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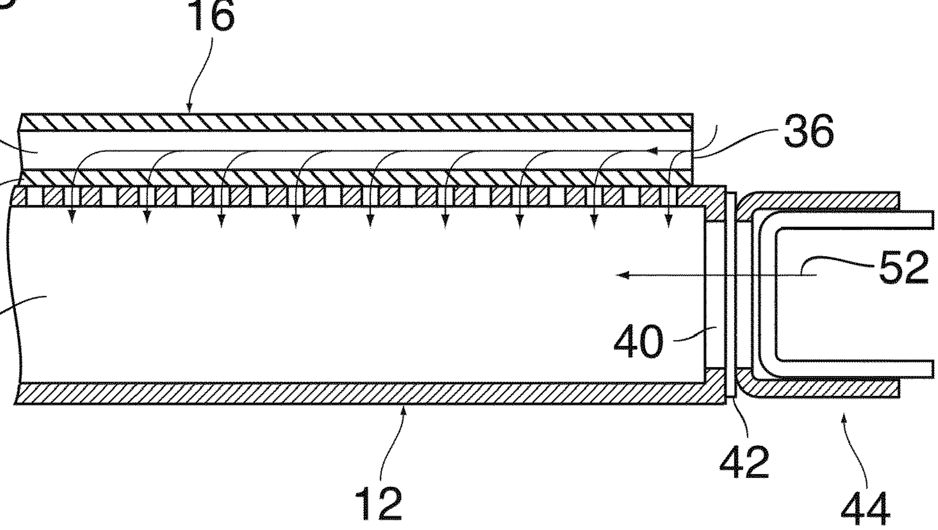
(54) METHOD OF INK JET PRINTING ON POROUS MEDIA

(57) When printing card board media on flat bed printers, it was found that near edges of the cardboard the jetted ink was dispersed, disrupting the printed image near said edges. It was further found that this was due to a flow of air into said edges of the cardboard. Said air flow was reduced by providing at least one vent hole in a side wall of the suction box of the printer as well as a valve mechanism for opening and closing said at least one vent hole.

Fig. 3



EP 3 427 961 A1

Description

[0001] The invention relates to a method of ink jet printing on a multi-layer media sheet having a porous outer layer and parallel internal passages that are bounded on one side by the porous layer and are open at an edge of the sheet, the method comprising the steps of:

- placing the sheet on a perforated print surface with the porous layer facing the print surface, the print surface being constituted by a top wall of a suction box; and
- applying a suction pressure to the suction box so as to attract the sheet to the print surface while the sheet is scanned with a print head.

[0002] When an ink jet printer is used for printing an image on media sheets that have the properties described above e.g. a sheet of corrugated cardboard, it is frequently found that only a poor image quality is obtained in an area adjacent to the edge of the sheet that contains the open ends of the internal passages. In order to obtain high quality print products, it has therefore been necessary to leave a relatively wide blank margin at that edge of the sheet. This implies however that only a smaller portion of the sheet can actually be used for printing, so that the costs are increased due to increased consumption of media material.

[0003] US 20140210155 A1, JP 2010094870 A, JP 2001239712 A, and JP 411091293 A show printing devices comprising a transport mechanism for stepwise transporting a print medium over a print surface, which print surface comprises suction holes for applying an under-pressure to the print medium. Air is drawn into a suction box below the print surface via an inlet to disperse the vacuum inside the suction box, such that the print medium is released and is free to move. Printing is halted while the underpressure is absent.

[0004] It is therefore an object of the invention to improve the print quality in an ink jet print process that utilizes this type of media.

[0005] In order to achieve this object, the method according to the invention is characterized by allowing air to enter into the suction box through a vent hole in a side wall along a lateral side of the suction box only after the sheet has been fully attracted to the print surface.

[0006] It has been considered that the reason for the poor print quality near the edge of the sheet is the existence of rapid air currents or turbulences in a zone above the top surface of the sheet and adjacent to the edge. The rapidly moving air interacts with the ink droplets that are jetted out onto the sheet surface in the print process, so that the ink droplets are not deposited on the media sheet in the correct positions.

[0007] The following mechanism is considered to be responsible for the rapid air currents near the edge of the sheet. When a vacuum pressure exists in the suction box while the internal passages of the sheet are open to the atmosphere at the sheet edge, a differential pressure develops across the layer of the sheet that bounds the passages and is supported on the perforated print surface. Since this layer is porous, air will be sucked-in through the porous layer, and this air has to be replaced by ambient air, so that there is a considerable inflow of ambient air at the open ends of the passages at the edge of the sheet, and this inflow of air disturbs the trajectories of the ink droplets.

