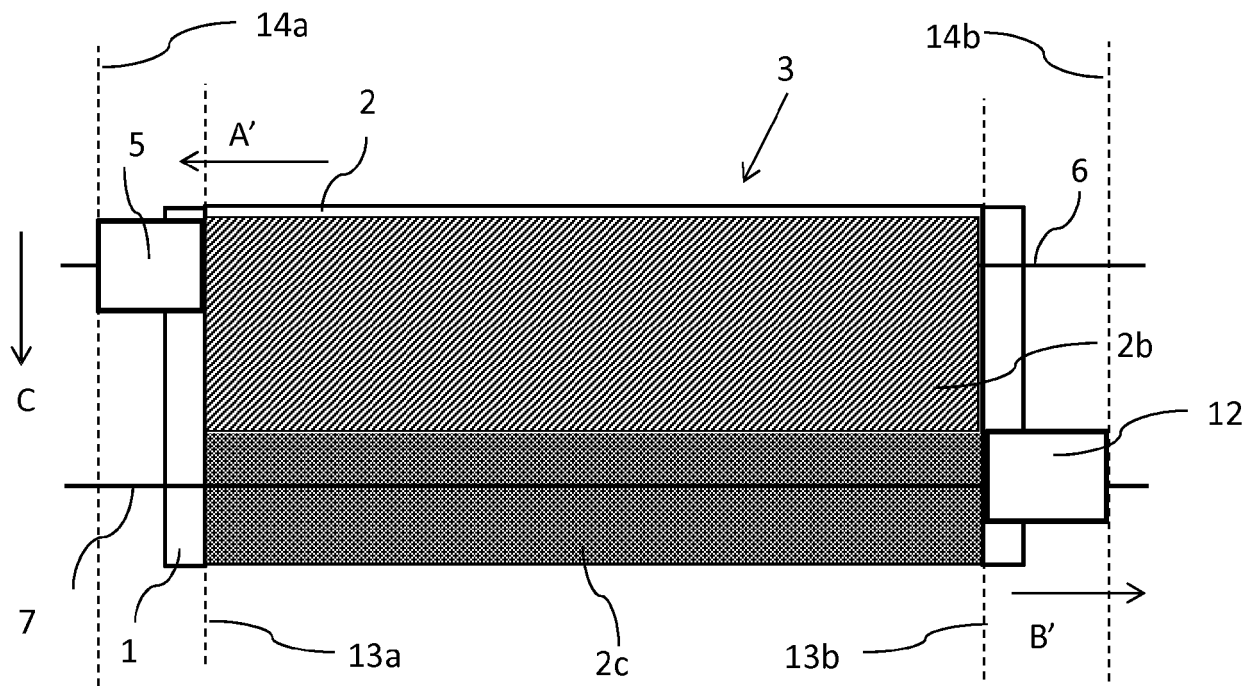


Fig. 2E

