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(54) Title: PRINT CARTRIDGE BODY

(57) Abstract: An embodiment provides a print cartridge body (300) with three or more compartments in series (310₁, 310₂, 310₃), and a partition (312) formed between each successive pair of compartments (310₁, 310₂, 310₃). Each partition (312) is substantially parallel to a scanning direction of the cartridge body (300).



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PRINT CARTRIDGE BODY

BACKGROUND

[0001] Multicolored ink-jet cartridges usually include a body having a plurality of ink reservoirs, each for containing different colored ink, and a print head having a print head die with a plurality of slots communicatively coupled to the plurality of ink reservoirs via an ink-delivery manifold. Ink-delivery manifolds increase the size of ink-jet cartridges. This is a problem, especially for applications involving ink-jet cartridges having smaller form factors. Ink delivery manifolds may increase the number and complexity of the process steps used to manufacture ink-jet cartridges and thus the cost of the ink-jet cartridges. Moreover, the body of some ink-jet cartridges is formed as a one-piece injection-molded part and may involve using one or more mold-slide inserts for forming channels in an ink-delivery manifold. Each mold-slide insert leaves behind one or more openings (or mold-slide-insert access holes) in the cartridge body. One or more plugs subsequently seal each mold-slide-insert access hole. The use of a plug and mold-slide-inserts can be costly from a manufacturing standpoint.

DESCRIPTION OF THE DRAWINGS

[0002] Figure 1 is a three-dimensional representation of an embodiment of a print cartridge, according to an embodiment of the present invention.

[0003] Figure 2 is a three-dimensional representation of an embodiment of a print cartridge, viewed from the bottom, according to another embodiment of the present invention.

[0004] Figure 3 is a three-dimensional representation of an embodiment of a cartridge body, according to another embodiment of the present invention.

[0005] Figure 4 is a top view of an embodiment of a cartridge body, according to another embodiment of the present invention.

[0006] Figure 5 is a bottom view of an embodiment of a cartridge body, according to another embodiment of the present invention.

[0007] Figures 6, 7, and 8 are cross-sectional views respectively taken along lines 6-6, 7-7, and 8-8 of Figure 5, according to another embodiment of the present invention.

[0008] Figure 9 is a three-dimensional representation of an embodiment of a single-colored print cartridge, according to another embodiment of the present invention.

[0009] Figure 10 is a three-dimensional representation of an embodiment of a single-colored print cartridge, viewed from the bottom, according to another embodiment of the present invention.

[0010] Figure 11 is a top view of an embodiment of a cartridge body, according to another embodiment of the present invention.

[0011] Figure 12 is a bottom view of an embodiment of a cartridge body, according to another embodiment of the present invention.

[0012] Figure 13 is a cross-sectional view taken along line 13-13 of Figure 12, according to another embodiment of the present invention.

[0013] Figure 14 is a top view of an embodiment of a single-color, two-compartment cartridge body, according to another embodiment of the present invention.

DETAILED DESCRIPTION

[0014] In the following detailed description of the present embodiments, reference is made to the accompanying drawings that form a part hereof, and in which are shown by way of illustration specific embodiments that may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice disclosed subject matter, and it is to be understood that other embodiments may be utilized and that process, electrical or mechanical changes may be made without departing from the scope of the claimed subject matter. The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of the claimed subject matter is defined only by the appended claims and equivalents thereof.

[0015] Figure 1 is a three-dimensional representation of a print (or ink-jet) cartridge 100, according to an embodiment. For one embodiment, ink-jet cartridge 100 may be a

multi-colored, e.g., two or more colors, or a single-colored, e.g., black, ink-jet cartridge. For another embodiment, ink-jet cartridge 100 may be used in various imaging devices, such as facsimile machines, desktop printers, manual hand-held printers, etc. Ink-jet cartridge 100 includes a cartridge body 102. A head assembly 104, such as a Tab-Head-Assembly (THA), is attached to cartridge body 102. For one embodiment, head assembly 104 includes flexible circuit and a print head die with an orifice plate (not shown in Figure 1), as is known by those of skill in the art. Head assembly 104 includes a plurality of interconnect pads 105 for coupling the flexible circuit to a printer controller. A cover 106 closes one or more ink compartments formed in body 102. For one embodiment, one or more vent channels are formed in cover 106 that communicate with the ink compartments, as is known in the art. For another embodiment, a vent label 108 is adhered to cover 106 and overlies at least a portion of the vent channels.

[0016] For one embodiment, alignment lugs 109 are optionally formed on cartridge body 102 to facilitate installation in a printer. For another embodiment, elimination of alignment lugs 109 eliminates a need for using a front mold slide during manufacture. For another embodiment, zero draft surfaces 110 are formed in cartridge body 102 and are used for assembly registration to tooling and alignment in a printer. For another embodiment, a plurality of legs 120 extends from a bottom of cartridge body 102. Legs 120 provide clearance between the bottom cartridge body 102 and a surface on which ink-jet cartridge 100 may be located for protecting the print head die located at the bottom of cartridge body 102. Alternatively, legs 120 may be unitary structures, such as ribs extending from the bottom of cartridge body 102.

[0017] Figure 2 is a three-dimensional representation of ink-jet cartridge 100, viewed from the bottom, according to another embodiment. The ink-jet cartridge 100 of Figure 2 is configured as a multi-colored ink-jet cartridge, e.g., a tri-colored ink-jet cartridge. Head assembly 104 includes a print head die 210 with the orifice plate removed. An encapsulant 212 encapsulates a plurality of electrical interconnects that interconnect the flexible circuit of head assembly 104 to electrical contacts of print head die 210. For one embodiment, the electrical contacts of print head die 210 selectively supply electrical power to a plurality of resistors or piezoelectric devices that are used to expel ink from print head die 210. A plurality of slots 220 is formed in print head die 210. Slots 220 are communicatively (or fluidly) coupled to the ink compartments within

cartridge body 102 and receive ink from the ink compartments and deliver it to orifices in the orifice plate.

[0018] Note that the bottom of ink-jet cartridge 100 is substantially one plane and is not stepped as is common for many conventional ink-jet cartridges. That is, ink-jet cartridge 100 has a substantially rectangular (or square for some embodiments) profile when viewed along a direction parallel to a scanning direction (indicated by arrows 250 in Figures 1 and 2) of ink-jet cartridge 100 during printing. This acts to reduce the complexity of the ink-delivery channels for delivering ink to print head die 210 and to eliminate the need for an ink-delivery manifold and thereby acts to reduce manufacturing time and thus costs. In addition, the bottom of ink-jet cartridge 100 being substantially one plane provides for a longer print head die, in a direction perpendicular to scanning direction 250, relative to a length of the ink-jet cartridge in the direction perpendicular to scanning direction 250, thus enabling a longer print swath.

[0019] Figure 3 is a three-dimensional representation of a cartridge body 300, e.g., that can be used as the cartridge body of ink-jet cartridge 100 of Figures 1 and 2, according to another embodiment. Common reference numbers denote similar elements in Figures 1-3. For one embodiment, cartridge body 300 includes a plurality of compartments 310 for containing different colored inks, such as red, blue, and green, magenta, yellow, and cyan, etc. Partitions 312 are disposed in the interior of cartridge body 300 to separate compartments 310 from each other, and thereby form compartments 310. For one embodiment, compartments 310 have substantially equal volumes.

[0020] Figure 4 is a top view of a cartridge body, such as cartridge body 102 of Figures 1 and 2 or cartridge body 300 of Figure 3, according to another embodiment. The cartridge body includes a plurality of compartments 410 for containing different colored inks. Outlet ports 420₁-420₃ are respectively formed at the bottoms of compartments 410₁-410₃. Note that compartments 410 are in series along a direction perpendicular to the scanning direction 250. Alternatively, partitions 412 disposed in an interior of the cartridge body and that separate compartments 410 from each other are substantially parallel to the scanning direction 250. For one embodiment, a capillary medium, such as foam, may be disposed in each of compartments 410 for exerting a

capillary force on the ink that acts to prevent the ink from leaking. Alternatively, other suitable backpressure generating mechanisms may be used in the cartridge, such as free-ink spring-bag, bellows systems, etc., to prevent the ink from leaking.