[0008] A possible counter measure would be to reduce the suction pressure in the suction box and thereby to reduce also the inflow of air. This, however, involves the risk that the sheet is not reliably attracted to the print surface. In particular, when the top layer of the sheet is wetted in a print process and is then subject to ink curing treatments in which it is exposed to heat or radiation, the sheet may tend to warp and bend, so that parts of the sheet, especially near the edge, may be lifted off the print surface. Since there is only a small gap between the top surface of the sheet and the print head scanning the sheet, there is a risk that the print head collides with the elevated portions of the sheet.

[0009] Since, according to the invention, air is allowed to enter into the suction box through a vent hole in a side wall along a side of the suction box, the total air flow across the porous layer is reduced, in particular in the area close to the edge of the sheet, and this reduces the inflow of air into the open ends of the internal passages in the sheet, so that the detrimental air turbulences are mitigated. The majority of air enters via the vent hole as this offers the path of least air resistance. On the other hand, the overall suction pressure in interior of the suction box may be kept at a high level. This has the consequence that, whenever portions of the sheet tend to bend and to be lifted off the print surface, so that the perforations in the print surface are no longer obstructed by the porous sheet layer, air will be drawn in through these perforations with a high velocity which is sufficient to re-attract the sheet to the print surface due to the Bernoulli-effect. In this way, the disturbing effect of the inflow of air into the internal sheet passages can be mitigated without increasing the risk that portions of the sheet are lifted off from the print surface.

[0010] Generally, in flatbed printing the suction box is sealed air tight, as any leak air will reduce the holding force on the print substrates. Insufficient holding could result in print artifacts or damage due to the print heads colliding with the sheet on the print surface. It will be appreciated that the present invention overcomes this technical prejudice in flatbed printing by purposely allowing air to enter the suction box during printing operations.

[0011] More specific optional features of the invention are indicated in the dependent claims.

[0012] A flatbed ink jet printer adapted to carry out the method that has been described above is also subject of the invention.

[0013] In a preferred embodiment, the suction box of the ink jet printer comprises a relatively low air flow resistance. The suction box preferably comprises a plurality of spacers defining the distance between the print surface and a support surface. The spacers ensure suitable flatness over the entire print surface. The spacers preferably comprise relatively large vertical openings which reduce the air flow resistance in the horizontal direction. Such a spacer structure is known from European Patent Application 16186922.7 and is herein included by reference, specifically the details regarding the spacer structure shown Figs. 1 to 5B. By using a suction box with relatively low air flow resistance in the horizontal direction, the positioning of the sheet with respect to the at least one vent hole becomes substantially irrelevant. The air entering via the vent hole distributes itself easily through the suction box. In consequence, the amount of air entering the sheet through the open ends of the internal passages of the sheet is significantly reduced. Though it may be beneficial to position the open ends near the side wall with the vent hole, such a positioning is not required. The present invention reduces the air inlet through the open ends of a sheet, regardless of the relative position of the vent hole with respect to the open ends.

[0014] In an embodiment, the method according to the present invention, further comprises the step of operating a valve mechanism connected to the side wall to set an air flow resistance of the side wall. The valve mechanism determines the air flow resistance of the at least one vent hole, for example by determining the effective size of the at least one vent hole. The valve mechanism may in one example be configured to partially block or close one or more vent holes, thereby setting the airflow resistance through the air inlet formed in the side wall by the vent holes. The air flow resistance or effective size is selected by a controller or operator conforming to the requirements of the print job. As such, the effective size of the openings in the lateral side wall may be determined by media properties or process parameters set by an operator, for example print speed. The lateral side wall preferably extends along an edge of the print surface and preferably at an angle or perpendicular thereto.

[0015] In another embodiment, the air flow resistance of the side wall is substantially less than an air flow resistance of the print surface with the sheet on it, such that an amount of air entering the suction box via the side wall substantially exceeds an amount of air entering the suction box via the the print surface. The so-called misting of the ink near the open edges of the substrate is reduced by reducing the amount of air being sucked into said open ends. The present invention achieves this by allowing air to enter the suction box below the print surface. By letting in air via the at least one vent hole, the amount of air being sucked via the print surface is reduced. Compared to the at least one vent hole, the air flow resistance through the print surface with the sheet on it is relatively large. The air travels via the path of least resistance and the majority of air enters the suction box through the at least one vent hole. As such, the air flow at the open ends of the sheet is significantly reduced to a point where said air flow does not substantially affect the ink jet droplet dispersion by the print heads. The air flow resistance through a sheet varies per print job dependent on e.g. media type and the sheet's position on the print surface. By controlling the valve mechanism, an air flow resistance of the air inlet formed by the at least one vent hole is selected and set for a print job. The air flow resistance through the covered print surface is much higher than the selected air flow resistance of the at least one vent hole. The total surface of the effective opening of the at least one vent hole greatly exceeds that of the print surface with the media on it. The effective surface of the vent holes is sufficiently large to reduce flow to reduce image artifacts.