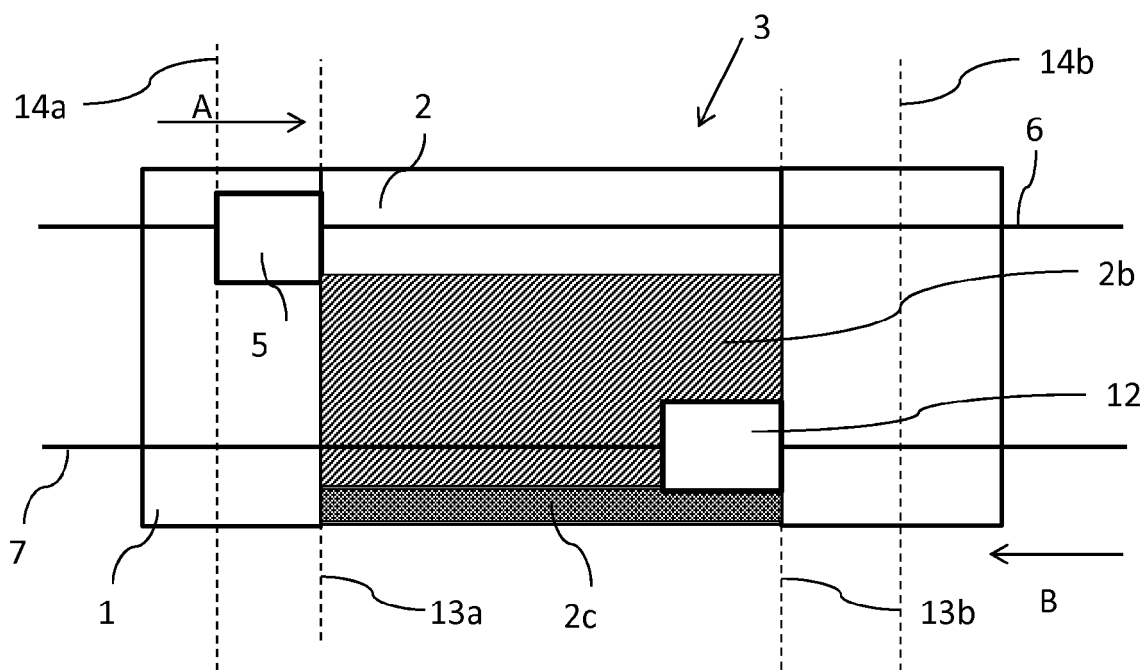
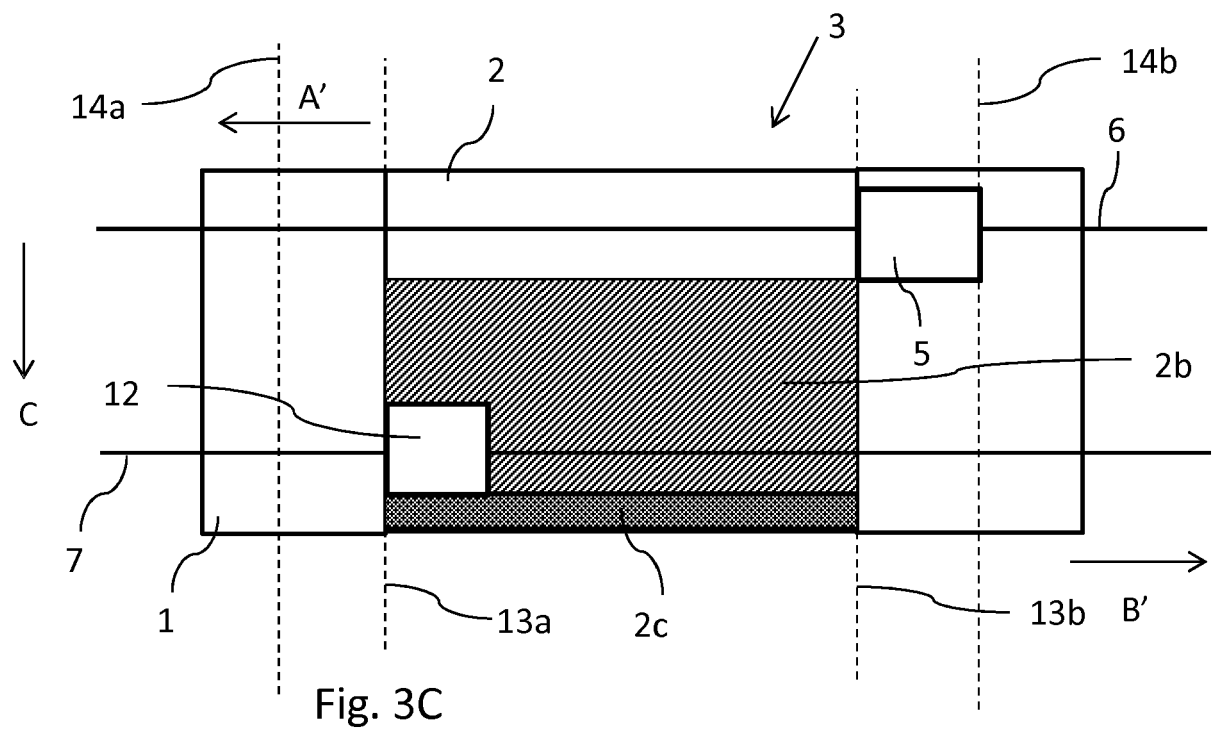
