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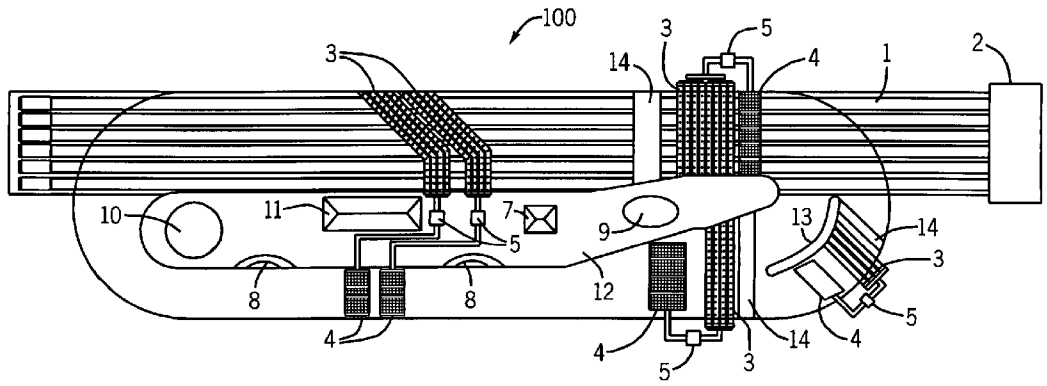


FIG. 1

(57) **Abstract:** Embodiments of the invention provide a sheet flow wave generator including a ride surface and a plurality of nozzles or jets coupled to the ride surface. The nozzles or jets can be configured to form an artificial wave upon the ride surface. Embodiments of the invention also provide an apparatus and method of forming an artificial wave that moves in a direction against current flow. An apparatus and method of making an artificial wave can include forming an artificial wave that moves in one direction and using current moving in another direction to slow the speed of the artificial wave. Some embodiments of the invention can also be used to make a standing wave that is suitable for recreational use by causing water to flow through nozzles or jets.

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# SHEET FLOW WATER RIDE APPARATUS AND METHOD

## RELATED APPLICATIONS

**[0001]** This application claims priority under 35 U.S.C. § 119 to United States Provisional Patent Application No. 60/893,923 filed on March 9, 2007, and United States Provisional Patent Application No. 61/003,080 filed on November 14, 2007, the entire disclosures of which are incorporated herein by reference.

## BACKGROUND

**[0002]** Wave pools and water rides often use conventional wave generators to produce waves. The design of the pool is very important for producing waves. If the design of the pool is flawed, the pool will not produce waves. Even in nature with the correct beach, perfect waves are rare, because the waves depend upon environmental conditions, such as tides, wind, and off-shore storms.

**[0003]** One conventional wave generator is the pneumatic surf wave. The pneumatic surf wave stores water in caissons and uses the water to produce the desired wave. The pneumatic surf wave uses gravity to discharge the water from the caissons. The pneumatic surf wave uses a fan to expel the air in the chamber, causing a vacuum to draw the air upward. When the air is at its maximum capacity, the air is released into the chamber to create the wave. The caissons of the pneumatic surf wave are generally positioned upright.

**[0004]** Another conventional wave generator is the surf wave generator. The surf wave generator uses compressed air to release water from caissons to form a wave. The surf wave generator uses rows of caissons positioned along a side of the pool. More specifically, the caissons of the surf wave generator are generally positioned vertically along a back side of the pool.

**[0005]** Yet another conventional wave generator is the pneumatic wave generator. The pneumatic wave generator uses water-filled caissons to produce the desired wave. The pneumatic wave generator uses compressed air to expel the wave from the caisson. The

pneumatic wave generator includes many caissons in a single pool. The pneumatic wave generator includes caissons that are generally positioned vertically on a back side of the pool.

## SUMMARY

**[0006]** Some embodiments of the invention provide an apparatus and method for creating an artificial wave for a water ride with pneumatic wave generators enhanced by nozzles or jets. Some embodiments of the invention provide a sheet flow wave generator including a ride surface and nozzles or jets coupled to the ride surface. The nozzles or jets can be configured to form an artificial wave upon the ride surface. Embodiments of the invention also provide an apparatus and method of forming an artificial wave that moves in a direction against current flow. An apparatus and method of making an artificial wave can include forming an artificial wave that moves in one direction and using current moving in another direction to slow the speed of the artificial wave. Some embodiments of the invention can also be used to make a standing wave that is suitable for recreational use by causing water to flow through nozzles or jets.

**[0007]** Other aspects of the invention will become apparent by consideration of the detailed description and accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0008]** FIG. 1 is a top schematic view of a water ride according to one embodiment of the invention.

**[0009]** FIG. 2 is side perspective view of the water ride of FIG. 1.

**[0010]** FIGS. 3A-3E are top views of a water ride including various configurations of nozzles or jets according to another embodiment of the invention.

**[0011]** FIGS. 4A-4E are end perspective view of a water ride including various configurations of nozzles or jets according to another embodiment of the invention.

**[0012]** FIGS. 5A-5E are top views of a water ride including various configurations of nozzles or jets according to another embodiment of the invention.

[0013] FIG. 6 is a top view of a wave-generating device including nozzles formed in a rifling pattern according to one embodiment of the invention.

[0014] FIG. 7 is a top view of a water ride including the wave-generating device of FIG. 6.

[0015] FIGS. 8A-8D are perspective views of a water ride and a pivot jet according to another embodiment of the invention.

[0016] FIG. 9 is a perspective view of a water ride according to another embodiment of the invention.

[0017] FIGS. 10A-10C are top and side views of a water ride according to another embodiment of the invention.

[0018] FIG. 11 is a perspective view of a water ride according to another embodiment of the invention.

[0019] FIG. 12 is a perspective view of a water ride according to another embodiment of the invention.

[0020] FIGS. 13A-13J are schematic top views of a wave-generating device for use with the water rides of FIGS. 1-12.

[0021] FIG. 14 is a schematic top view of a wave-generating device for use with the water rides of FIGS. 1-12.

[0022] FIGS. 15A-15D are front and side views of artificial waves created by jets or nozzles.

[0023] FIGS. 16A-16B are side and front views of artificial waves created by jets or nozzles.

[0024] FIG. 17 is a perspective view of a water ride according to one embodiment of the invention.

[0025] FIG. 18 is a center cross-sectional view of the water ride of FIG. 17.

[0026] FIG. 19 is a side cross-sectional view of the water ride of FIG. 17.

**[0027]** FIG. 20 is a top view of a wave generating device matrix according to one embodiment of the invention.

**[0028]** FIGS. 21A-21b are perspective and side views of a concave feature for use with water rides according to some embodiments of the invention.

**[0029]** FIGS. 22A-22C are side and perspective views of a concave feature for use with water rides according to some embodiments of the invention.

**[0030]** FIGS. 23A-23C are perspective and side views of a concave feature for use with water rides according to some embodiments of the invention.

**[0031]** FIGS. 24A-24B are top and perspective views of a concave feature for use with water rides according to some embodiments of the invention.

**[0032]** FIG. 25 is a top view of a concave feature for use with water rides according to some embodiments of the invention.

**[0033]** FIGS. 26A-26B are top views of concave features for use with water rides according to some embodiments of the invention.

**[0034]** FIGS. 27A-27B are perspective and side views of a wave generating device module for use with water rides according to some embodiments of the invention.

**[0035]** FIG. 28A-28B are top and side views of a water ride according to one embodiment of the invention.

## DETAILED DESCRIPTION

**[0036]** Before any embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The invention is capable of other embodiments and of being practiced or of being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of

"including," "comprising," or "having" and variations thereof herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items. Unless specified or limited otherwise, the terms "mounted," "connected," "supported," and "coupled" and variations thereof are used broadly and encompass both direct and indirect mountings, connections, supports, and couplings. Further, "connected" and "coupled" are not restricted to physical or mechanical connections or couplings.

**[0037]** FIGS. 1 and 2 illustrate a water ride 100 according to one embodiment of the invention. The water ride 100 can include one or more chambers or caissons 1, a primary pump room 2, and wave-generating devices 3. In some embodiments, the water ride 100 can include water return grates 4, water return pipes 5, a water pump 7, a water suction intake system 8, and a secondary pump room 9. The water ride 100 can include one or more sets of stairs 14 that allow a rider to enter and exit the water ride 100. In some embodiments, the water ride 100 can be positioned adjacent to various commercial establishments or recreational activities, such as a concession stand 10, a hot tub 11, or a restaurant 12. In some embodiments, a bar or wall 13 can be positioned within the water ride 100 to divide the water ride 100 into two or more sections.

**[0038]** The primary pump room 2 can include pumps positioned close to the surface of the pool in order to produce a current to propel riders. The wave-generating devices 3 can be coupled to the water return pipes 5 in order to use the water flowing through the water return grates 4 to power the wave-generating devices 3. The water return pipes 5 can be connected to the water pump 7. The water pump 7 can also be connected to the water suction intake system 8. The secondary pump room 9 can supply the caissons 1 with air to produce the primary wave of the water ride 100.

**[0039]** The wave-generating devices 3 can include pipes with nozzles or individual jets that force water upward to create a wave that moves in a direction against the current flow of the primary wave generated by the caissons 1. As used herein and in the appended claims, the terms "nozzle" and "jet" may be used interchangeably, with both terms referring to any device capable of propelling water upward from a surface in a desired direction and at a desired pressure. In one embodiment, as shown in FIG. 6, a pattern of nozzles 102 formed in a pipe can generate a wave at a starting location 15.

**[0040]** In some embodiments, additional wave-generating devices can be used to create a small non-curling wave or "bump" before a curling wave created by the wave-generating devices 3. This small non-curling wave can cause the rider to dip down before rising up the curling wave.

**[0041]** In some embodiments, the water ride 100 can use gravity to force water out of the caissons 1 to produce the primary wave. The water ride 100 can include one or more caissons 1 positioned vertically along a back side of the pool. In other embodiments, the water ride 100 can use a set wave system to generate primary and/or secondary waves as disclosed in applicant's co-pending U.S. utility patent application entitled "Set Wave System for Wave Generation," the entire contents of which is herein incorporated by reference, and which also claims priority to U.S. provisional patent application number 60/893,923.

**[0042]** The wave-generating devices 3 can be used to form an artificial wave that moves in a direction against current flow, such as the current flow produced by the primary wave generated by the caissons 1. The artificial wave generated by the wave-generating devices 3 can also move in a direction that is against the current flow of a river type of water ride that does not provide primary waves.

**[0043]** In some embodiments, as shown in FIG. 1, the artificial wave formed by the wave-generating devices 3 can move against the current flow in a channel (such as a stream or river, whether natural or artificial). The current flow in the channel can slow down the speed of the artificial wave. For example, in some embodiments, the current flow can slow down the speed of the artificial wave to about one-quarter of its original speed. In general, the water ride 100 can form an artificial wave that moves in one direction and can use current moving in another direction to slow the speed of the artificial wave.

**[0044]** In some embodiments, the wave-generating devices 3 include one or more nozzles or jets that can be used to change or enhance the shape of the artificial wave. In some embodiments, the nozzles or jets can be positioned beneath a surface of the water. In some embodiments, a series of nozzles or jets can be positioned on a floor of the water ride and can be used to change or enhance the shape of the artificial wave. For example, a series of nozzles or

jets can be used to make the wave higher, steeper, and/or curl over. Also, a combination of nozzles or jets and current flow caused by the caissons 1 can be used to make the wave higher, steeper, and/or curl over.