[0016] In a preferred embodiment, the printer according to the present invention further comprises a suction device, such as a pump or fan, for applying an underpressure to the suction box. When a sheet is positioned on the print surface, the underpressure in the suction box is applied to the sheet via the suction holes in the print surface. Thereby, the sheet is attracted to and held in place on the print surface. A controller is provided which is configured to move the carriage over the print surface with the sheet stationary thereon, while the suction device applies an underpressure to the suction box. Underpressure is thus applied during the printing of an image on the sheet. As explained above initially (prior to printing) the vent hole was closed to seal the suction box (with the exception of the print surface which was at least partially sealed by the sheet). This allowed for the formation of high underpressure to draw the sheet flat against the print surface. Subsequently, the vent hole was opened, thereby drawing ambient air into the suction box via at the least one vent hole. The vent hole remains open during printing while the suction device sucks air from the suction box to maintain an underpressure therein. The underpressure is however reduced from the initial high underpressure, resulting in less or no air being sucked into the open ends of the so-called flutes in case of a corrugated cardboard sheet. Misting is thereby reduced or even prevented. Additionally, should a side of the sheet become removed from the print surface, then the locally increased air flow below said side results in said side becoming sucked down onto the print surface. Reliable holding is thus achieved at reduced underpressures.

[0017] An embodiment example will now be described in conjunction with the drawings, wherein:

Fig. 1 is a cross-sectional view of a portion of a media sheet made of corrugated cardboard that is supported on a top wall of a suction box;

Fig. 2 is a sectional view taken along the line II-II in Fig. 1 and illustrates an airflow pattern in a condition in which air is allowed to enter into the suction box only through perforations in the top wall;

Fig. 3 illustrates an air flow pattern that is obtained in a condition where vent holes are opened in a side wall of the suction box;

Fig. 4 illustrates an air flow pattern in a condition where an edge of the sheet tends to bend away from the top wall of the suction box; and

Figs. 5 to 9 are side views of the suction box and a valve mechanism controlling an inflow of air into the suction box, the control mechanism being shown in five different positions.

[0018] As is shown in Fig. 1, an ink jet printer comprises a print head 10 and a suction box 12 constituting a print surface 14 which supports a media sheet 16. As is well known in the art, the print head 10 is arranged to scan the media sheet 16 on the print surface so as to form an image on the top surface of the media sheet 16 by ejecting ink droplets onto the media sheet.

[0019] The suction box 12 has a bottom wall 18 and a flat top wall 20 the top surface of which constitutes the print surface 14. The space between the bottom wall 18 and the top wall 20 of the suction box 12 constitutes a suction chamber 22 to which a vacuum pressure is applied by means of a blower or pump that has not been shown here. The suction box is described in detail in European Patent Application 16186922.7. The top wall 20 has a fine raster of perforations 24 which are obstructed by the media sheet 16 so that the suction pressure causes the media sheet 16 to be attracted against the print surface 14.

[0020] In the example shown, the media sheet 16 is a sheet of corrugated cardboard comprising a porous bottom layer 26, a top layer 28 (which may be non-porous), and a corrugated intermediate sheet 30 which serves as a spacer between the bottom layer 26 and the top layer 28 and divides a space between them into a number of parallel passages 32, 34 which extend in the direction normal to the plane of the drawing in Fig. 1. The passages 32 are bounded by the porous bottom layer 26.

[0021] Fig. 2 is a sectional view taken along the line II-II in Fig. 1 and shows an edge 36 of the media sheet 16. The internal passages 32 of the media sheet are open to the atmosphere at this edge 36.

[0022] In the example shown in Fig. 2, the suction box 12 has a side wall 38 that extends in parallel with the edge 36 of the sheet 16 which has been placed on the print surface 14 in such a position that the edge 36 is located close to the side wall 38. It will be appreciated that within the present invention the sheet 16 may be positioned at any position and in any orientation on the print surface 14. In practice, the print surface 14 may hold a plurality of sheets 16 or substrates 16. In the example described below the edge 36 of the sheet 16 is advantageously positioned near the side wall 38 to improve the workings of the present invention. The inventors however found that the reduction of the inkjet misting is achieved regardless of the distance between the edge 36 of the sheet 16 and the side wall 38.

[0023] The side wall 38 has vent holes 40, which, in the condition shown in Fig. 2, are closed-off by obstruction pads 42 of a valve mechanism 44. The valve mechanism 44 comprises C-shaped support brackets 46 that are fixed relative to the suction box 12, and a C-shaped slide rail 48 that straddles the support brackets 46 and is slidably supported thereon. A base leg of the slide rail 48 carries the obstruction pads 42.