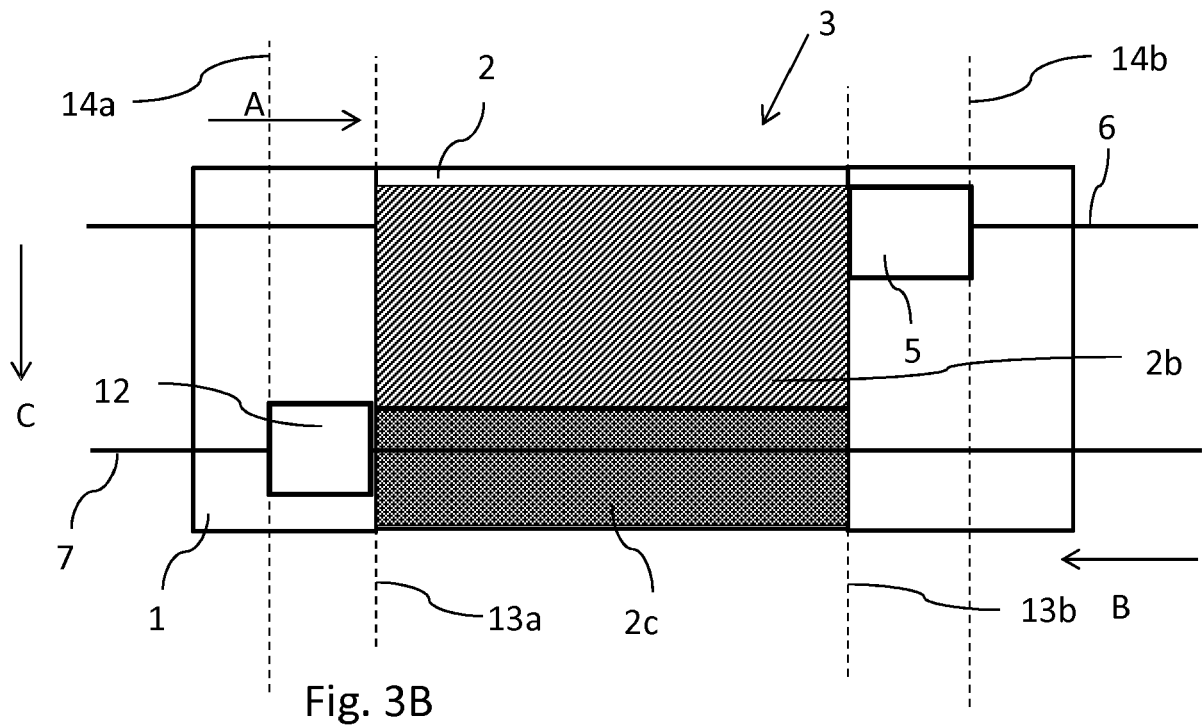