**[0045]** In some embodiments, the water ride 100 can be used to make a standing wave that is suitable for recreational use by causing water to flow through nozzles or jets. In some embodiments, the nozzles or jets can be articulated or moveable to facilitate varying a shape of the standing wave.

**[0046]** As shown in FIGS. 3-5, some embodiments of the invention provide a sheet flow wave ride including a ride surface and a series of nozzles or jets coupled to, formed in, or positioned proximate to the ride surface. The nozzles or jets can be configured to form an artificial wave upon the ride surface. The ride surface can be generally planar. The ride surface can be positioned to be substantially horizontal or inclined with respect to the ground. The nozzles or jets can be configured to cause water to flow across the ride surface. If the ride surface is inclined, the nozzles or jets can be configured to cause water to flow upwardly over the ride surface. Depending on the intended use of the water ride, the nozzles or jets can be configured to define water depths on the ride surface from approximately 2 inches to approximately 36 inches. For a sheet flow water ride, the water depth on the ride surface can be substantially less than for a river type of water ride.

**[0047]** In some embodiments, the nozzles or jets are angled to cause the wave to curl forward on one side. The pressure of the water flowing through the nozzles or jets can be varied. For example, the pressure can be varied through each individual nozzle or jet or through groups of nozzles or jets. The water pressure can be varied through the nozzles or jets to change the shape and/or position of the wave. In some embodiments, the nozzles or jets can be articulated either in groups or individually. The nozzles or jets can be articulated to change the shape and/or position of the wave. In some embodiments, the water pressure can be varied through the nozzles or jets and the nozzles or jets can be articulated to move the wave left or right, move the wave up or down, and/or to vary the shape of the wave. In some embodiments, the water pressure is higher in the front (or lower or upstream) nozzles or jets than in the back (or higher or downstream) nozzles or jets. In some embodiments, a portion of the nozzles or jets are

positioned along a front end (or lower end or upstream) of the ride surface to cause water flow upwardly across the ride surface. In some embodiments, a drain can be formed at the back end (upper end or downstream) of the ride surface.

**[0048]** FIG. 3A illustrates one embodiment of a sheet flow water ride 200 with a ride surface 202. The sheet flow water ride 200 can include wave-generating devices 3, additional wave-generating or flow-creating devices 4, a water suction intake system 8, and stairs 14. The wave-generating devices 3 can be used to create artificial waves on the ride surface 202. The wave-generating devices 3 can be configured in a number of manners, such as those shown in FIGS. 3B-3E. If the configuration of FIG. 3B is used, the artificial wave can be formed at a central portion 204 of the wave-generating devices 3. If the configuration of FIG. 3C is used, the artificial wave can be formed at a diagonal portion 206 of the wave-generating devices 3. If the configuration of FIG. 3D is used, the artificial wave can substantially span the width of the water ride 200. If the configuration of FIG. 3E is used, the artificial wave can be formed at another diagonal portion 208 of the wave-generating devices 3. In some embodiments, as shown in FIG. 3A, a bar or wall 13 can be positioned within the water ride 200 to create two ride surfaces for two riders. Each ride surface can include one of the nozzle or jet configurations shown in FIGS. 3B-3E.

**[0049]** FIGS. 4A-5E illustrate a water ride 300 similar to the water ride 200 shown in FIGS. 3A-3E, except that no bar or wall 13 is included in the water ride 300. As a result, the water ride 300 only includes a single ride surface 302.

**[0050]** In some embodiments, at least some of the nozzles of the wave-generating devices 3 are defined by openings formed in pipes. As shown in FIGS. 6-7, the openings in the pipes can spiral at least part of the way around the pipes in a rifling-like fashion. These types of nozzles can also be configured within the water rides described herein in the manner shown and described with respect to FIGS. 3A-5E.

**[0051]** FIGS. 8A-8D illustrate a water ride 400 according to another embodiment of the invention. The water ride 400 can include a body 402 divided into two or more parts, such as four parts 404, 406, 408, and 410, as shown in FIGS. 8A and 8C. More specifically, the body

402 can include an upper left body 404, an upper right body 406, a lower left base 408, and a lower right base 410. In some embodiments, each of the four parts 404, 406, 408, and 410 can be constructed of fiberglass. The water ride 400 can be substantially portable by disassembling and reassembling the four parts in a new location. In one embodiment, as shown in Fig. 8A, the assembled water ride 400 can have a length L of about 50 feet, a width W for each half of about 12 feet, and a maximum height H of about 7 feet. The upper left body 404 can be secured to the upper right body 406 using fasteners within holes 420 in flanges 422.

**[0052]** As shown in FIGS. 8A and 8C, the upper left body 404 and the upper right body 406 can include grating lips 412 that can support grating 414. In some embodiments, the upper left body 404 and the upper right body 406 can also include lateral grating 416 for de-watering the water ride 400 along its lateral sides 418.

**[0053]** In some embodiments, as shown in FIG. 8A, one or both of the upper left body 404 and the upper right body 406 can include stairs 424 that allow riders to enter and exit the water ride 400. In some embodiments, the upper left body 404 and the upper right body 406 can include a curb 425 formed around a bottom perimeter of the water ride 400.

**[0054]** One or both of the upper left body 404 and the upper right body 406 can include openings 426 (as shown in FIG. 8A) through which jets 428 (as shown in FIG. 8C) can be positioned. The jets 428 can propel a sheet of water up a ride surface 430. In addition to the jets 428, the water ride 400 can include a series of wave-generating devices 432, as shown in FIG. 8A, such as a series of pivot jets, that can propel water upward and/or in a direction that is against the current flow produced by the jets 428. FIG. 8B illustrates a wave-generating device 432 in the form of a pivot jet that can be articulated with respect to the ride surface 430.

**[0055]** FIGS. 8C-8D illustrate the jets 428 that propel water upwardly onto the ride surface 430. As the water moves up the ride surface 430, the water creates a sheet of water on the ride surface 430 flowing at a particular rate. Water is also being propelled upwardly from the wave-generating devices 432 positioned across the width W of the water ride 400. When the sheet of water meets the area adjacent to the wave-generating devices 432, the sheet of water is slowed down. The water being propelled upward by the wave-generating devices 432 combines with the

sheet of water being propelled upward by the jets 428. As these two bodies of water meet, an artificial wave is generated on the ride surface 430. The shape, height, and curl of this artificial wave can be altered by varying the pressure and/or position of the wave-generating devices 432. The artificial wave can also be altered by varying the pressure of the jets 428. In some embodiments, the pressures and positions of the wave-generating devices 432 and the jets 428 can be automated with an automation system.

**[0056]** As shown in FIGS. 8C-8D, the water ride 400 can include grating 414 through which return water can flow once the sheet of water has passed over the ride surface 430. The return water can flow downward into a basin 434. As shown in FIG. 8D, the return water in the basin 434 can flow through water return grating 436 and into water intake ports 438 in order to be returned to the jets 428 through caissons 440. In some embodiments, the de-watering of the water ride 400 can also be accomplished using the lateral grating 416, as shown in FIGS. 8A and 8C.

**[0057]** FIG. 9 illustrates a water ride 500 according to another embodiment of the invention. The water ride 500 is similar to the water ride 400 shown and described with respect to FIGS. 8A-8D. In one embodiment, the water ride 500 can have a length L of about 52 feet and a total width W of about 34 feet. FIG. 9 illustrates an artificial curling wave 502 created by a combination of a sheet of water flowing from jets 528 up the incline of the ride surface 530 and water being propelled upward by jets 532 coupled to the ride surface 530. In some embodiments, the jets 532 can be coupled to the ride surface 530 in groups, with each group being positioned in a particular direction and propelling water at a particular pressure. For example, the jets 532 can be positioned in four rows across the width W of the water ride 500. In addition, the rows of jets 532 can create an angled portion across part of the width W of the water ride 500. The angled portion can be used to direct the curling portion of the artificial wave to the desired position on the ride surface 530.

**[0058]** FIGS. 10A-10C illustrate a water ride 600 according to another embodiment of the invention. The water ride 600 is similar to the water ride 400 shown and described with respect to FIGS. 8A-8D, except that the water ride 600 includes water intake ports 638 positioned along lateral sides 618 of the water ride 600, rather than under a ride surface 630 of the water ride 600.

**[0059]** As shown in FIG. 10A, a sheet of water is propelled up the ride surface 630 by jets 628. As the sheet of water flows up the inclined ride surface 630, the sheet of water can meet a first set of wave-generating jets 640 that can create a small non-curling wave or bump. The sheet of water can then met a second set of wave-generating jets 632 positioned across the width of the water ride 600. The jets 632 can create a curling wave, for example, as shown and described with respect to FIG. 9. The sheet of water can pass the jets 632 and continue up the inclined ride surface 630 until reaching the grating 614. As shown in FIG. 10B, the return water can fall through the grating 614 and be directed into a basin 634 and then toward the water intake ports 638 positioned along the lateral sides 618 of the water ride 600. The return water can be directed into chambers or caissons 642 (in one embodiment, three caissons 642 on each lateral side 618 of the water ride 600) and through additional piping 643 back to the jets 628. In some embodiments, a portion of the return water can be routed directly back onto the ride surface 630 by piping 644 (as shown in FIGS. 10A and 10B) rather than being returned to the jets 628.

**[0060]** FIGS. 11 and 12 illustrate an artificial curling wave created by a combination of a sheet of water flowing from jets up the incline of the ride surface and water being propelled upward by jets coupled to the ride surface. In some embodiments, the jets can be coupled to the ride surface in panels or groups (such as sixteen groups, as shown in FIGS. 11 and 12), with each group being positioned in a particular direction and propelling water at a particular pressure. For example, the jets can be positioned in four rows and four sections across the width of the water ride to create sixteen groups of jets. In addition, the rows of jets can create an angled portion across part of the width of the water ride. The angled portion can be used to direct the curling portion of the artificial wave to the desired position on the ride surface. In one embodiment, each panel or group can be about 24 inches long and about 7 ½ inches wide. Four panels can span about 96 inches across the width of the water ride. In another embodiment, each panel or group can be about 8 inches long, with four panels spanning about 32 inches across the width of the water ride in order to create a two foot high barrel standing wave.

**[0061]** FIGS. 13A-13J illustrate a wave-generating device 700 for use with the water rides shown and described with respect to FIGS. 1-12. The wave-generating device 700 can include groups of jets that can be operated, positioned, and/or pressurized in the same manner. FIG. 13A

illustrates a top left group 702, a top right group 704, a top middle group 706, a bottom left group 708, a bottom right group 710, and a bottom middle group 712. By selectively controlling each of the groups of jets, the configurations shown in FIGS. 13B-13J can each be created. Each of the configurations shown in FIGS. 13B-13J can produce a different type, shape, or size of artificial wave. FIG. 13B illustrates the use of the top left group 702, the top middle group 706, and the bottom right group 710. FIG. 13C illustrates the use of the bottom left group 708, the top middle group 706, and the top right group 704. FIG. 13D illustrates the use of the bottom left group 708, the bottom middle group 712, and the bottom right group 710. FIG. 13E illustrates the use of the top left group 702 and the top right group 704. FIG. 13F illustrates the use all the groups except for the bottom middle group 712. FIG. 13G illustrates the use of the top left group 702, the top middle group 706, and the bottom left group 708. FIG. 13H illustrates the use of the top right group 706, the top middle group 706, and the bottom right group 310. FIG. 13I illustrates the use of the top left group 702, the top right group 704, and the bottom right group 710. FIG. 13J illustrates the use of the top left group 702, the bottom left group 708, and the bottom right group 710.