[0024] When a vacuum pressure is applied to the suction chamber 22, a differential pressure between the interior of the passages 32 (substantially under atmospheric pressure) and the suction chamber 22 causes air to be sucked-in through the perforations 24 and the porous bottom layer 26 of the sheet 16. Consequently, ambient air is drawn in at the open ends of the passages 32 in the edge 36 of the sheet 16, as has been indicated by arrows in Fig. 2. The inflow of air into the passages 32 at the edge 36 induces a flow of air in the vicinity of the edge 36, and a part of this air flow passes along the top surface of the media sheet 16, as has been indicated by an arrow 50 in Fig. 2. When the area on the top surface of the media sheet 16 adjacent to the edge 36 is scanned with the print head 10, the air flow 50 disturbs the trajectories of the ink droplets jetted out by the print head, so that the image quality is compromised. This effect is sometimes referred to as 'misting'.

[0025] This unwanted effect can however be eliminated or least mitigated by opening the vent holes 40, as has been shown in Fig. 3. When the vent holes 40 are fully or partly opened, the suction pressure in the suction box 12 causes an additional flow 52 of ambient air through the vent holes 40 and into the suction chamber 22. As a result, air rushes into the suction box 12 through the side wall 38. Air follows the path of least resistance and the air flow resistance of the vent holes 40 is substantially less than that of the print surface 14 with the sheet 16 on it. Most or all of the vacuum holes 24 in the print surface 14 are covered by a (porous) medium 16. The vent holes 40 are preferably significantly larger than the vacuum holes 24, e.g. at least twice as large.

[0026] During operation, the blower or pump determines the vacuum level or under-pressure in the suction box 12. The pump preferably operates at a predetermined setting. The under-pressure in the suction box 12 is further dependent on the amount of air being sucked into the suction box 12. The local air resistance of each individual opening 24, 40 determines the relative amount of air being let in through said opening 24, 40. By setting the valve mechanism 44 such that the air flow resistance of the vent holes 40 is much greater than that of the vacuum holes 24 (which are covered by the sheet 16) in the print surface 14, the present invention reduces the air flow through the open ends 35 of the sheet 16.

[0027] As explained, the airflow resistance inside the suction box 12 is preferably relatively low, which may be achieved by using plate-shaped spacers with relatively large vertical openings. The low air flow resistance allows the effect of a vent hole 40 in a first side wall 38 to have the air flow reducing effect even on a side edge of the sheet 16 at a second side wall opposite the first side wall 38. The air that is flowing in the internal passages 32 of the media sheet will also experience a considerable air flow resistance and a corresponding pressure drop, so that, with increasing distance from the edge 36, the differential pressure across the porous layer 26 remains small and contributes only little to the inflow of air at the edge 36. Thus, as has been symbolized by the lengths of the vertical arrows in Fig. 2, the main contribution to the inflow of air into the passages 32 stems from the region close to the side wall 38, and this contribution is reduced significantly by opening the vent holes 40. Consequently, in the condition shown in Fig. 3, there is very little flow of air at the top surface of the sheet 16 in the vicinity of the edge 36, so that a high print quality can be obtained even in the edge zone of the sheet.

[0028] It is observed that, because this effect is obtained only by opening the vent holes 40, it is not necessary to reduce the displacement of the blower that creates the vacuum pressure in the suction box. Due to the high suction pressure in the main part of the suction chamber 22 remote from the side wall 38, the flow 52 of air through the vent holes 40 will have a considerable velocity.

[0029] Fig. 4 illustrates a situation where a part of the sheet 16 adjacent to the edge 36 tends to bend upwards, so that there would be a risk of collision between the sheet 16 and the print head 10. In this situation, however, a gap 54 opens between the bottom side of the sheet 16 and the print surface 14, so that the perforations 24 of the print surface 14 in this gap 54 are no longer obstructed by the porous layer 26 of the media sheet 16. This results in a much stronger flow 56 of air through these unobstructed perforations and through the gap 54, so that the velocity of the air flow in the gap 54 will also be considerably high and, due to the Bernoulli-effect, will create a vacuum pressure in the gap 54, with the result that the sheet 36 is re-attracted to the print surface 14 and the risk of print head collision is removed. This effect will of course be particularly strong as long as the gap 54 is still small. It will be clear to the skilled person that the part of the sheet 16 forming the gap 54 need not be positioned near the side wall 38 in order to benefit from the above mentioned effect. Sufficient under-pressure in the suction box 12 ensures the gap 54 is closed regardless of its position on the print surface 14.

[0030] When a print process starts, it is preferred to close the vent holes 40 in order to forcefully attract the sheet 16 to the print surface 14. Then, the vent holes 40 may be opened because the effect described above will prevent the sheet 16 from separating from the print surface 14.