[0021] Figure 5 is a bottom view of the cartridge body of Figure 4, according to another embodiment. Common reference numbers denote similar elements in Figures 1-3 and Figure 5. The cartridge body includes a plurality of ink-feed channels 520 that are communicatively coupled to outlet ports 420. In other words, outlet ports 420 open into ink-feed channels 520. Ink-feed channels 520 open directly to an exterior of the cartridge body and communicatively couple compartments 410 to the exterior of the cartridge body. Ink-feed channels 520 are configured to respectively align with slots in the print head die, such as slots 220 of print head die 210 of Figure 2, for delivering ink thereto. For one embodiment, portions of the bottom of the cartridge body surrounding ink-feed channels 520 are attached directly to portions of the print head die that surround the slots of the print head die, e.g., using an adhesive or encapsulant. For example, the portions of the bottom of the cartridge body surrounding ink-feed channels 520 may be attached directly to portions of print head die 210 of Figure 2 that surround slots 220 of print head die 210 on a side opposite to that shown in Figure 2. In operation, ink flows from compartments 410 (Figure 4), through outlet ports 420 (Figures 4 and 5), into ink-feed channels 520 (Figure 5), and subsequently into slots 220 of print head die 210 (Figure 2), for example. It should be noted that although generally square or rectangular outlet ports 420 are shown, they could be other shapes such as circles, slots, etc. Additionally, ink-feed channels 520 could be other shapes, sizes or eliminated altogether. For embodiments where ink-feed channels 520 are eliminated, outlet ports 420 open directly into slots of a print head die, such as slots 220 of print head die 210 (Figure 2).

[0022] For one embodiment, a ratio of the length L_C (Figure 5) of the cartridge body perpendicular to the scanning direction 250 to a length L_S of ink-feed channels 520 and/or a length of slots of a print head die, such as slots 220 of print head die 210 (Figure 2) perpendicular to the scanning direction 250 is less than about 2. In other words, length L_S of ink-feed channels 520 and/or of the slots 220 of print head die 210 are greater than about 1/2 the length L_C of the cartridge body. The ratio of the length of a conventional cartridge body perpendicular to its scanning direction to a length of ink-

feed channels of the conventional cartridge body or the slots of a print head die coupled to a conventional cartridge body is greater than about 3. In other words, the ink-feed slots in the die and/or channels of conventional cartridge bodies are typically less than about 1/3 of the length of the cartridge body. A ratio of the length L_C of the cartridge body to the length L_S of ink-feed channels 520 less than about 2 eliminates the need for an ink-delivery manifold and thereby acts to reduce manufacturing time and the part count and thus costs.

[0023] Figures 6, 7, and 8 are cross-sectional views respectively taken along lines 6-6, 7-7, and 8-8 of Figure 5, according to another embodiment. In one embodiment, a duct (or standpipe) 620 (see also Figure 4) is located within each compartment 410 and is connected (or opens) to an outlet port 420, as shown in Figures 6, 7, and 8. Outlet ports 420 open into ink-feed channels 520. For another embodiment, a filter may be located over an inlet 625 (Figures 6, 7, and 8) of each of ducts 620. For one embodiment, the capillary material overlies the filter.

[0024] Arrows 650 (Figure 6) illustrate a flow path of ink from compartment 410₁ through duct 620₁, through outlet port 420₁, and into ink-feed channel 520₁. Note that ink-feed channel 520₁ acts as a channel expansion, and the ink-flow expands as it passes substantially vertically downward through outlet port 420₁ and into ink-feed channel 520₁. As the ink-flow expands to fill ink-feed channel 520₁, it flows substantially horizontally and substantially perpendicular to the scanning direction, which is perpendicular to the plane of Figure 6.

[0025] Arrows 750 (Figure 7) illustrate a flow path of ink from compartment 410₂ through duct 620₂, through outlet port 420₂, and into ink-feed channel 520₂. Note that ink-feed channel 520₂ acts as a channel expansion, and the ink-flow expands as it passes substantially vertically downward through outlet port 420₂ and into ink-feed channel 520₂. As the ink-flow expands to fill ink-feed channel 520₁, it bifurcates and flows in opposite directions, each substantially horizontally and substantially perpendicular to the scanning direction, which is perpendicular to the plane of Figure 7.

[0026] Arrows 850 (Figure 8) illustrate a flow path of ink from compartment 410₃ through duct 620₃, through outlet port 420₃, and into ink-feed channel 520₃. The ink-flow exits outlet port 420₃ parallel to a normal to a plane of outlet port 420₃ at an angle

to the vertical, and thus at outlet port 420₃, the ink-flow and the normal to the plane of outlet port 420₃ has a vertically downward directed component and a horizontal component substantially perpendicular to the scanning direction, which is perpendicular to the plane of Figure 8. After exiting outlet port 420₃, the ink-flow flows substantially horizontally and substantially perpendicular to the scanning direction to fill ink-feed channel 520₃.

[0027] With reference to Figures 5 and 6, it is seen that for one embodiment, outlet port 420₁ may extend over a portion of the length of ink-feed channel 520₁ in a direction perpendicular to scanning direction 250, starting at an end 540 of ink-feed channel 520₁. Figures 5 and 8 illustrate that a portion of outlet port 420₃ may extend past an end 542 of ink-feed channel 520₃, and a remaining portion may extend into ink-feed channel 520₃. Figures 5 and 7 illustrate that outlet port 420₂ may be located away from ends 544 of ink-feed channel 520₂.

[0028] Note that the cartridge body of Figures 4-8 and ink-feed channels 520 thereof are formed as single-piece and form a unitary structure. Attaching a print head nozzle array, such as print head die 210 of Figure 2, seals ink-feed channels 520 to the corresponding slots 220 in the print head die.

[0029] Figure 9 is a three-dimensional representation of a single-colored, e.g., black, print (or ink-jet) cartridge 900, according to another embodiment. Ink-jet cartridge 900 includes a cartridge body 902. Common reference numbers denote similar elements in Figures 1 and 2 and Figure 9. Cartridge body 902 includes a single compartment 910 for containing ink. For one embodiment, the cover 106 of the ink-jet cartridge 100 of Figure 1 may be used to close compartment 910. This means that for some embodiments cover 106 can be used for both the three-compartment cartridge body 300 of Figure 3 and the single-compartment cartridge body 902 of Figure 9. Moreover, for one embodiment, essentially the same molding process used for cartridge body 102 (Figure 1) or cartridge body 300 (Figure 3), but with a different mold core for forming the interior, may form cartridge body 902.

[0030] Figure 10 is a three-dimensional representation of ink-jet cartridge 900 viewed from the bottom, according to another embodiment. Note that the head assembly 104 includes an orifice plate 1010 having a plurality of orifices 1015. Orifices 1015 are

communicatively coupled to compartment 910 for receiving ink therefrom through slots in the print head die that includes orifice plate 1010.

[0031] Figure 11 is a top view of cartridge body 902, according to another embodiment. Outlet ports 1120₁-1120₄ are formed at the bottom of compartment 910. For one embodiment, a capillary medium, bellows or other backpressure generating means may be disposed in compartment 910. Figure 12 is a bottom view of cartridge body 902, according to another embodiment. Cartridge body 902 includes a pair of ink-feed slots (or channels) 1220 that are communicatively coupled to outlet ports 1120. In other words, outlet ports 1120 open into ink-feed channels 1220. Ink-feed channels 1220 open directly to an exterior of cartridge body 902 and communicatively couple compartments 410 to the exterior of cartridge body 902. Ink-feed channels 1220 are configured to respectively align with slots in the print head die on which orifice plate 1110 is mounted for delivering ink thereto. For one embodiment, portions of the bottom of cartridge body 902 surrounding ink-feed channels 1220 are attached directly to portions of the print head die that surround the slots of the print head die, e.g., using an adhesive or encapsulant. In operation, ink flows from compartment 910 (Figures 9 and 11), through outlet ports 1120 (Figures 11 and 12), into ink-feed channels 1220 (Figure 12), into the slots of the print head die and subsequently through orifices 1015 (Figure 10). It should be noted that although generally square or rectangular outlet ports 1120 are shown, they could be other shapes such as circles, slots, etc. Additionally, ink feed channels 1220 could be other shapes, sizes or eliminated altogether, as discussed above in conjunction with Figure 5.