**[0062]** FIG. 14 illustrates a wave-generating device 800 for use with the water rides shown and described with respect to FIGS. 1-12. The wave-generating device 800 can include a matrix 802 having a particular bed size. In one embodiment, the bed size is about 35 ½ inches by 20 inches. The matrix 802 can include a horizontal matrix 804 and an inclined matrix 806. The horizontal matrix 804 can include, for example, 66 jets (6 rows by 11 columns). The inclined matrix 806 can include, for example, 144 jets (6 rows by 24 columns). Accordingly, in one embodiment, the matrix 802 can include a total of 210 jets.

**[0063]** FIGS. 15A-15D illustrate wave profiles created with various embodiments of the invention. FIG. 15A is a side view of an artificial curling wave 900 created with jets 902 being operated at different pressures. FIG. 15B is a front view of the artificial curling wave of FIG. 15A. FIG. 15D is a side view of a rolling wave 904 and FIG. 15C is a front view of the rolling wave 904. FIG. 15D illustrates the jets 902 being positioned across two wavelengths. FIG. 16A also illustrates the jets 902 being positioned across two wavelengths including a first crest 906, a trough 908, and a second crest 910. FIG. 16B is a front view of the waves of FIG. 16A.

**[0064]** Rather than being controlled in groups or panels as described herein, each jet of the wave-generating devices can be individually controlled. For example, the jets can be connected to an automation system in order to be individually controlled. Also, rather than being positioned in relatively narrow rows across the width of the riding surface, the jets can cover more of the floor of the riding surface, for example, covering two or more wavelengths of the artificial wave.

**[0065]** FIGS. 17-19 illustrate a water ride 1000 according to another embodiment of the invention. The water ride 1000 can include a ride surface 1010 with a concave feature 1012. The water can flow into the concave feature 1012 to create a dip in the height of the water with respect to the height of the ride surface 1010. The concave feature 1012 can have several suitable configurations as described below. In general, the concave feature 1012 results in the rider dropping down before reaching the area where the rider is elevated onto a wave form 1026 created by wave-generating devices 1028. In some embodiments, the water ride 1000 can include additional wave-generating devices positioned upstream of the concave feature 1012. The additional wave-generating devices can create a small non-curling wave before the rider drops down into the concave feature 1012.

**[0066]** The water ride 1000 can include one or more side de-watering grates 1022 positioned on the lateral sides of the water ride 1000 generally outside of the concave feature 1012. The water ride 1000 can also include a central de-watering grate 1024 positioned in the center of the concave feature 1012. The water flow, as represented by arrows 1032, can flow past the concave feature 1012 where some water can be removed through the grates 1022, 1024. In some embodiments, the water collected with the grates 1022, 1024 can be used to power the wave-generating devices 1028. The remaining water flow 1032 can move into the wave-generating devices 1028 in order to form the wave form 1026. After flowing past the wave-generating devices 1028, the water can flow into water returns 1038 in order to be returned to the upstream portion of the water ride 1000. FIG. 18 illustrates a cross-section of the ride surface 1010 taken transverse to the water flow 1032. FIG. 19 illustrates another cross-section of the ride surface 1010 taken parallel to the water flow 1032. FIG. 19 illustrates that the water flowing into the

central de-watering grate 1024 can flow through a pipe 1034 to a reservoir 1036 used to provide water to the wave-generating devices 1028.

**[0067]** FIG. 20 illustrates a wave generating device matrix 1050 according to one embodiment of the invention. The wave generating device matrix 1050 can include a top surface 1052 that can form part of the ride surface 1010. Individual jets or nozzles 1054 can be coupled to the top surface 1052 in an evenly-space rectangular matrix configuration or another suitable configuration. The individual jets or nozzles 1054 can each include a valve or groups of the jets or nozzles 1054 can be controlled by one valve. As shown in FIG. 20, the jets or nozzles 1054 for which the valve is open are identified by circles 1056 and create a wave generation pattern 1058 suitable for generating a particular waveform.

**[0068]** FIGS. 21A-21B illustrate one embodiment of a concave feature 1100 for use with various water rides as described herein. The concave feature 1100 can include a generally planar bed 1102, a perimeter 1104, a depression 1106, a de-watering grate 1108, wave-generating devices 1110, a primary flow area 1112, a secondary flow area 1114, and a surfing zone 1116.

**[0069]** FIGS. 22A-23C also illustrate embodiments of a concave feature similar to the concave feature 1100 of FIGS. 21A-21B. In addition to the structure shown in FIGS. 21A-21B, FIGS. 22A and 23C illustrate a platform 1118, water return piping 1120, and piping 1122 for the wave-generating devices 1110. FIG. 22B illustrates that the depression 1106 can include various zones with different elevation levels. FIG. 22C illustrates a curling barrel wave that can be created in the secondary flow area 1114. FIG. 23A illustrates the depression 1106 without any wave-generating devices 1110. FIG. 23B illustrates platforms 1118 that can be positioned, in some embodiments, upstream and downstream of the depression 1106 and the wave-generating devices 1110.

**[0070]** FIGS. 24A-24B illustrate a concave feature 1100 similar to the concave feature of FIGS. 21A-23C. The concave feature 1100 of FIGS. 24A-24B can include various zones with different elevation levels. The wave-generating devices 1110 of FIGS. 24A-24B can include several panels of nozzles or jets, such as left side panels 1124, left diagonal panels 1126, center panels 1128, right diagonal panels 1130, and right side panels 1132. The wave-generating

devices 1110 of FIGS. 24A-24B can generate a curling wave in a central portion of the depression 1106, for example, upstream of the center panels 1128. The water ride of FIGS. 24A-24B can also include grating 1108 at the bottom of the depression 1106 and grating 1134 downstream from the wave-generating devices 1110.

**[0071]** FIG. 25 illustrates another concave feature 1100 similar to the concave feature of FIGS. 24A-24B, except that the wave-generating devices 1110 are configured in a different manner. The wave-generating devices 1110 of FIG. 25 include several panels of nozzles or jets, including left top panels 1136, diagonal panels 1138, and right bottom panels 1140.

**[0072]** FIGS. 26A-26B illustrate another concave feature 1100 including two depressions 1106 and wave-generating devices 1110 in a V-shaped configuration that can create two separate curling waves. The wave-generating devices 1110 of FIG. 26A can include several panels of nozzles or jets, including top left panels 1142, left diagonal panels 1144, central panels 1146, right diagonal panels 1148, and top right panels 1150. FIG. 26B illustrates a depression 1106 with three elevation zones.

**[0073]** FIG. 27A illustrates a wave generating device module 1200. FIG. 27B illustrates two wave generating device modules 1200 connected together by connectors 1202 on each end and/or other suitable fasteners on the elongated sides. Each wave generating device module 1200 can include an evenly-space rectangular matrix configuration or another suitable configuration of wave generating devices 1204 As shown in FIG. 27B, each wave generating device 1204 can include an angled exit orifice 1206 designed to direct the water in a particular manner. The angled exit orifice 1206 can be formed in a panel having a thickness that allows each orifice 1206 to give direction to the water flowing through it. The wave generating device modules 1200 can each be designed to generate different wave forms depending on the number and arrangement of the modules 1200. As shown in FIG. 27B, the modules 1200 can be connected together using suitable connectors 1202. A desired number and arrangement of modules 1200 can be coupled together and attached as decking (such as with bolts) to create a portion of the ride surface of one of the water ride embodiments described herein. The modules 1200 can be easily removed from the ride surface in order to change the type of wave form that is being generated, for example, during testing of the water ride or in order to provide different

wave forms for different riders. The modules 1200 can be changed in order to change the level of difficulty of the water ride. Different modules 1200 can be designed for the following activities: body boarding (no curl), surfing (curl), kayaking (deep flow), and body surfing (deep flow). Different modules 1200 can also be designed for different depths of flow within the water ride, such as sheet flow versus deep river flow.

**[0074]** In the various embodiments of water rides described herein, different types of water flows can be introduced into the water rides from different angles and perspectives. For example, water can be angled to flow up an inclined ride surface. Also, water can be introduced to form an intersecting flow that can be diagonal or transverse to the main water flow in the water ride. In addition, water can be introduced from the side of the water ride and then join the main water flow of the water ride.

**[0075]** FIGS. 28A-28B illustrate a generally circular water ride 1300 according to another embodiment of the invention. The water ride 1300 can include a wave generation system 1302 positioned in a central portion of the water ride 1300. The wave generation system 1302 can push water to flow upward into a dome 1304 and then create a sheet flow 1306 on a conical ride surface 1308. The conical ride surface 1308 can include wave generating devices 1310 positioned in a ring around an outer portion 1312 of the water ride 1300. The wave generating devices 1310 can be jets or nozzles that help to create a wave form 1313 around a portion of the perimeter of the water ride 1300 or around substantially the entire perimeter of the water ride 1300. Water can be provided from the wave generation system 1302 to the wave generating devices 1310 with pipes 1311. The water ride 1300 can also include de-watering grates 1314 positioned in a ring around the outside perimeter of the water ride 1300. The water can flow through the grates 1314 into water returns 1316 that lead back to the wave generation system 1302.

**[0076]** Various features and advantages of the invention are set forth in the following claims.

CLAIMS

1. A method of making an artificial wave, the method comprising forming an artificial wave that moves in a direction against current flow.

2. The method of claim 1, wherein the artificial wave moves against current flow in a channel.

3. The method of claim 1, wherein the current flow slows down a speed of the artificial wave.

4. The method of claim 3, wherein the current flow slows down the speed of the artificial wave to about one quarter of its original speed.

5. The method of claim 1, further comprising causing water to flow through at least one jet to change a shape of the artificial wave.

6. The method of claim 1, further comprising causing water to flow through at least one jet to enhance a shape of the artificial wave.

7. The method of claim 6, wherein the jet is disposed beneath a water surface.

8. The method of claim 1, wherein a plurality of jets are used to change a shape of the artificial wave.

9. The method of claim 1, wherein a plurality of jets are used to enhance a shape of the artificial wave.

10. The method of claim 1, wherein a plurality of jets are used to make the artificial wave higher.

11. The method of claim 1, wherein a plurality of jets are used to make the artificial wave steeper.

12. The method of claim 1, wherein a plurality of jets are used to make the artificial wave curl over.

13. The method of claim 1, wherein a combination of a plurality of jets and the current flow are used to make the artificial wave curl over.

14. The method of claim 1, wherein a combination of a plurality of jets and the current flow are used to make the artificial wave higher.

15. A method of making an artificial wave, the method comprising forming an artificial wave that moves in one direction and using current moving in another direction to slow the speed of the artificial wave.

16. A method of making a standing wave that is suitable for recreational use, the method comprising causing water to flow through at least one jet.

17. The method of claim 16, wherein a plurality of jets are used to change a shape of the artificial wave.

18. The method of claim 16, wherein at least one jet is articulated to vary a shape of the standing wave.

19. An apparatus for making an artificial wave, the apparatus comprising a wave-generating device that causes the artificial waves to move in a direction against current flow.