[0031] Fig. 5 is a side view of the suction box 12 as seen in the direction of arrows V - V in Fig. 3. What has been shown here are the side wall 38 of the suction box, the vent holes 40 in this side wall 38, and the positions and shapes of the obstruction pads 42 shown in Figs. 2 and 3 and further obstruction pads 58, 60 and 62. Further, an actuator 64 for the slide rail 48 has been shown. The actuator 64 may be an electric, hydraulic or pneumatic actuator and may be accommodated in a space between two neighboring vent holes 40. The actuator 64 is preferably controlled by a controller (not shown), which instructs the actuator 64 to set the slide rail 48 in a position corresponding to a print job setting. The print job setting may be supplied via a user interface or be determined by the controller based on e.g. media properties. Thereby, the controller sets the air flow resistance of the vent holes 40 to a desired value to prevent 'misting'.

[0032] The vent holes 40 are arranged in regular intervals, and one of the obstruction pads 42, 58, 60 and 62 is associated with each vent hole 40. However, the obstruction pads 42, 58, 60 and 62 have different lengths, which permits to change the proportion of open and closed vent holes 40 by changing the position of the slide rail 48 by means of the actuator 64, as will be explained below.

[0033] It is observed that the sequence of obstruction pads 42, 58, 60 and 62 is repeated cyclically when going from right to left in Fig. 5. Fig. 5 illustrates a condition in which, similarly as in Fig. 2, all vent holes 40 are closed.

[0034] Fig. 6 shows a condition wherein the obstruction pads (and the entire slide rail 48) has been moved one step to the left, so that only the short obstruction pads 42 are offset from their corresponding vent holes 40 and, consequently, one out of four vent holes 40 is opened. In Fig. 7, the slide rail 48 has been shifted one step further so that, now, the obstruction pad 60 is also offset from its vent hole 40 and every second vent hole 40 is opened. In Fig. 8 the slide rail 48 has been moved another step further, so that obstruction pad 62 is also offset from its vent hole 40 and three out of four vent holes 40 are open. In Fig. 9 the slide rail has been moved to its leftmost position, so that also the longest obstruction pad 58 is offset from its vent hole 40 and all vent holes 40 are open.

[0035] In this way, the amount of inflow of air through the vent holes 40 can be finely controlled in five discrete steps, which permits to adjust the amount of inflow to the respective properties of the media sheets 16. When the media sheets 16 have a strong tendency to warp and a large force is required for attracting them to the print surface 14, more vent holes 40 will be closed so as to safely hold the media sheet 16 in its place and its shape, though on the cost of print quality in the immediate vicinity of the edge 36. On the other hand, if a smaller attraction force is sufficient for holding the media sheet 16, more vent holes 40 may be opened, so that a satisfactory print quality can be obtained even in positions closer to the edge 36 of the sheet.

[0036] In another embodiment, the valve mechanism

44 may be configured to vary the open cross-section of the vent holes 40 continuously rather than step-wise.

Claims

1. A method of ink jet printing on a multi-layer media sheet (16) having a porous outer layer (26) and parallel internal passages (32) that are bounded on one side by the porous layer (26) and are open at an edge (36) of the sheet (16), the method comprising the steps of:

- placing the sheet (16) on a perforated print surface (14) of a flatbed printing system with the porous layer (26) facing the print surface, the print surface being constituted by a top wall (20) of a suction box (12); and
- applying a suction pressure to the suction box (12) so as to attract the sheet to the print surface (14) while the sheet is scanned with a print head (10),

the method being **characterized by** allowing air to enter into the suction box (12) through a vent hole (40) in a side wall (38) along a lateral side of the suction box (12) only after the sheet (16) has been fully attracted to the print surface (14).

2. The method according to claim 1, wherein the sheet (16) is a sheet of corrugated cardboard.

3. The method according to claim 1 or 2, further comprising the step of operating a valve mechanism (44) connected to the side wall (38) to set an air flow resistance of the side wall (38).

4. The method according to claim 3, wherein the air flow resistance of the side wall (38) is substantially less than an air flow resistance of the print surface (14) with the sheet (16) on it, such that an amount of air entering the suction box (12) via the side wall (38) substantially exceeds an amount of air entering the suction box (12) via the print surface (14).

5. The method according to any of the preceding claims, wherein the air is allowed to enter into the suction box (12) along the side of the box while the carriage moves over the sheet (16) for printing an image on said sheet (16).

6. The method according to any of the preceding claims, wherein the amount of air allowed to enter into the suction box (12) along the side of the box is adapted to the physical properties of the media sheet (16) by means of a valve mechanism (44).