[0032] Note that a web 1130 is formed between the pair of outlet ports 1120₁ and 1120₂ and the pair of outlet ports 1120₃ and 1120₄ and extends in a direction from the pair of outlet ports 1120₁ and 1120₂ to the pair of outlet ports 1120₃ and 1120₄ in a direction perpendicular to the scanning direction 250, as shown in Figures 11 and 12.

[0033] Figure 13 is a cross-sectional view taken along line 13-13 of Figure 12, according to another embodiment. In one embodiment a duct (or standpipe) 1320 is located within compartment 910 is connected (or opens) to outlet ports 1120₁- 1120₄ (see Figure 11). Outlet ports 1120₂ and 1120₃ are shown opening into ink-feed channel 1220₂ in Figure 13. Note that outlet ports 1120 may be located away from and between

ends 1244 of feed channels 1220 for one embodiment. For another embodiment, a filter may be located over an inlet 1325 of duct 1320. For one embodiment, the capillary material overlies the filter. The ratio of the length L_C of the cartridge body perpendicular to the scanning direction, perpendicular to the plane of Figure 13, to a length L_S of ink-feed channel 1220₂ and/or a length of slots of a print head die perpendicular to the scanning direction is less than about 2.

[0034] Arrows 1350 (Figure 13) illustrate a flow path of ink from compartment 910 through duct 1320, through outlet ports 1120₂ and 1120₃, and into ink-feed channel 1220₂. The ink-flow exits outlet ports 1120₂ and 1120₃ substantially vertically downward on either side of web 1130 and fills ink-feed channel 1220₂. Note that a portion of the ink-flow expands to fill ink-feed channel 1220₂ as it exits outlet ports 1120₂ and 1120₃. Note that the cartridge body 902 and ink-feed channels 1220 thereof are formed as single-piece and form a unitary structure. Attaching a print head nozzle array, such the print head die that includes orifice plate 1010 (Figure 10), seals ink-feed channels 1220 to the corresponding slots in the print head die.

[0035] Figure 14 is a top view of a two-color, two-compartment ink-jet cartridge 1402, according to another embodiment. Common reference numbers denote similar elements in Figures 9 and 14. For one embodiment, dividing the compartment 910 (Figure 11), by forming a partition 1420 on web 1130, forms two compartments 1410 within ink-jet cartridge 1402 that are generally equal in volume. For another embodiment, outlet ports 1120₂ and 1120₄ and the web 1130 formed therebetween may be positioned such that the volume of compartments 1410 are respectively different fractions, e.g., about 1/3 and 2/3 (or the volume of one compartments 1410 is about 1/2 the volume of the other), of the volume of compartment 910. As such, cover 106 (Figure 1) may be used to close compartments 1410. Moreover, for one embodiment, essentially the same molding process used for cartridge body 902 (Figure 9), but with a different mold core for forming the interior, may form ink-jet cartridge 1402. For one embodiment, a capillary medium, bellows or other backpressure generating means may be disposed in each of compartment 1410. For other embodiments, compartments 1410 have substantially equal volumes.

[0036] Ink-jet cartridge 1402 includes a pair of ink-feed channels (not shown) that for one embodiment may be similar to ink-feed channels 1220 of Figure 12 or ink-feed channels 520 of Figure 5. The ink-feed channels are communicatively coupled to outlet ports 1120, as described above. The ink-feed channels open directly to an exterior of ink-jet cartridge 1402 and communicatively couple compartments 1410 to the exterior of ink-jet cartridge 1402. The ink-feed channels are configured to respectively align with slots in a print head die on which an orifice plate is mounted for delivering ink thereto. For one embodiment, portions of the bottom of ink-jet cartridge 1402 surrounding the ink-feed channels are attached directly to portions of the print head die, e.g., using an adhesive or encapsulant. In operation, ink flows from compartment 1410, through outlet ports 1120, into the ink-feed channels, into the slots of the print head die, and subsequently through orifices of the orifice plate. For one embodiment, the ink-flow is substantially similar to the ink-flow depicted by arrows 1350 in Figure 13 or the ink-flow depicted by arrows 650 and 750 in Figures 6 and 7. In one embodiment, a duct (or standpipe) 1430 is located within each compartment 1410 and is connected (or opens) to an outlet port 1120.

[0037] It should be noted that the various embodiments of a cartridge disclosed herein do not require plugs for plugging mold-slide-insert access holes and thus act to reduce manufacturing costs.

CONCLUSION

[0038] Although specific embodiments have been illustrated and described herein it is manifestly intended that the scope of the claimed subject matter be limited only by the following claims and equivalents thereof.

CLAIMS

What is claimed is:

1. A print cartridge body (300), comprising:
three or more compartments (310₁, 310₂, 310₃) in series; and
a partition (312) formed between each successive pair of compartments (310₁, 310₂, 310₃);
wherein each partition (312) is substantially parallel to a scanning direction of the cartridge body (300).
2. The print cartridge body (300) of claim 1, wherein three or more outlet ports (420₁, 420₃, 420₃) respectively of the three or more compartments (310₁, 310₂, 310₃) respectively open directly into three or more ink-feed channels (520₁, 520₂, 520₃), the three or more ink-feed channels (520₁, 520₂, 520₃) respectively configured to open directly into three or more ink-feed slots (220) in a print head die (210).
3. The print cartridge body (300) of claim 2, wherein a normal to a plane of at least one of the three or more outlet ports (420₁, 420₃, 420₃) is oriented at an angle to vertical.
4. The print cartridge body (300) of claim 3, wherein at least one of the three or more outlet ports (420₁, 420₃, 420₃) opens into its respective ink-feed channel (520₁, 520₂, 520₃) away from ends of that ink-feed channel (520₁, 520₂, 520₃).
5. The print cartridge body (300) of any one of claims 1-4, wherein the three or more ink-feed channels (520₁, 520₂, 520₃) respectively have a length in a

direction perpendicular to a scanning direction of the cartridge body (300) that is greater than about 1/2 of a length of the cartridge body (300) in the direction perpendicular to the scanning direction of the cartridge body (300).

6. The print cartridge body (300) of any one of claims 1-5, wherein three or more outlet ports (420₁, 420₃, 420₃) respectively of the three or more compartments (310₁, 310₂, 310₃) respectively open directly into three or more ink-feed slots (220) in a print head die (210).
7. A method for delivering ink to a print head (210) of a print cartridge (100), the method comprising:

respectively directing first, second, and third inks from first, second, and third compartments (310₁, 310₂, 310₃) of the print cartridge (100) through first, second, and third channels (520₁, 520₂, 520₃) into first, second, and third slots (220) of the print head (210);

wherein the first ink enters the first channel (520₂) away from ends of that channel (520₂); and

wherein the second ink enters the second channel (520₃) while having a vertical component and a horizontal component substantially perpendicular to a scanning direction of the print cartridge (100).
8. The method of claim 7, wherein the third ink enters the third channel (520₁) adjacent an end of the third channel (520₁).

9. A print cartridge (1402), comprising:
a print head; and
a body (902), wherein the body (902) comprises:
first and second ink-feed channels (1220₁, 1220₂); and
a web (1130) disposed between the first and second ink-feed channels (1220₁, 1220₂), the web (1130) configured for forming a partition (1420) thereon that divides an interior of the body (902) into first and second compartments (1410₁, 1410₂) so that the first and second ink-feed channels (1220₁, 1220₂) respectively directly communicatively couple the first and second compartments (1410₁ and 1410₂) to first and second ink-feed slots of the print head.
10. A print cartridge (1402), comprising:
a print head; and
a body (902), wherein the body (902) comprises:
first and second outlet ports (1120₂, 1120₄); and
a web (1130) disposed between the first and second outlet ports (1120₂, 1120₄), the web (1130) configured for forming a partition (1420) thereon that divides an interior of the body (902) into first and second compartments (1410₁, 1410₂) so that the first and second outlet ports (1120₂, 1120₄) respectively directly communicatively couple the first and second compartments (1410₁, 1410₂) to first and second ink-feed slots of the print head.