20. The apparatus of claim 19, wherein the artificial wave moves against current flow in a channel.

21. The apparatus of claim 19, wherein the current flow slows down the speed of the artificial wave.

22. The apparatus of claim 21, wherein the current flow slows down the speed of the wave to about one quarter of its original speed.

23. The apparatus of claim 19, further comprising at least one jet through which water flows to change a shape of the artificial wave.

24. The apparatus of claim 19, further comprising at least one jet through which water flows to enhance a shape of the artificial wave.

25. The apparatus of claim 24, wherein the jet is disposed beneath a water surface.

26. The apparatus of claim 19, further comprising a plurality of jets configured to change a shape of the artificial wave.

27. The apparatus of claim 19, further comprising a plurality of jets configured to enhance a shape of the artificial wave.

28. The apparatus of claim 19, further comprising a plurality of jets configured to make the artificial wave higher.

29. The apparatus of claim 19, further comprising a plurality of jets configured to make the artificial wave steeper.

30. The apparatus of claim 19, further comprising a plurality of jets configured to make the artificial wave curl over.

31. The apparatus of claim 19, further comprising a plurality of jets configured to cooperate with the current flow to make the artificial wave curl over.

32. The apparatus of claim 19, wherein a combination of a plurality of jets and the current flow are used to make the artificial wave higher.

33. An apparatus for making artificial waves, the apparatus comprising a wave-generating device configured to make artificial waves that move in a direction so that current moving in another direction causes the speed of the artificial waves to be reduced.

34. A apparatus for making a standing wave that is suitable for recreational use, the apparatus comprising at least one jet through which water flows.

35. The apparatus of claim 34, wherein a plurality of jets are used to change a shape of the standing wave.

36. The apparatus of claim 34, wherein at least one jet is articulated to facilitate varying a shape of the standing wave.

37. A sheet flow wave generator comprising:

a ride surface; and

a plurality of jets coupled to the ride surface, the jets configured to form an artificial wave upon the ride surface.

38. The sheet flow wave generator of claim 37, wherein the ride surface is generally planar.

39. The sheet flow wave generator of claim 37, wherein the ride surface is inclined.

40. The sheet flow wave generator of claim 37, wherein the jets are configured to cause water to flow across the ride surface.

41. The sheet flow wave generator of claim 37, wherein the jets are configured to cause water to flow upwardly over the ride surface.

42. The sheet flow wave generator of claim 37, wherein the jets are angled to cause the artificial wave to curl forward at one side.

43. The sheet flow wave generator of claim 37, wherein water pressure can be varied through the jets.

44. The sheet flow wave generator of claim 37, wherein water pressure can be individually varied through the jets.

45. The sheet flow wave generator of claim 37, wherein water pressure can be varied through the jets to change at least one of a shape and a position of the artificial wave.

46. The sheet flow wave generator of claim 37, wherein the jets can be articulated.

47. The sheet flow wave generator of claim 37, wherein the jets can be individually articulated.

48. The sheet flow wave generator of claim 37, wherein the jets can be articulated to change at least one of a shape and a position of the artificial wave.

49. The sheet flow wave generator of claim 37, wherein water pressure can be varied through the jets and the jets can be articulated.

50. The sheet flow wave generator of claim 37, wherein water pressure can be varied through the jets and the jets can be articulated to at least one of move the wave left or right, move the wave up or down, and vary a shape of the artificial wave.

51. The sheet flow wave generator of claim 37, wherein water pressure is higher in the front jets than in the back jets.

52. The sheet flow wave generator of claim 37, wherein a portion of the jets are positioned along a front end of the ride surface to cause water to flow upwardly across the ride surface.