7. A flat bed ink jet printer, comprising a carriage on which the print head (10) is mounted, wherein the carriage is configured to move in a length direction as well as in a width direction of the print surface (14), a print surface (14) constituted by a perforated top wall (20) of a suction box (12), and a print head (10) arranged to scan the print surface (14), the suction box (12) having a side wall (38) extending along an edge of the print surface (14), **characterized in that** at least one vent hole (40) is formed in the side wall (38), and a valve mechanism (44) is provided for opening and closing said at least one vent hole (40).

8. The printer according to claim 7, wherein the at least one vent hole (40) forms an air inlet in the side wall (38) and the valve mechanism (44) comprises at least one obstruction plate (42, 58, 60, 62) moveable over the at least one vent hole (40) for at least partially closing the at least one vent hole (40).

9. The printer according to claim 8, wherein the valve mechanism (44) further comprises an actuator (64) for moving the at least one obstruction plate (42, 58, 60, 62).

10. The printer according to claim 9, further comprising a controller configured for controlling the actuator (64) to move the at least one obstruction plate (42, 58, 60, 62) into one of a plurality of predefined positions over the at least one vent hole (40) to set an air flow resistance of the air inlet in the side wall (38) in correspondence to a print job setting input via an user interface connected to the controller.

11. The printer according to any of the claims 7 to 10, wherein a plurality of vent holes (40) are formed in the side wall (38) in regular intervals, and the valve mechanism (44) is arranged to take a plurality of discrete positions which differ in the number of vent holes being closed, the open vent holes and the closed vent holes being evenly distributed along the side wall (38) in each position of the valve mechanism (44).

12. The printer according to any of the claims 7 to 11, wherein the valve mechanism (44) comprises a slide rail (48) slidably guided along the side wall (38) of the suction box (12), the slide rail (48) carrying at least one obstruction plate (42, 58, 60, 62) for partly or fully obstructing the vent hole or vent holes (40).

13. The printer according to claims 11 and 12, wherein obstruction plates (42, 58, 60, 62) form a regular pattern of obstruction pads with different lengths in the longitudinal direction of the side wall (38), and an actuator (64) is provided for moving the slide rail (48) in discrete steps in order to determine different proportions between the numbers of opened and closed vent holes (40).

14. The printer according to any of the claims 7 to 13, further comprising:

- a suction device for applying an underpressure to the suction box (12), such that a sheet (16) is attracted to and held in place on the print surface (14);
- a controller configured to move the carriage over the print surface (14) while the suction device applies an underpressure to the suction box (12) thereby drawing ambient air into the suction box via at the least one vent hole (40).

15. The printer according to any of the claims 7 to 14, wherein the print surface (14) is rectangular and the side wall (38) extends substantially perpendicular to the print surface (14).