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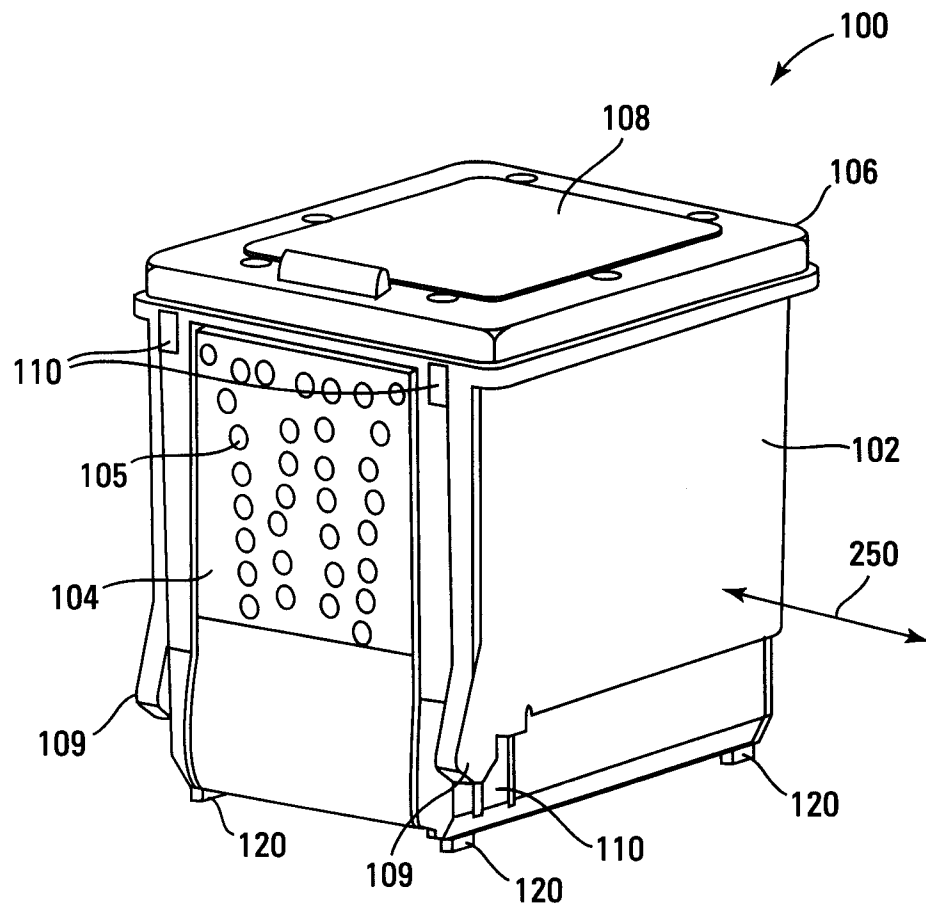


FIG. 1

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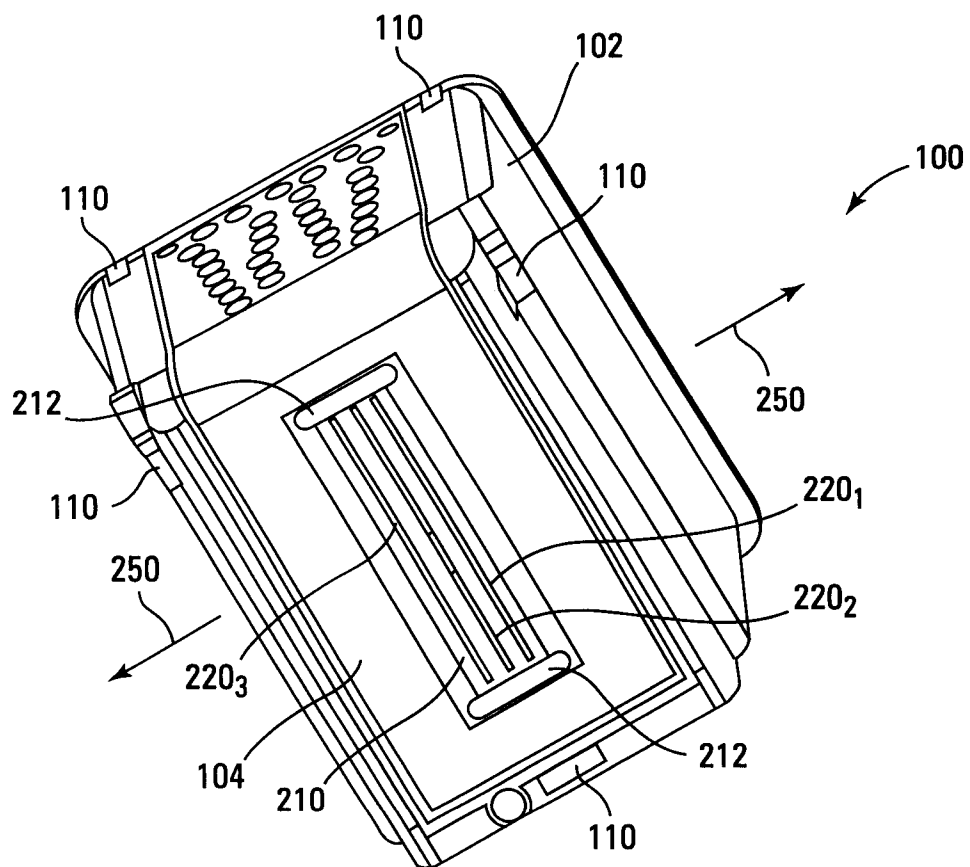


FIG. 2

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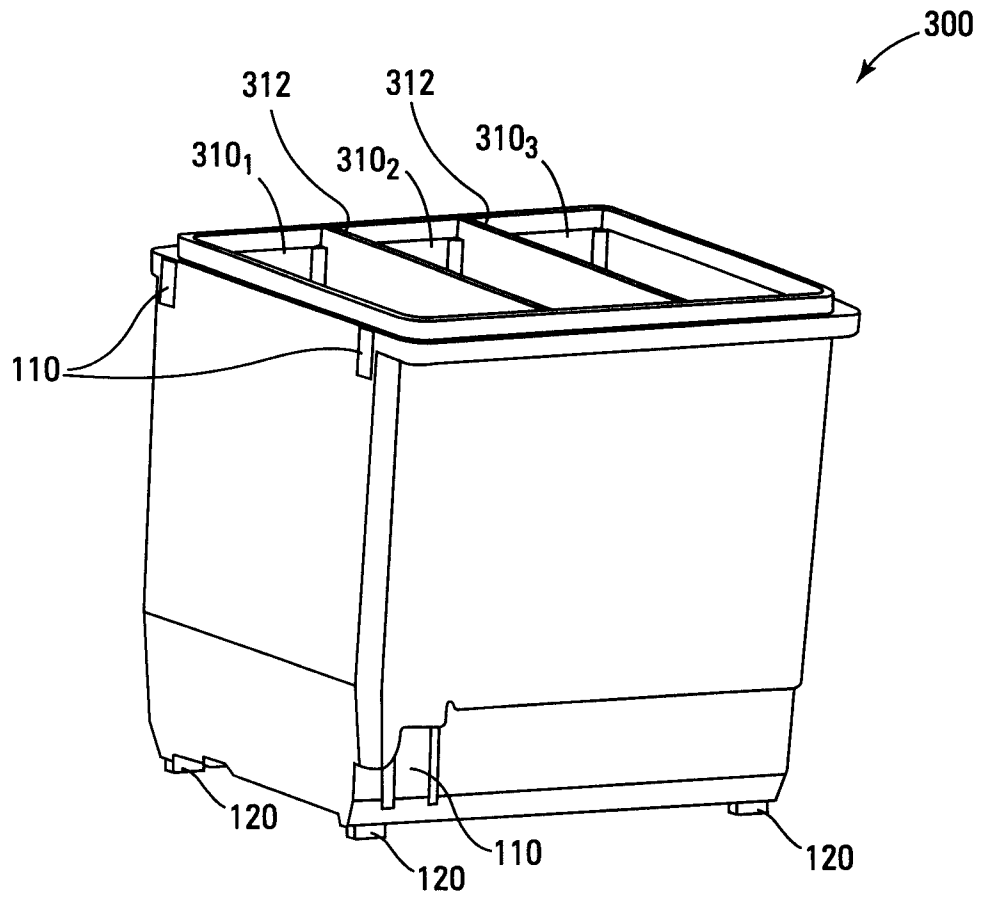