53. The sheet flow wave generator of claim 37, further comprising a drain formed at the back end of the ride surface.

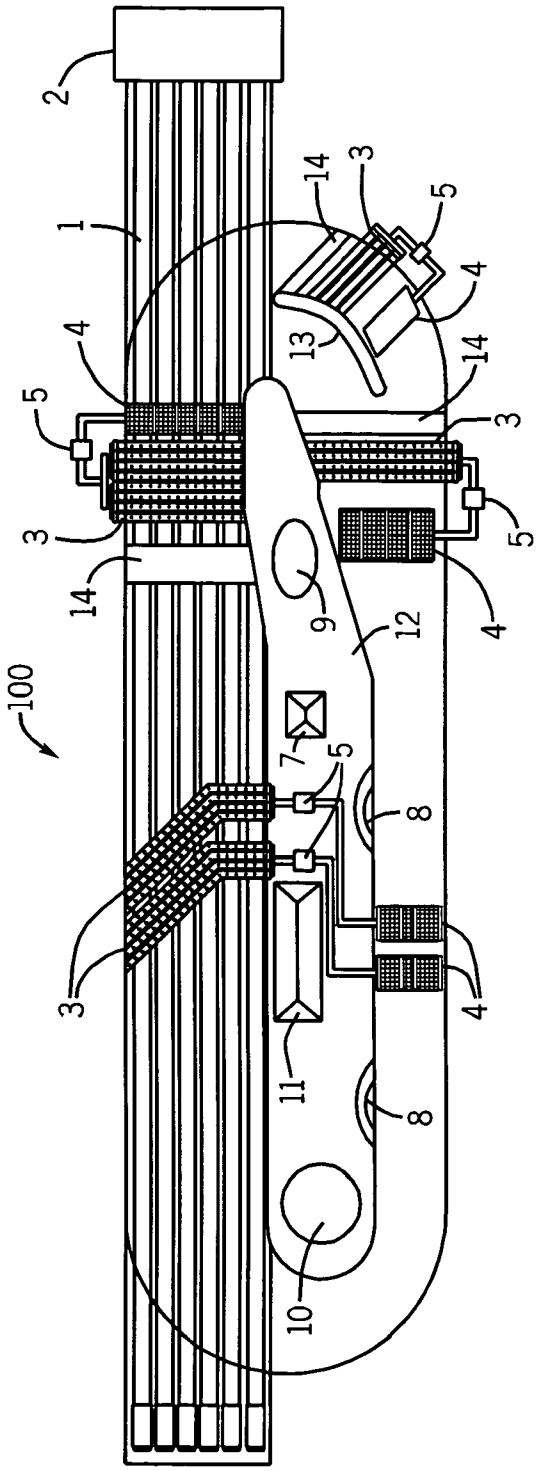



FIG. 1

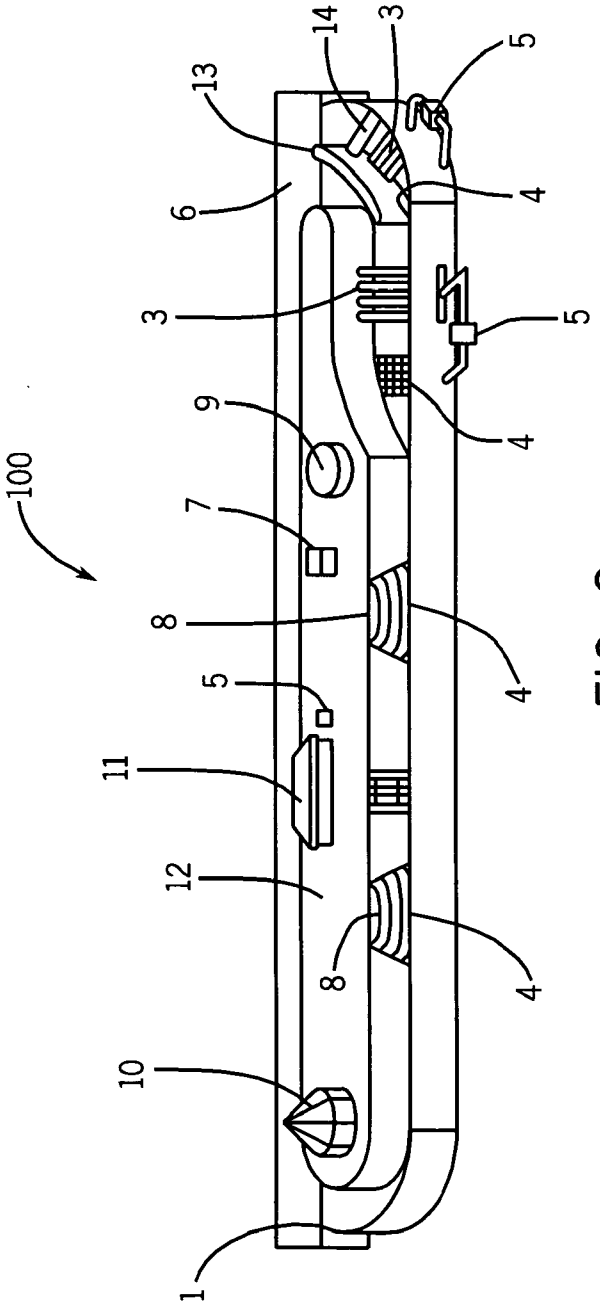



FIG. 2

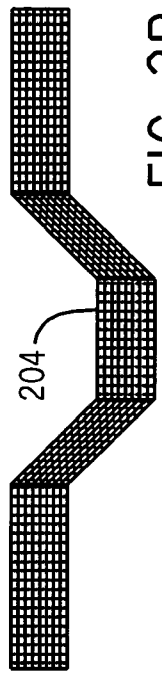



FIG. 3B

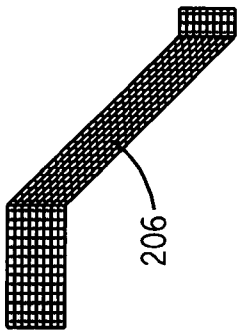



FIG. 3C

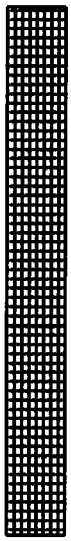


FIG. 3D

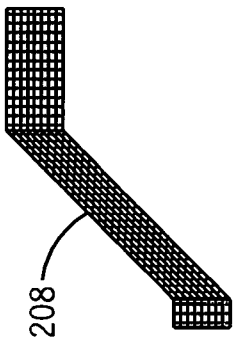



FIG. 3E

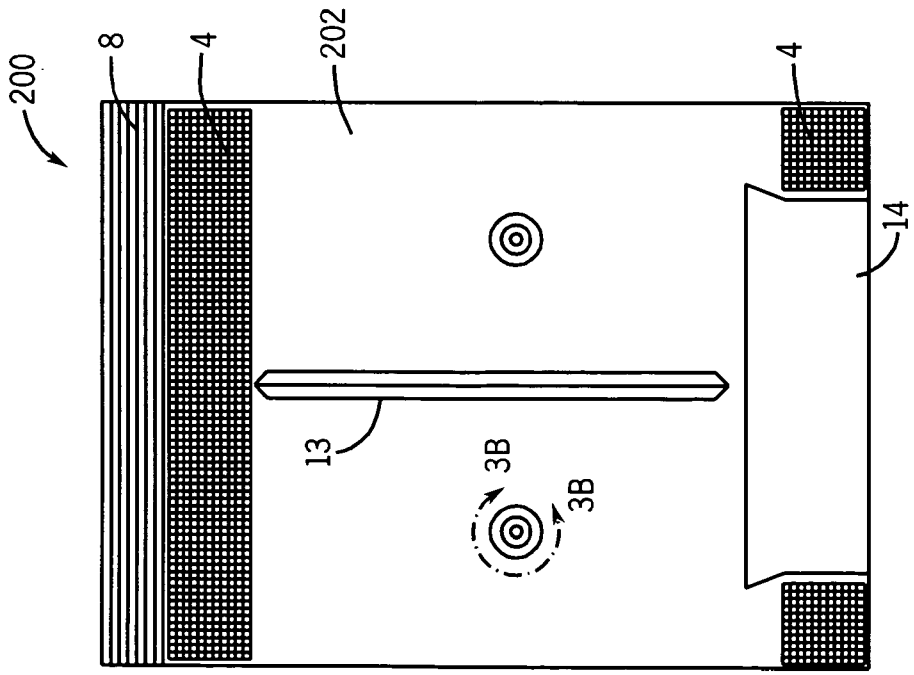



FIG. 3A

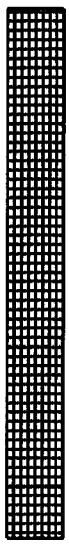


FIG. 4B

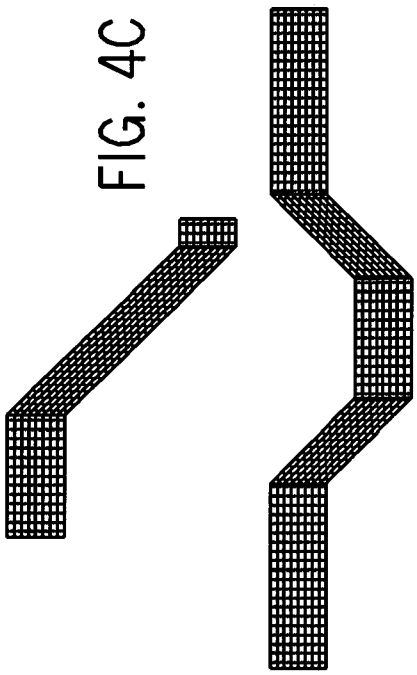


FIG. 4C

FIG. 4D

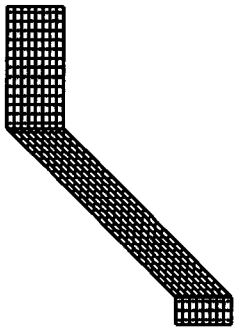