Fig. 1

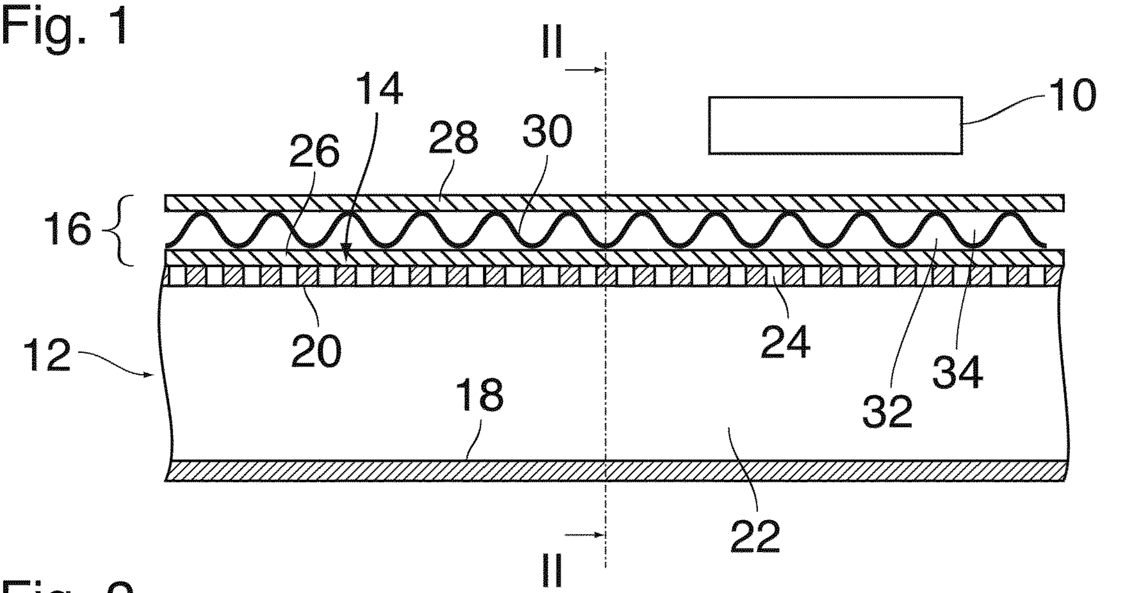


Fig. 2

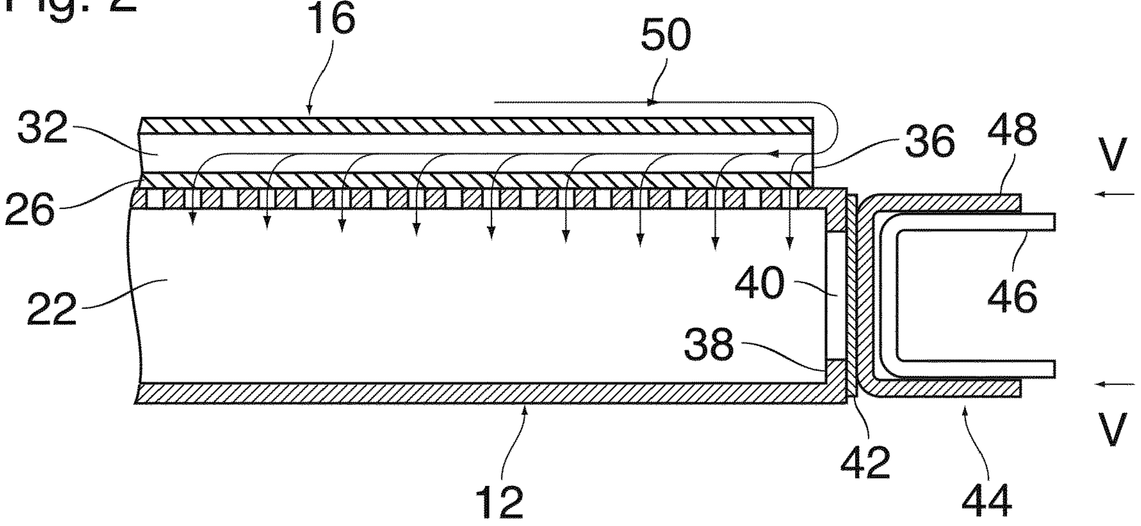


Fig. 3

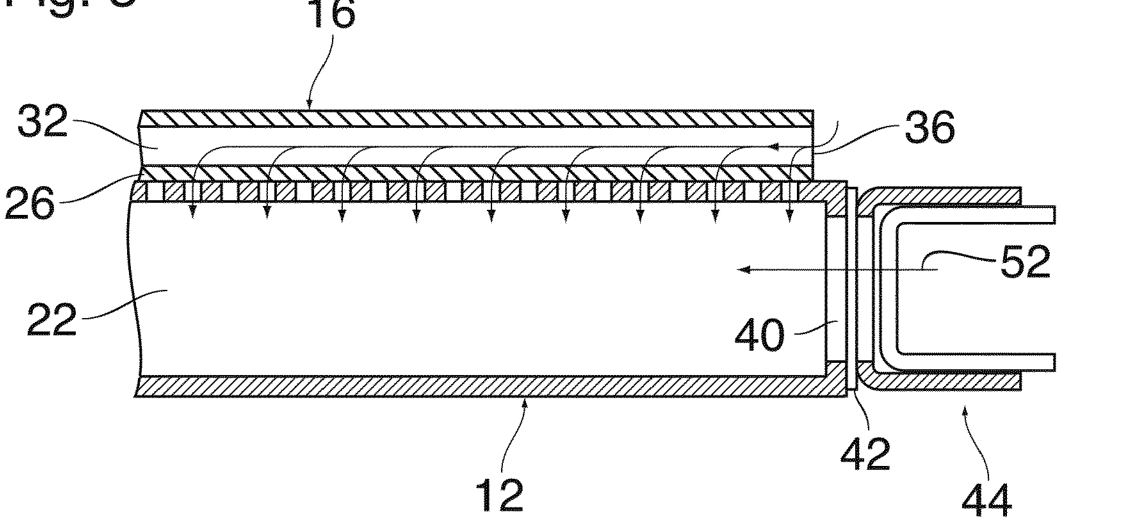


Fig. 4

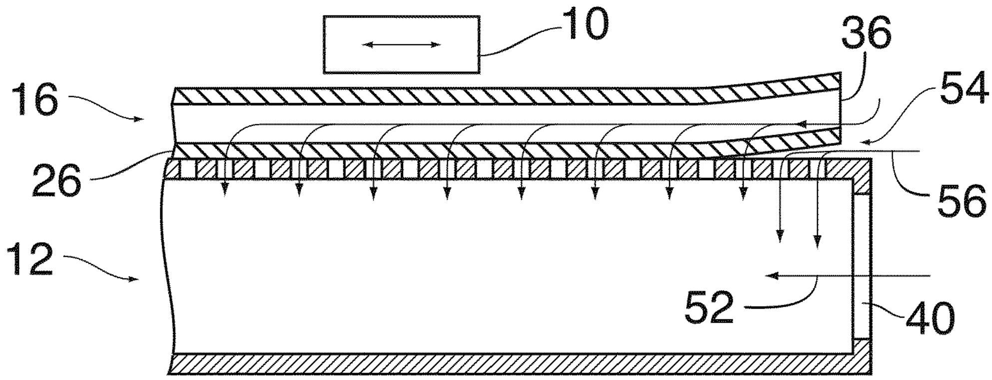


Fig. 5

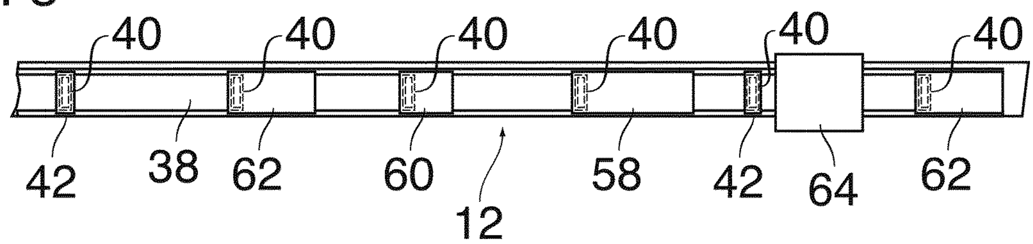


Fig. 6

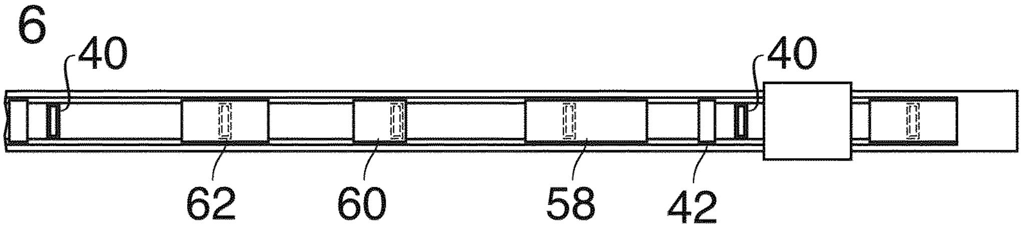


Fig. 7

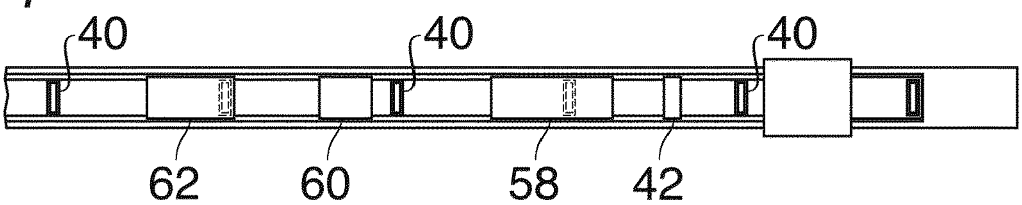