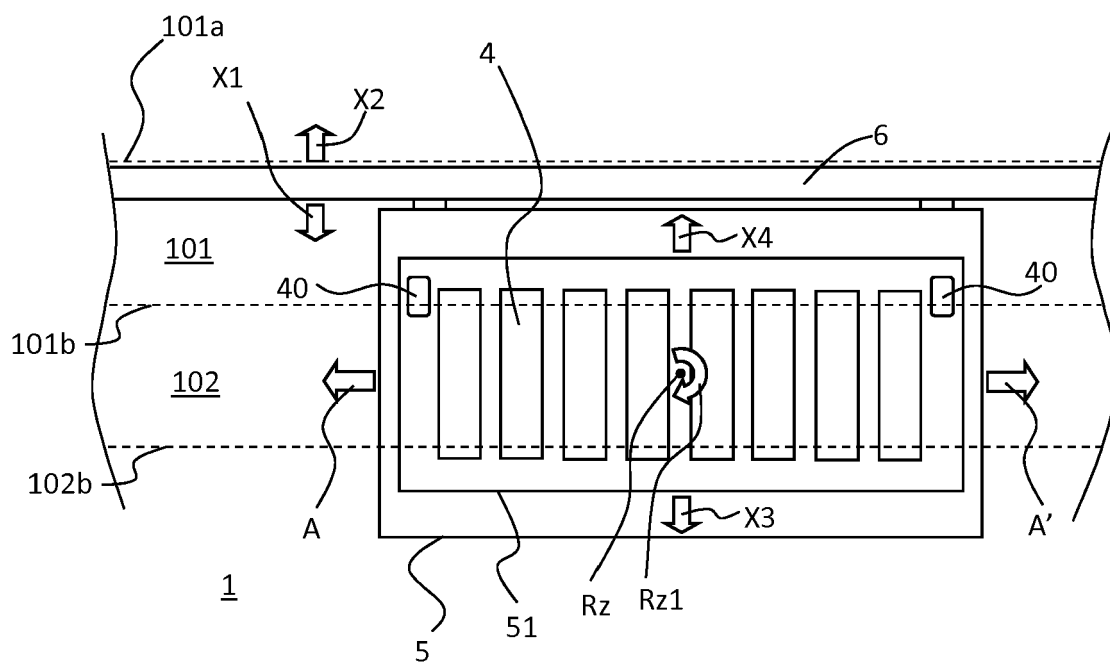
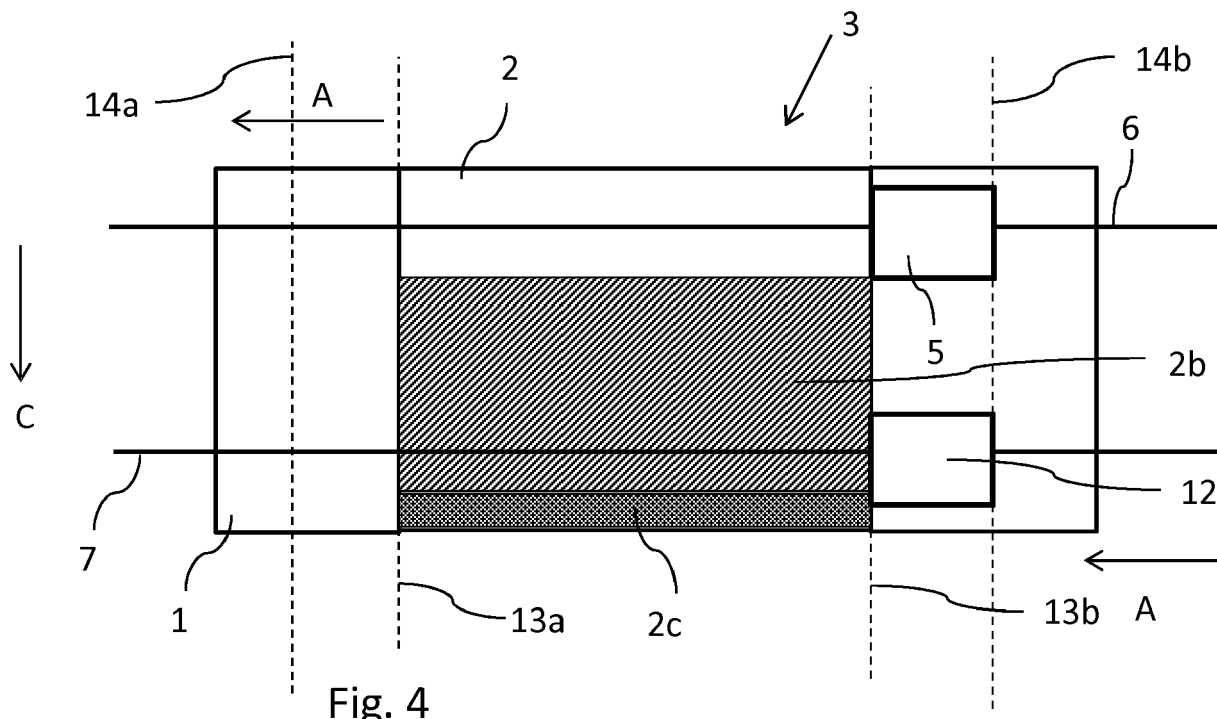