FIG. 4E

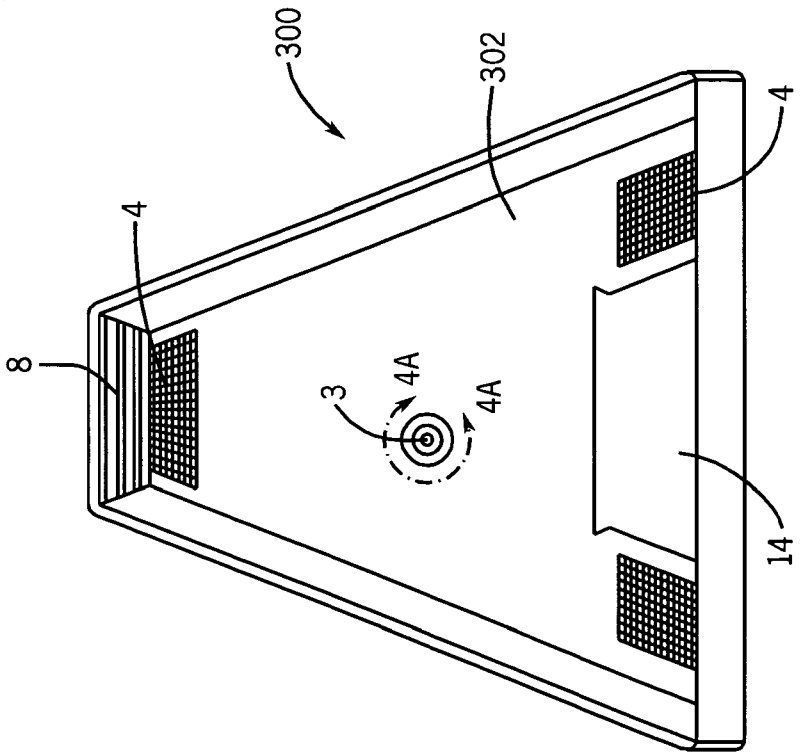



FIG. 4A

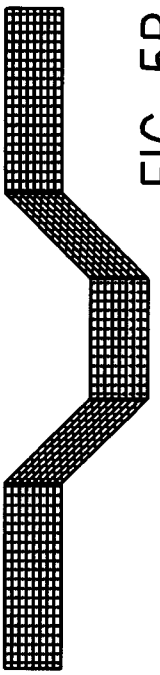


FIG. 5B

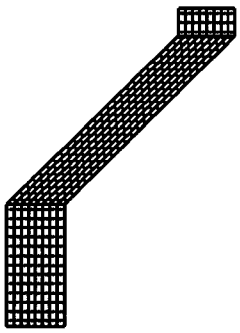


FIG. 5C

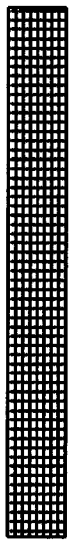


FIG. 5D

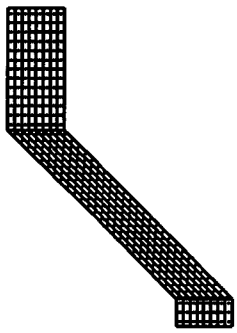


FIG. 5E

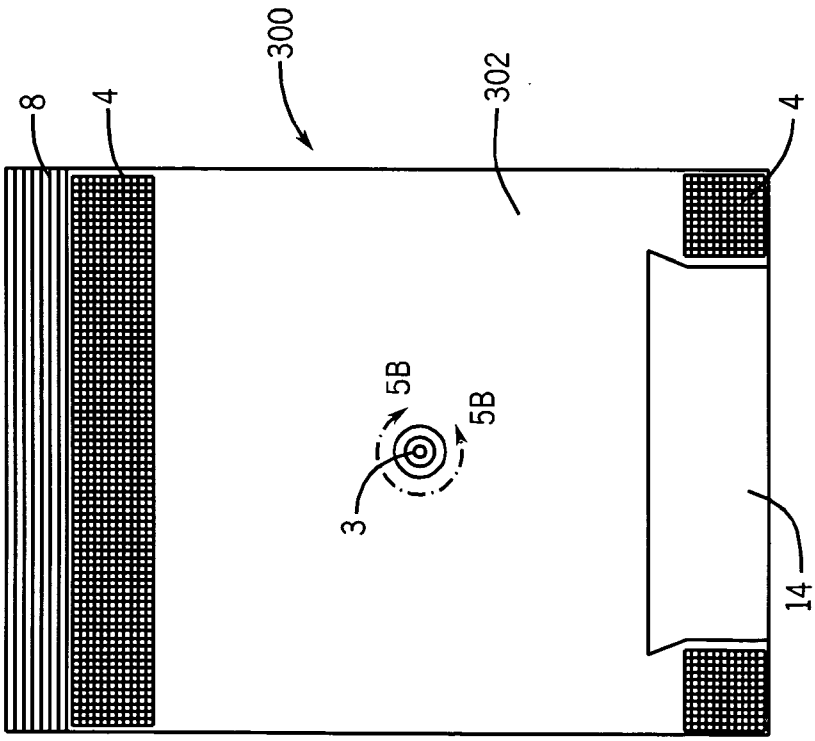



FIG. 5A

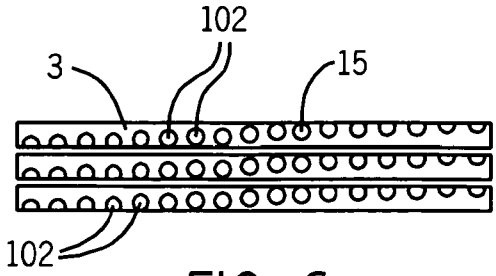



FIG. 6

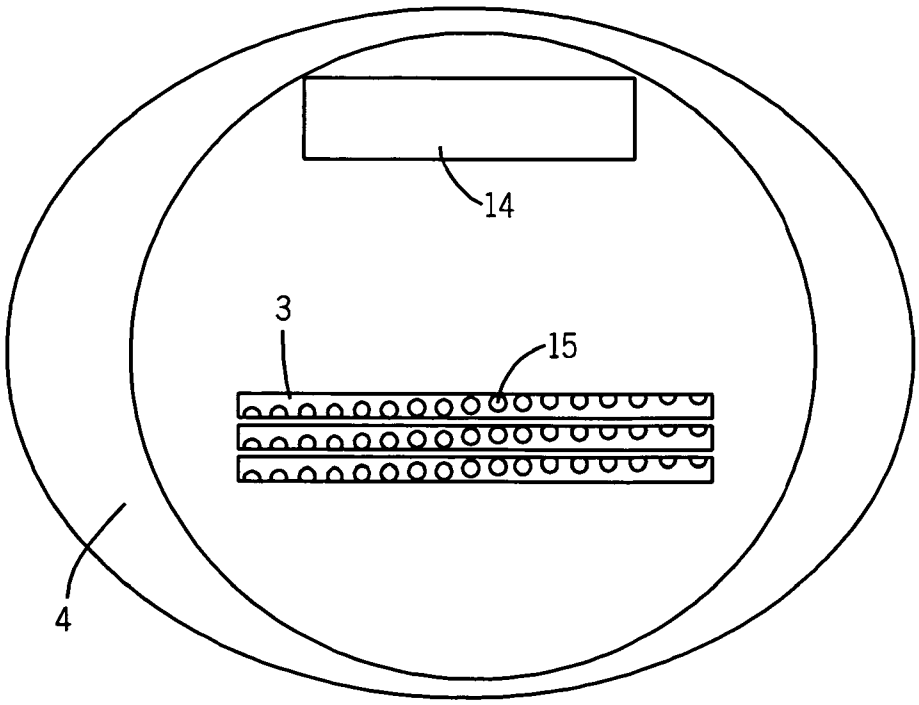



FIG. 7

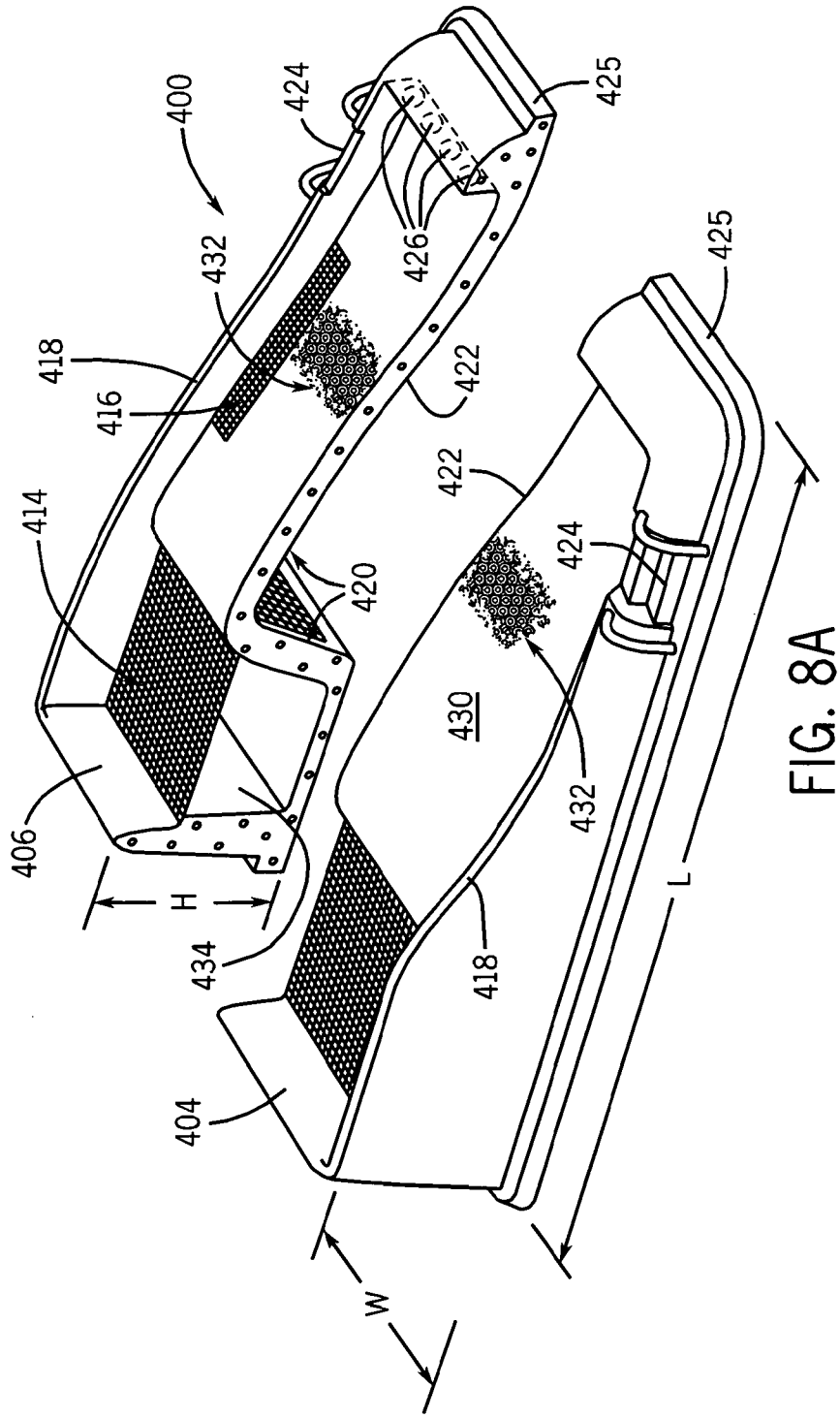
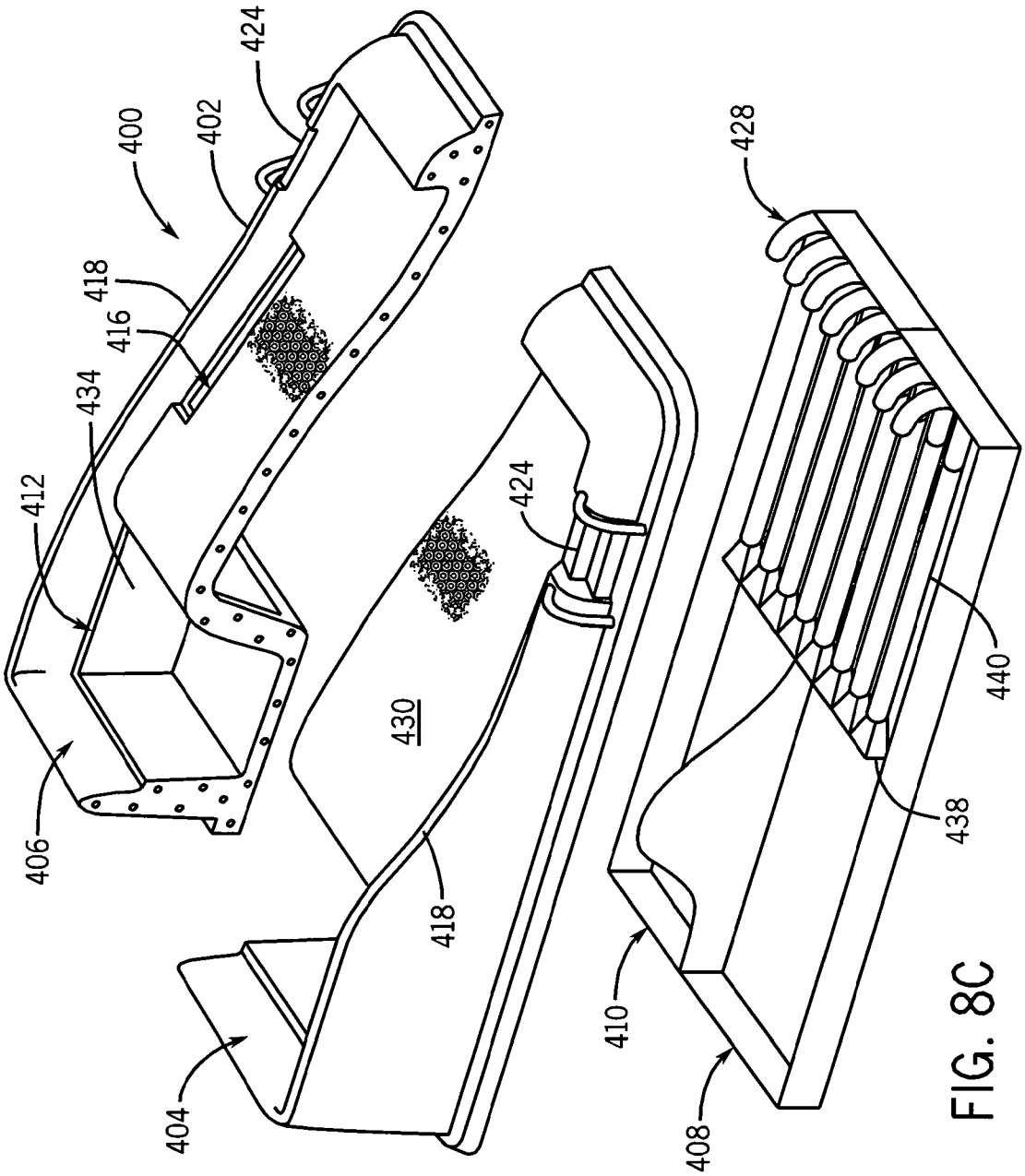



FIG. 8A


400
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404
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408