Fig. 8

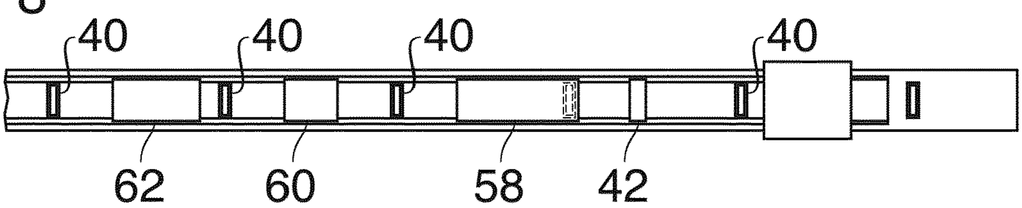
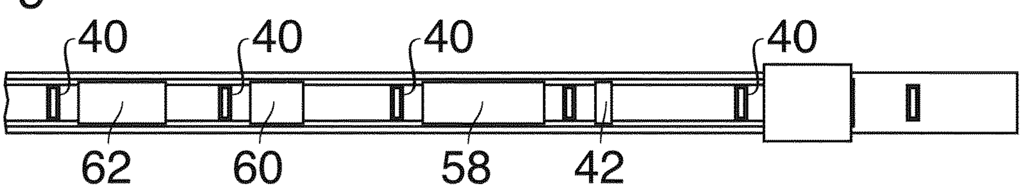


Fig. 9



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EUROPEAN SEARCH REPORT

Application Number
EP 18 18 1918

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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