FIG. 3

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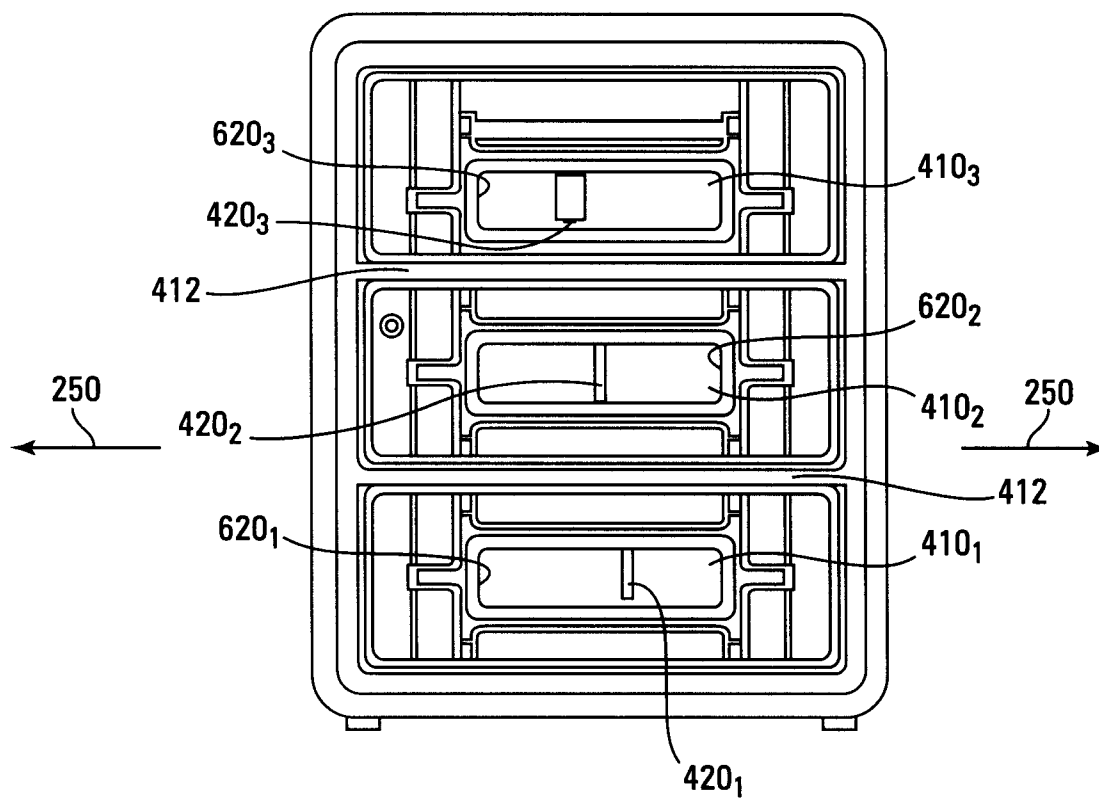


FIG. 4

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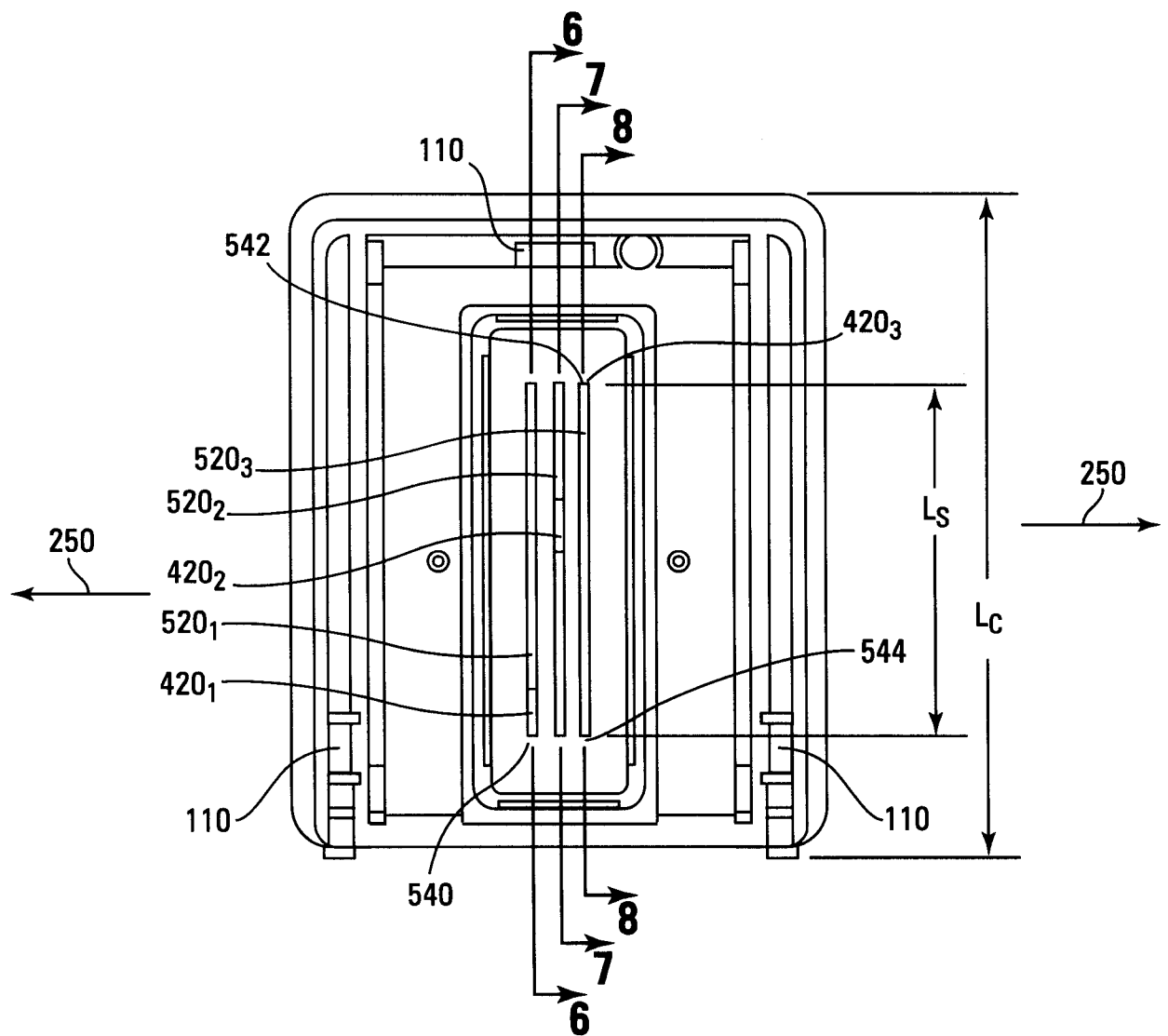
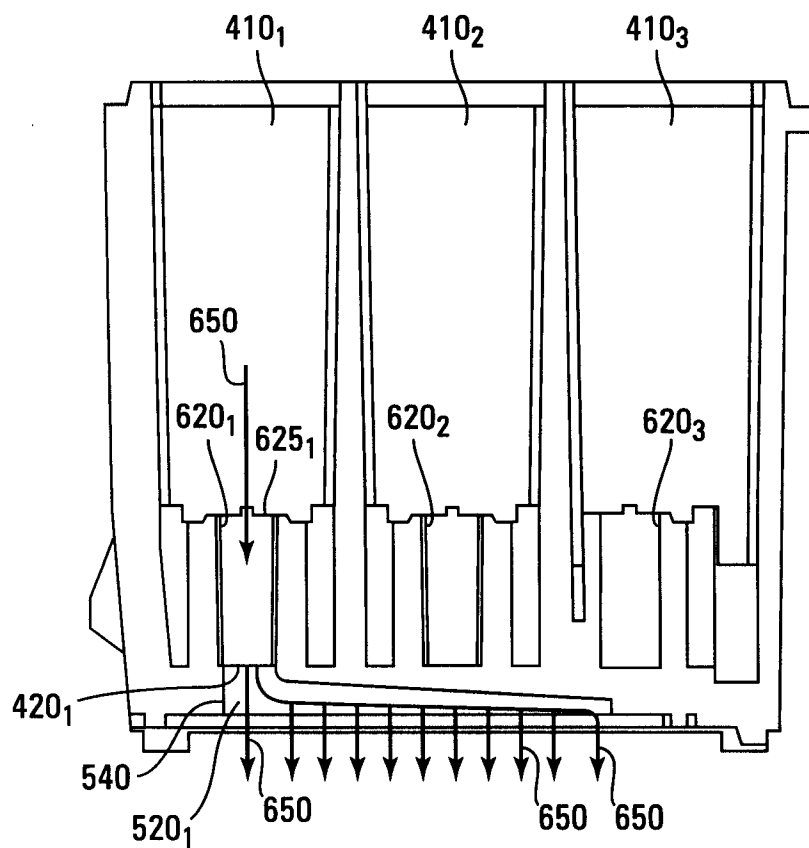