FIG. 8C

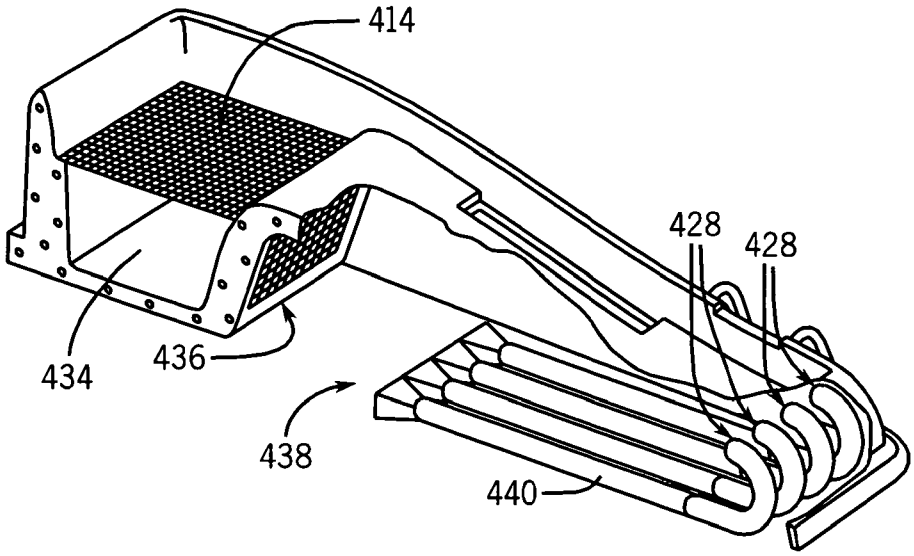



FIG. 8D

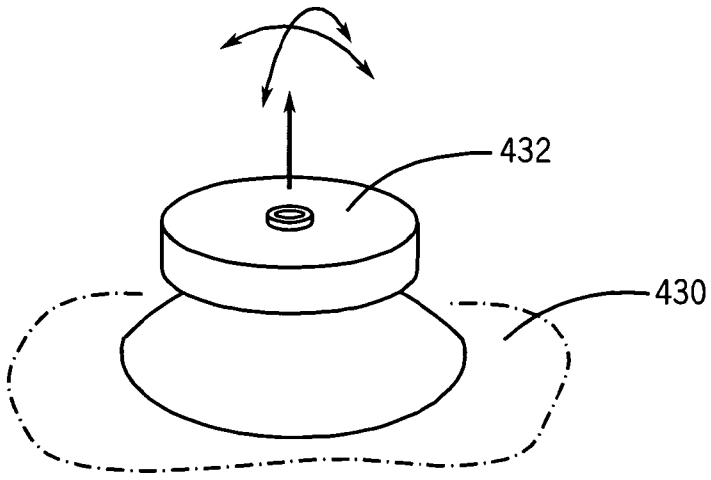



FIG. 8B

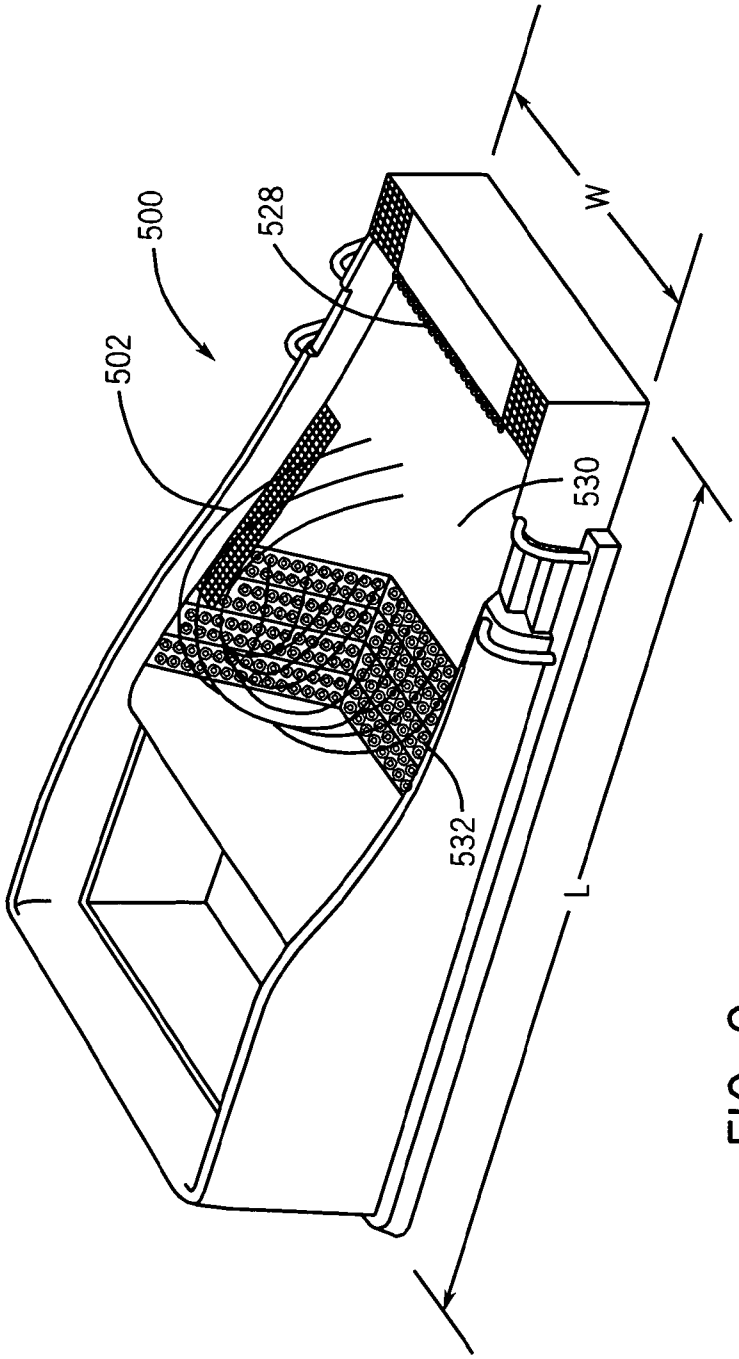



FIG. 9

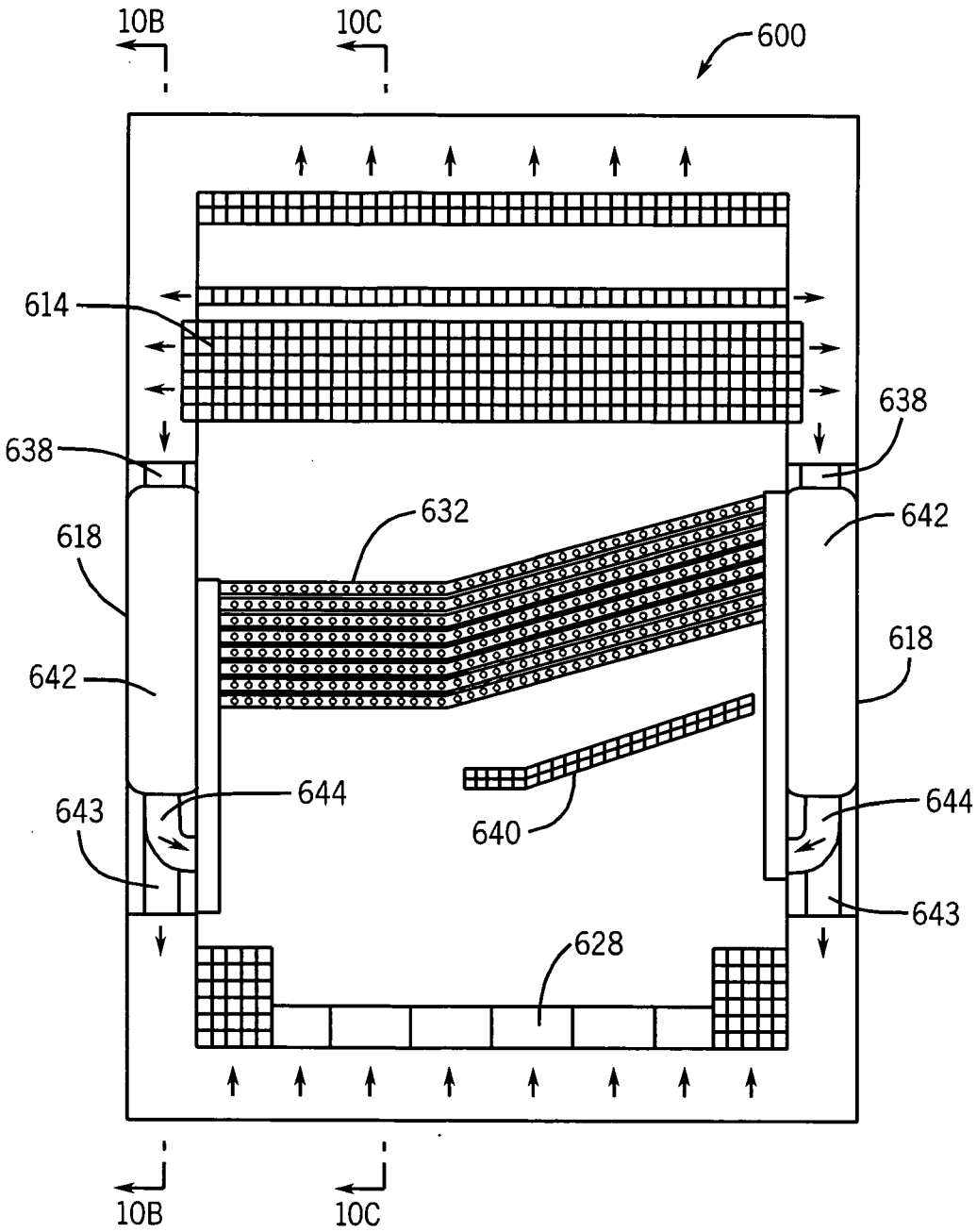

10B
10C
600
614
638
638
632
618
642
642
618
644
643
640
644
643
628
10B
10C

FIG. 10A

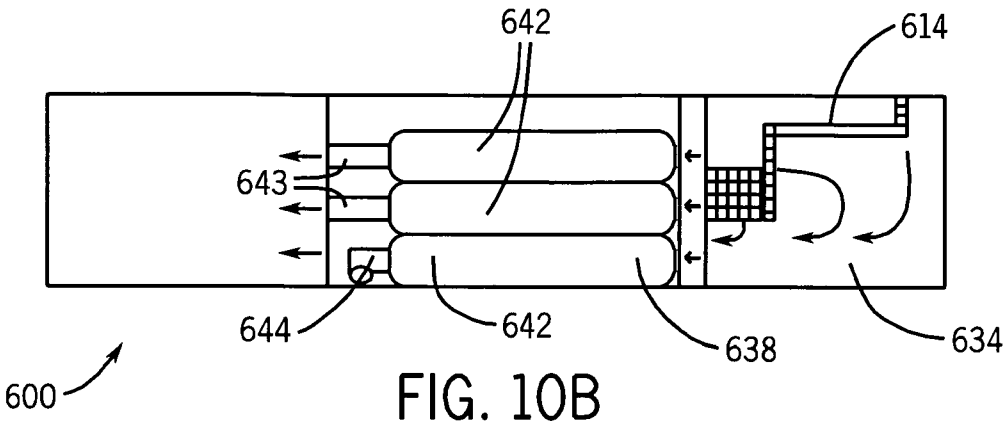



FIG. 10B

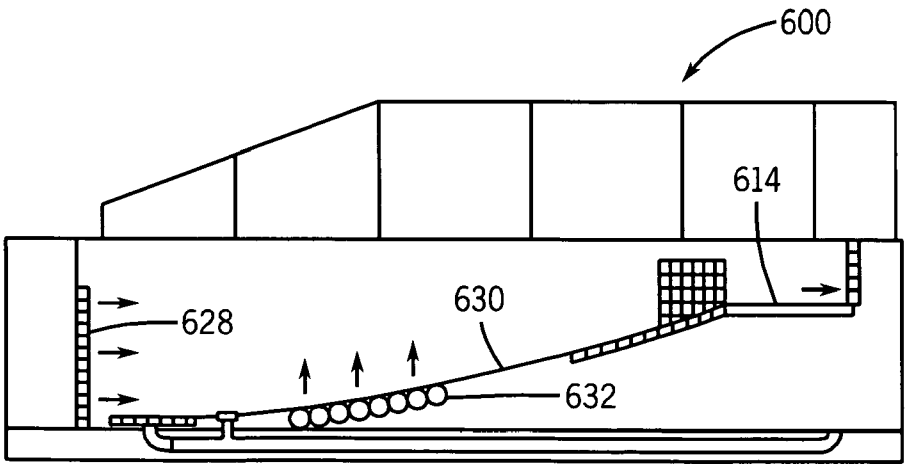



FIG. 10C

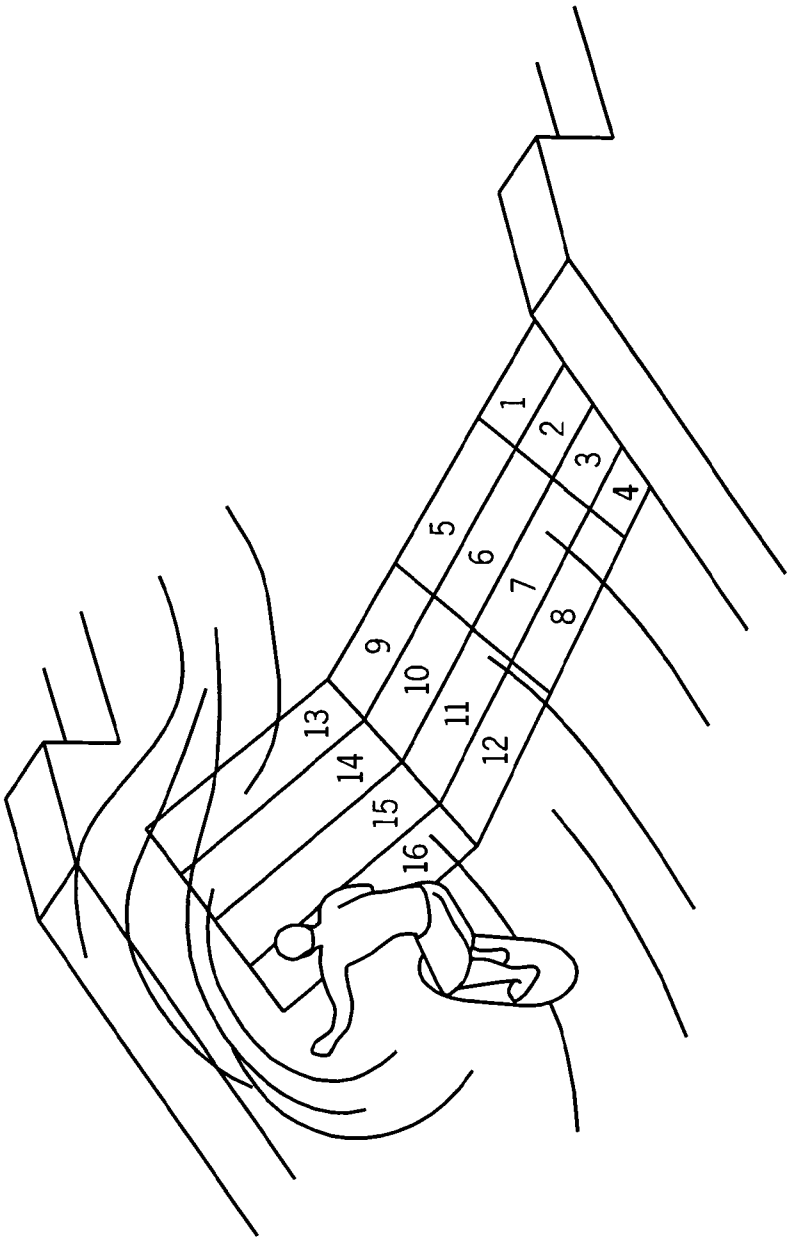



FIG. 11

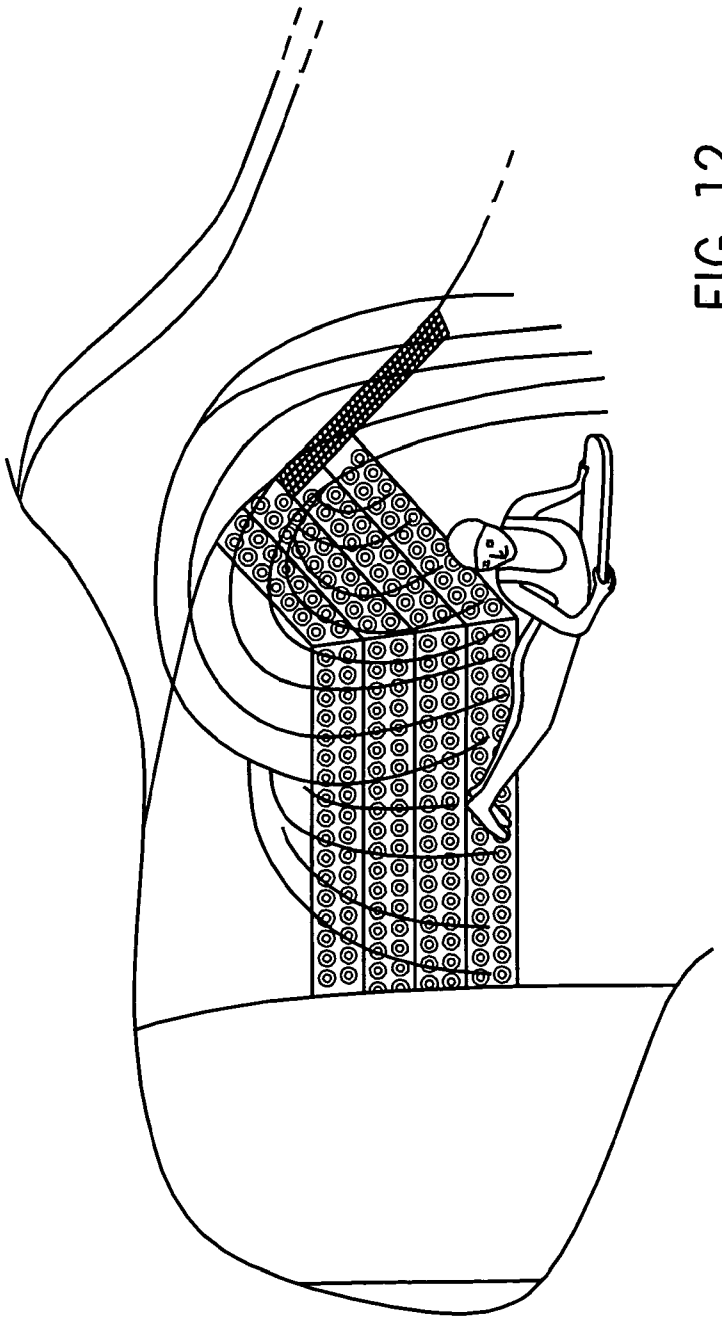


FIG. 12