Fig. 3A





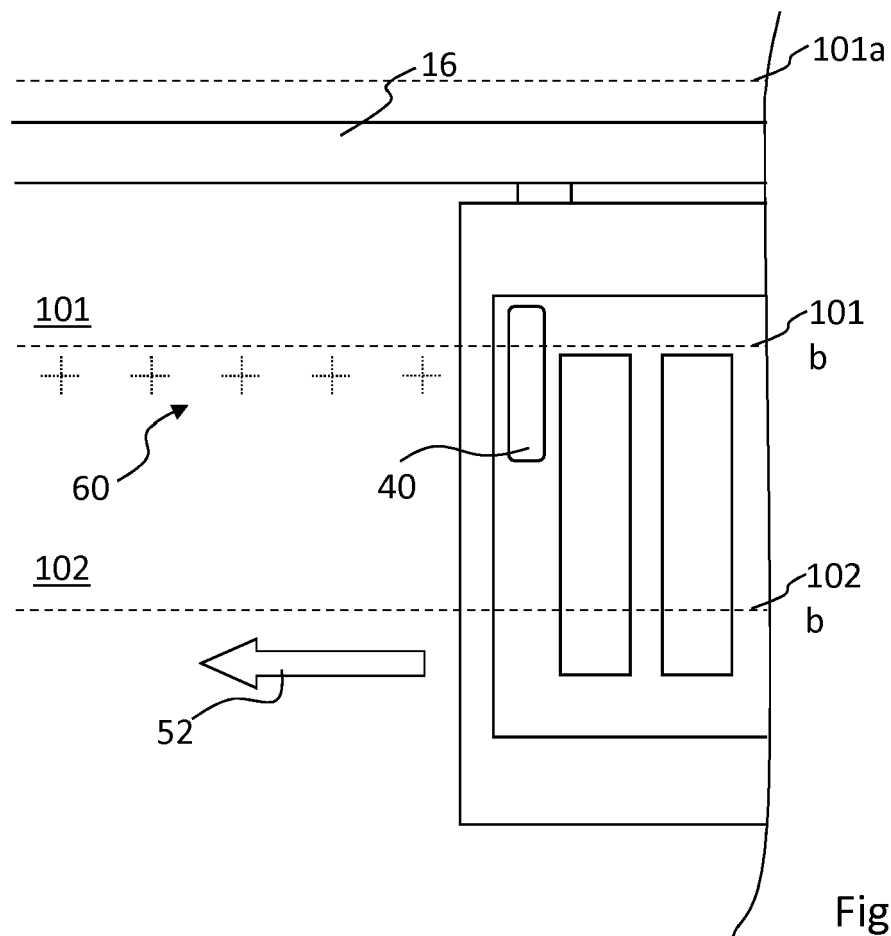


Fig. 6

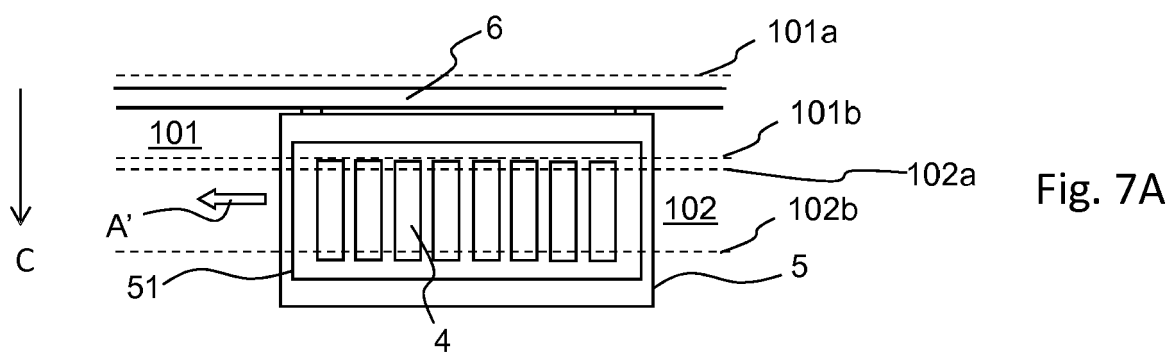


Fig. 7A

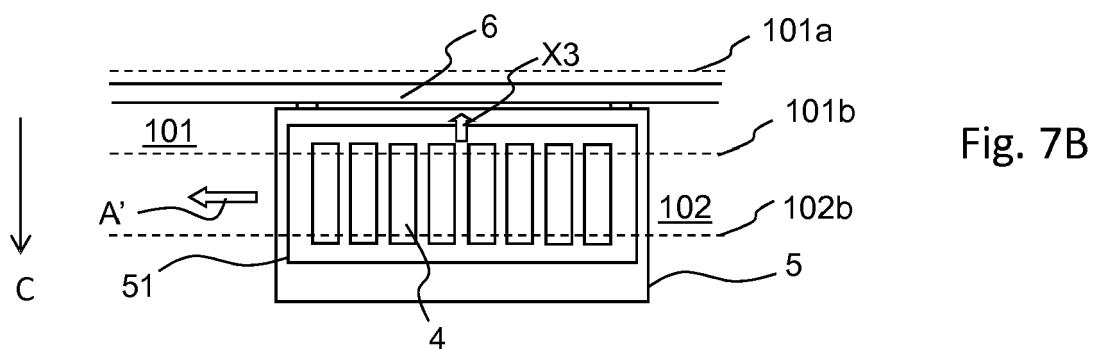


Fig. 7B



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Application Number
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A	JP H05 238004 A (CANON KK) 17 September 1993 (1993-09-17) * abstract * * paragraph [0001] - paragraph [0024]; figures 1,2,9,11,13 *	1,12	
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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 18 September 2018	Examiner Hartmann, Mathias
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