FIG. 5

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**FIG. 6**

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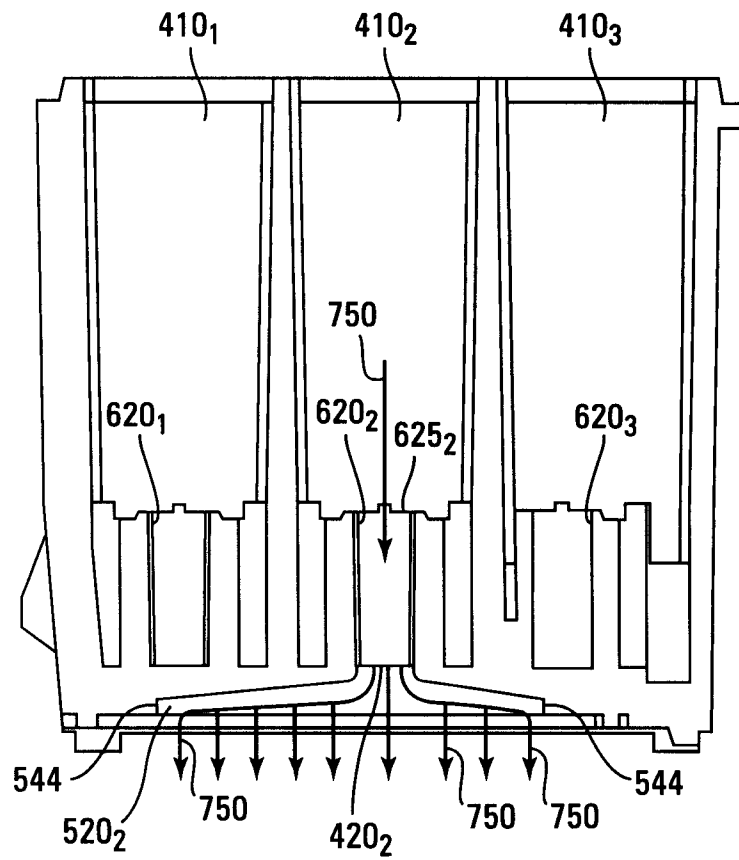


FIG. 7

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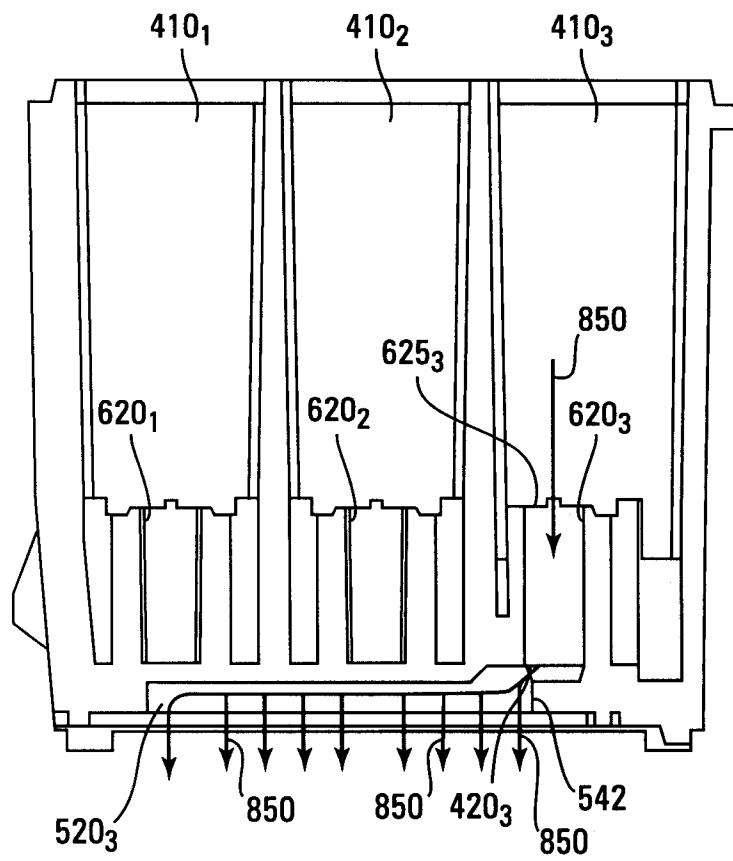


FIG. 8

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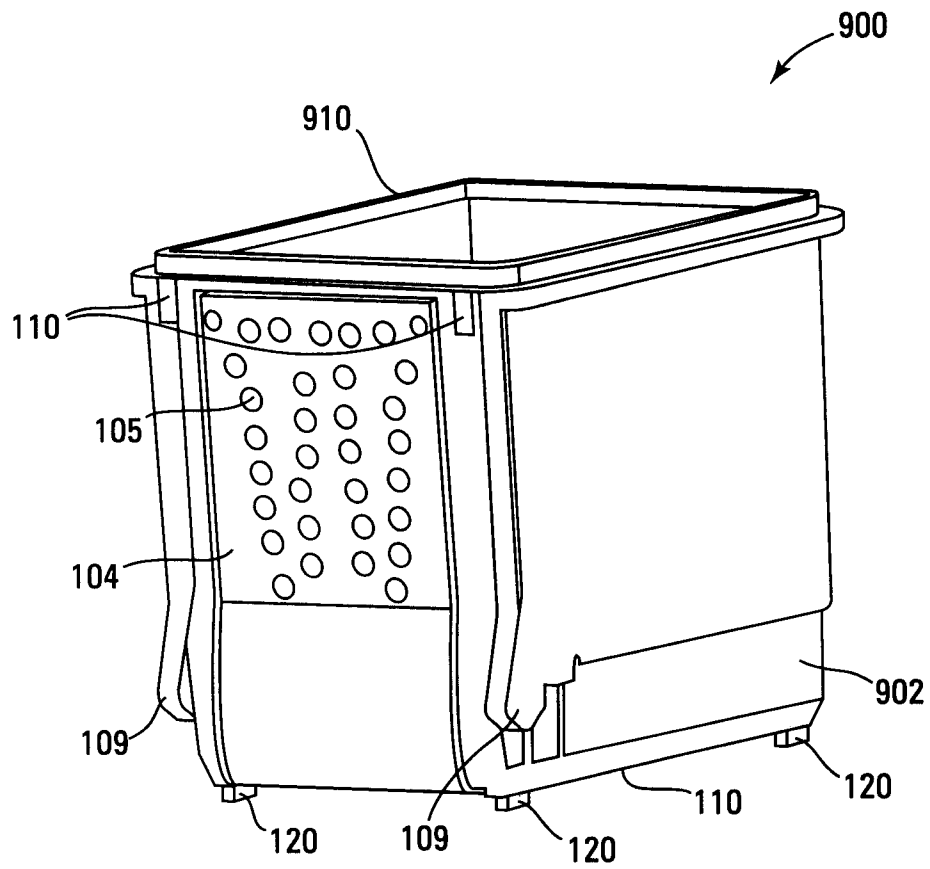


FIG. 9

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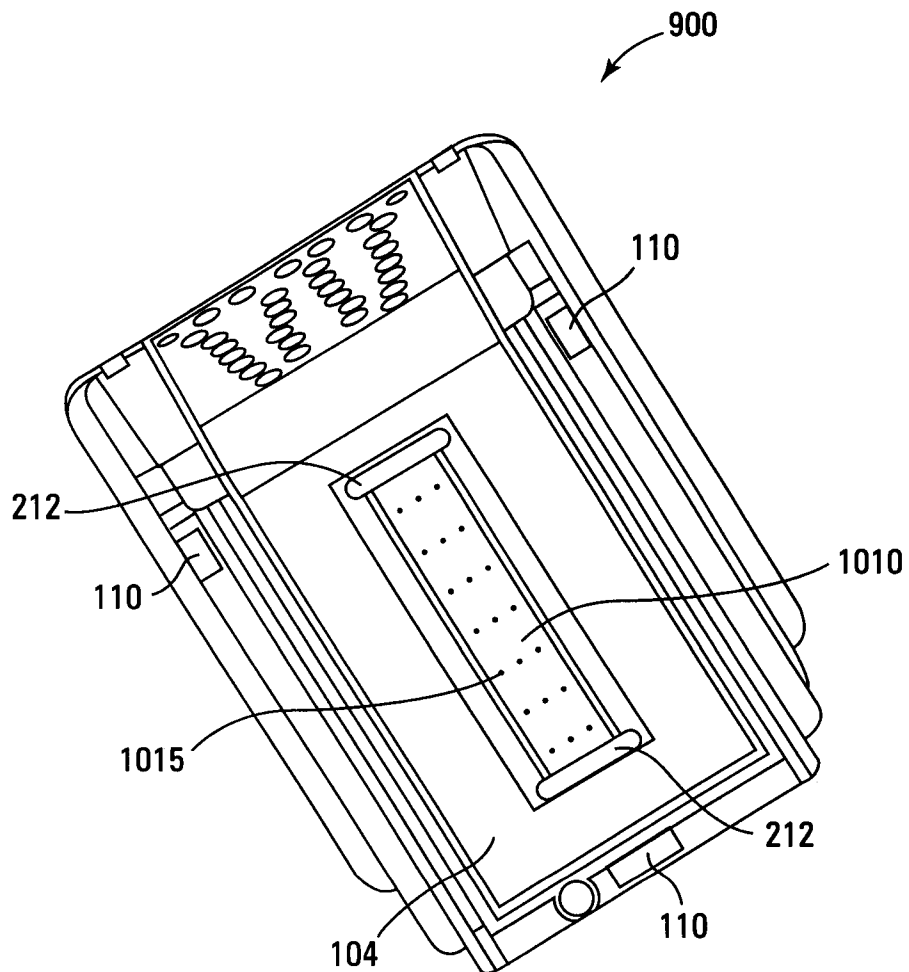


FIG. 10

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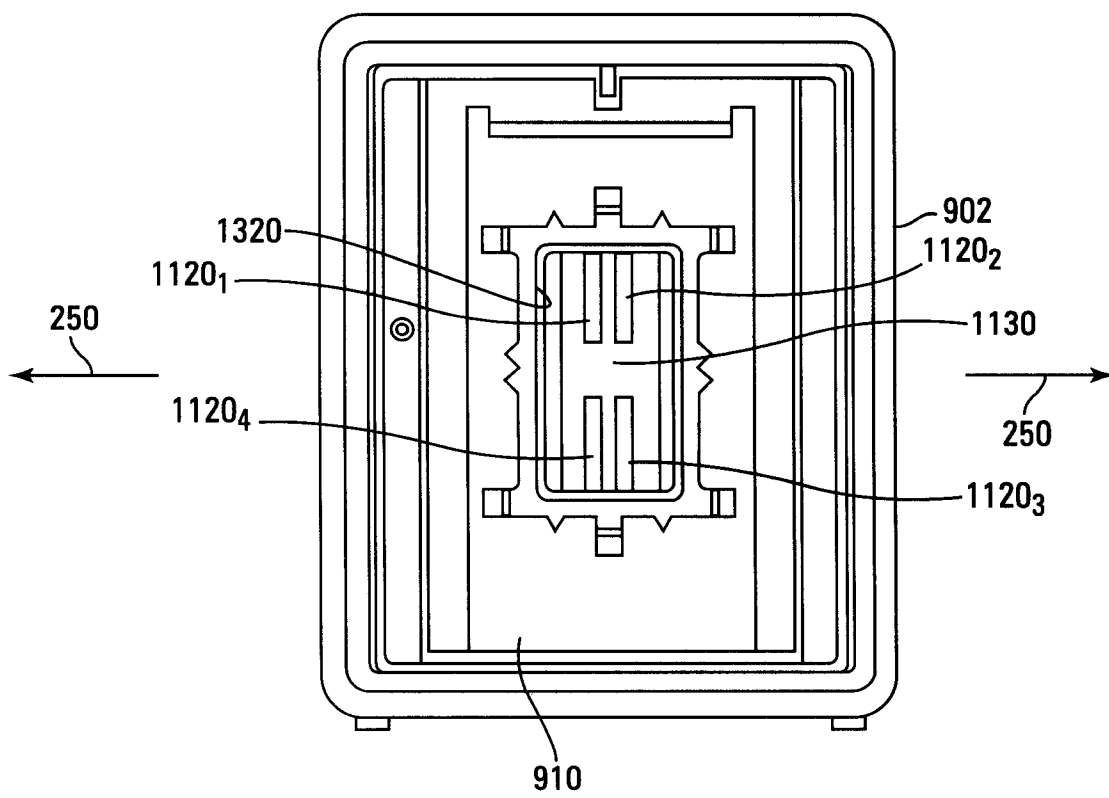


FIG. 11

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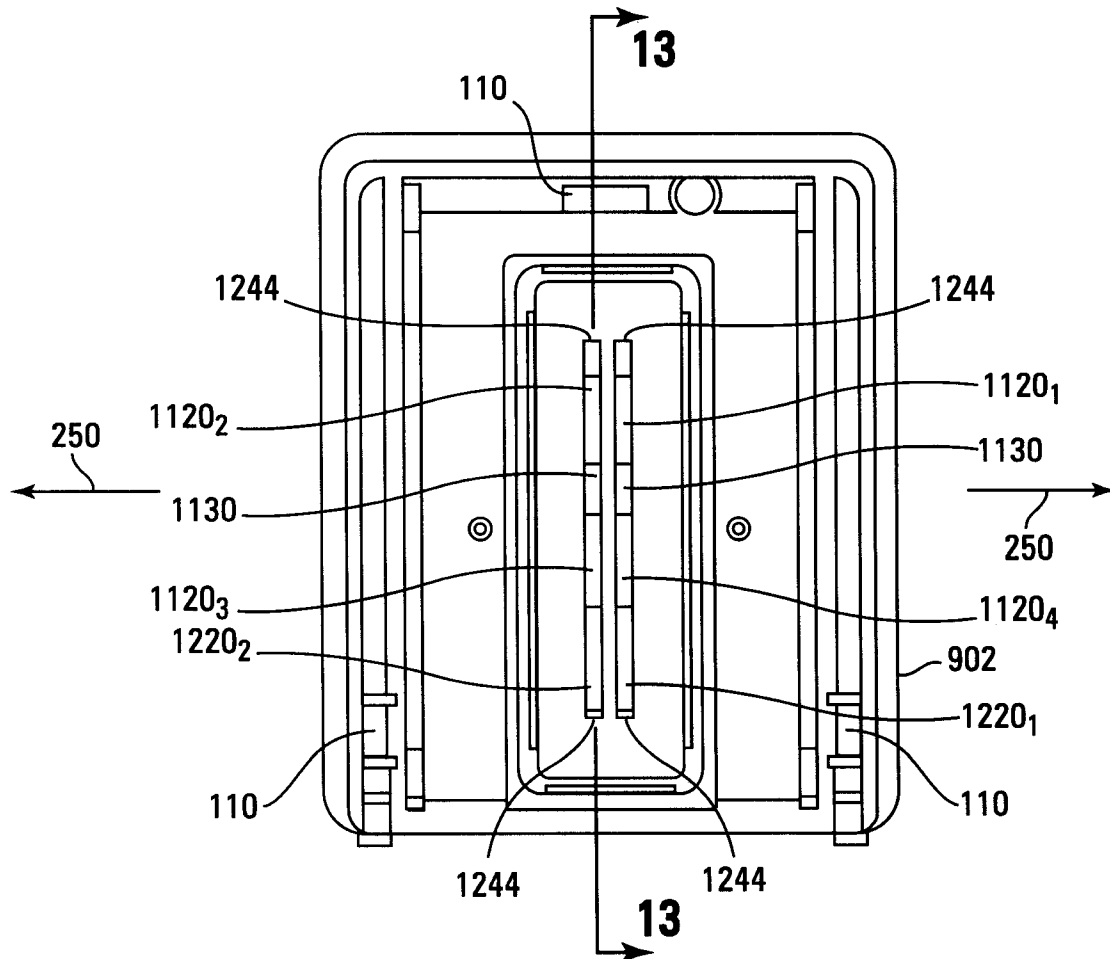


FIG. 12

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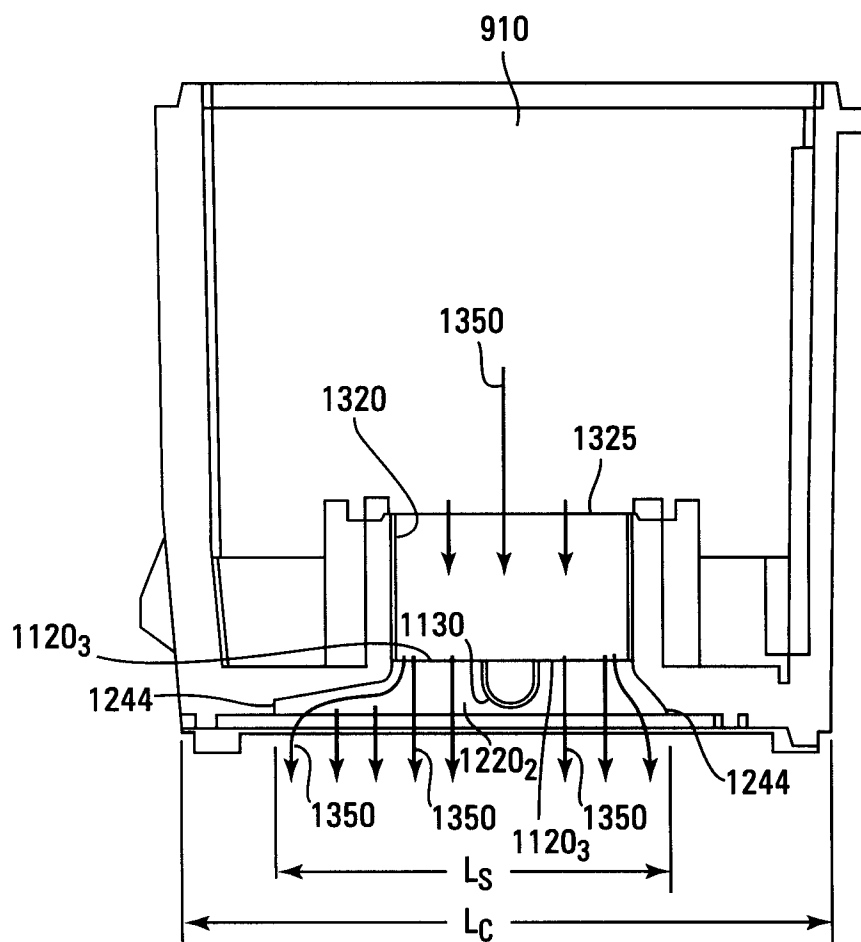


FIG. 13

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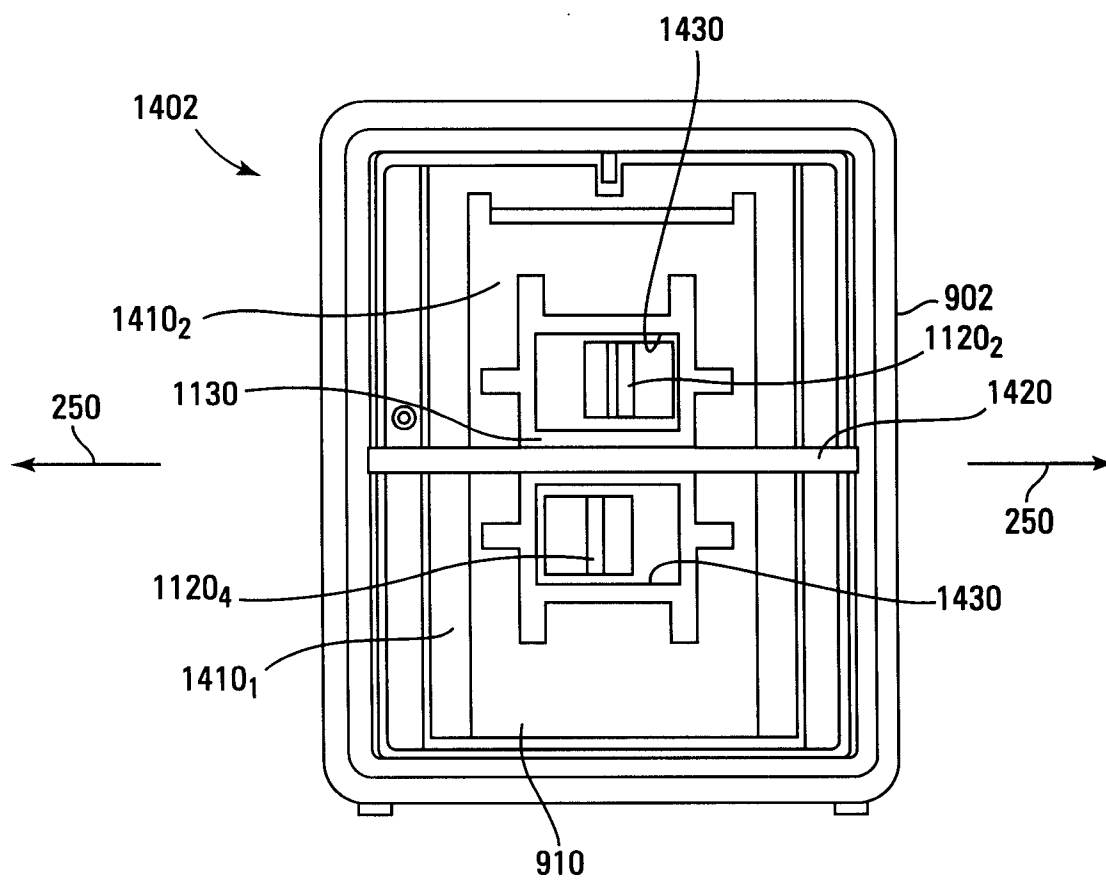


FIG. 14