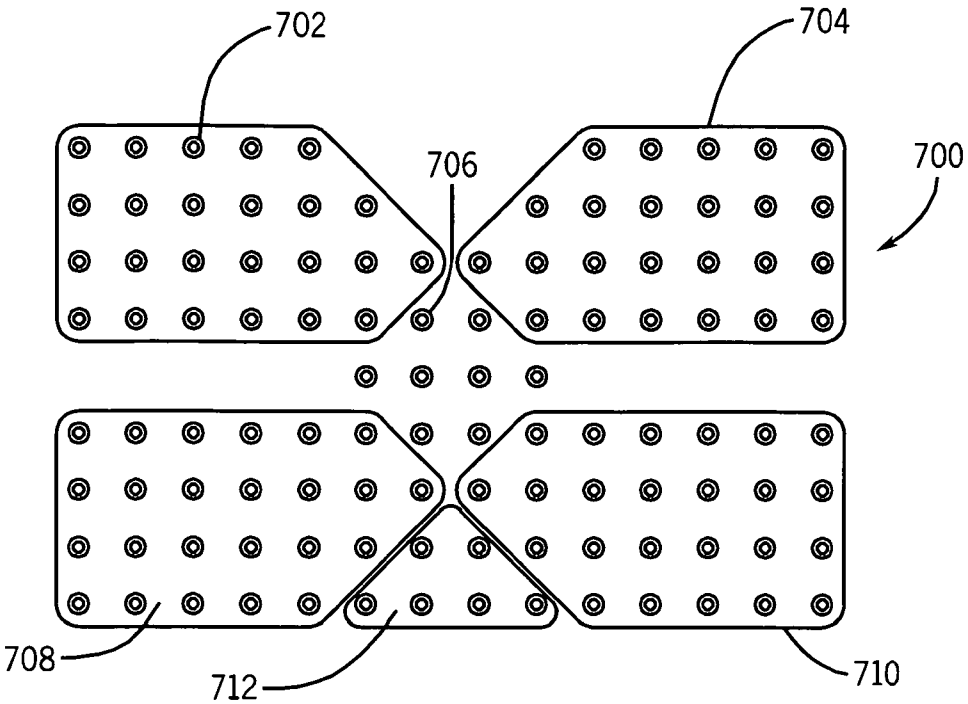



FIG. 13A

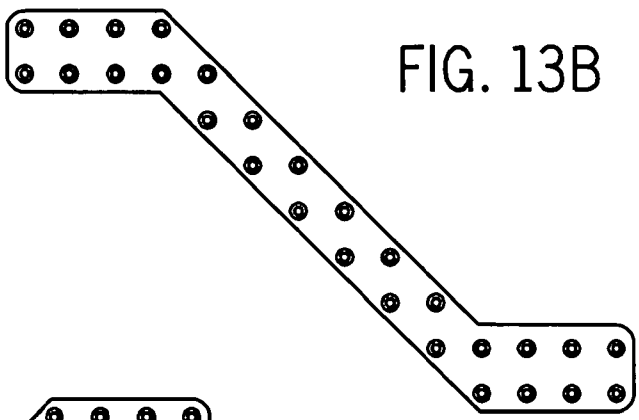
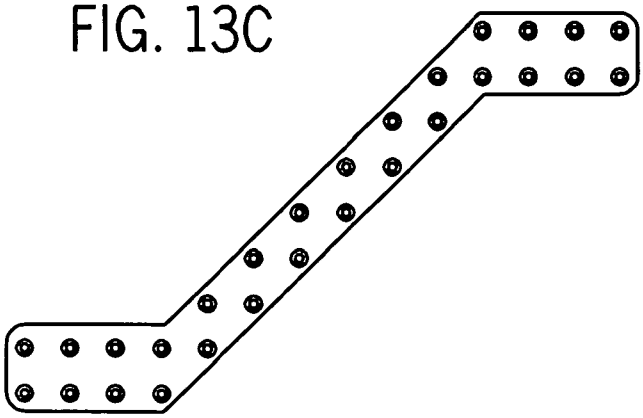


FIG. 13B

FIG. 13C



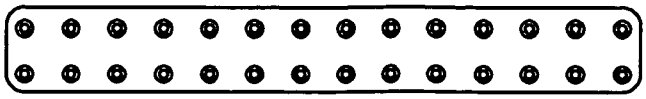


FIG. 13D

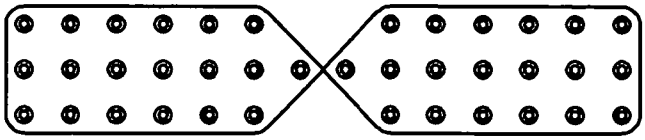


FIG. 13E

FIG. 13F

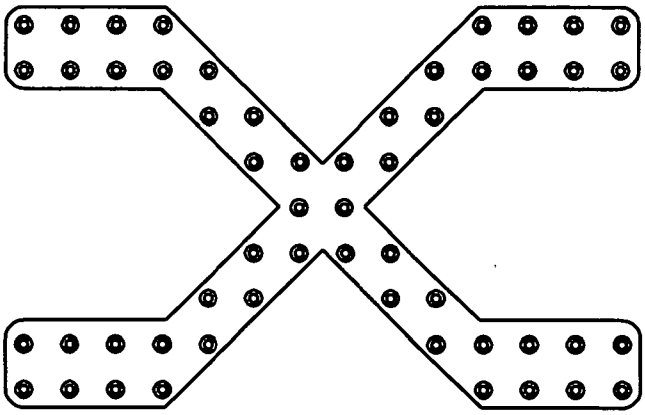


FIG. 13G

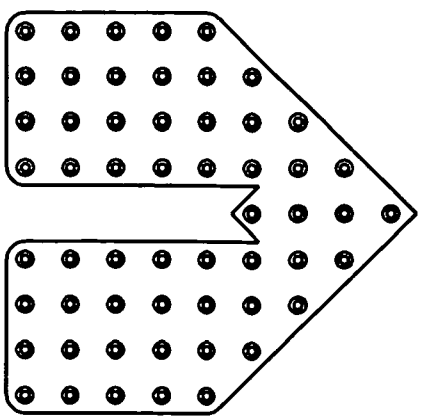


FIG. 13H

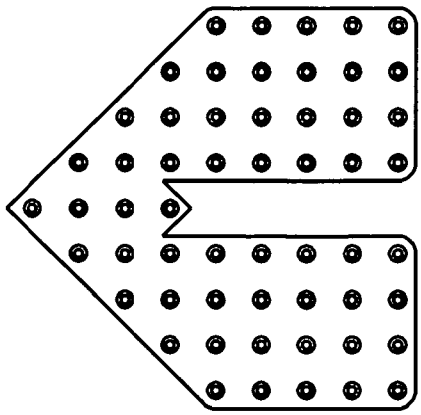


FIG. 13I

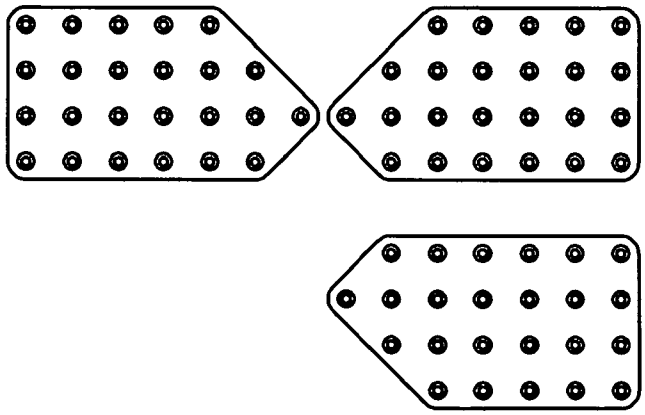
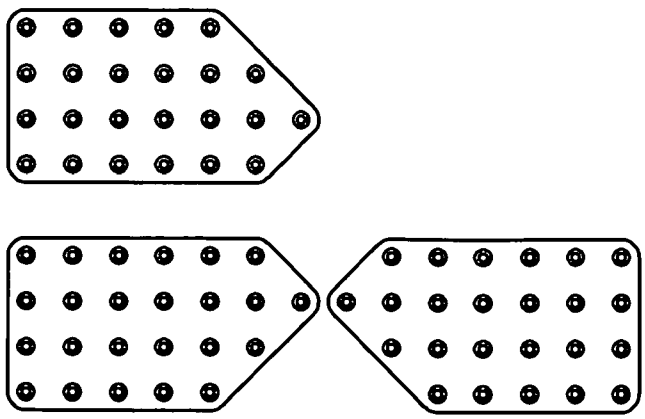


FIG. 13J



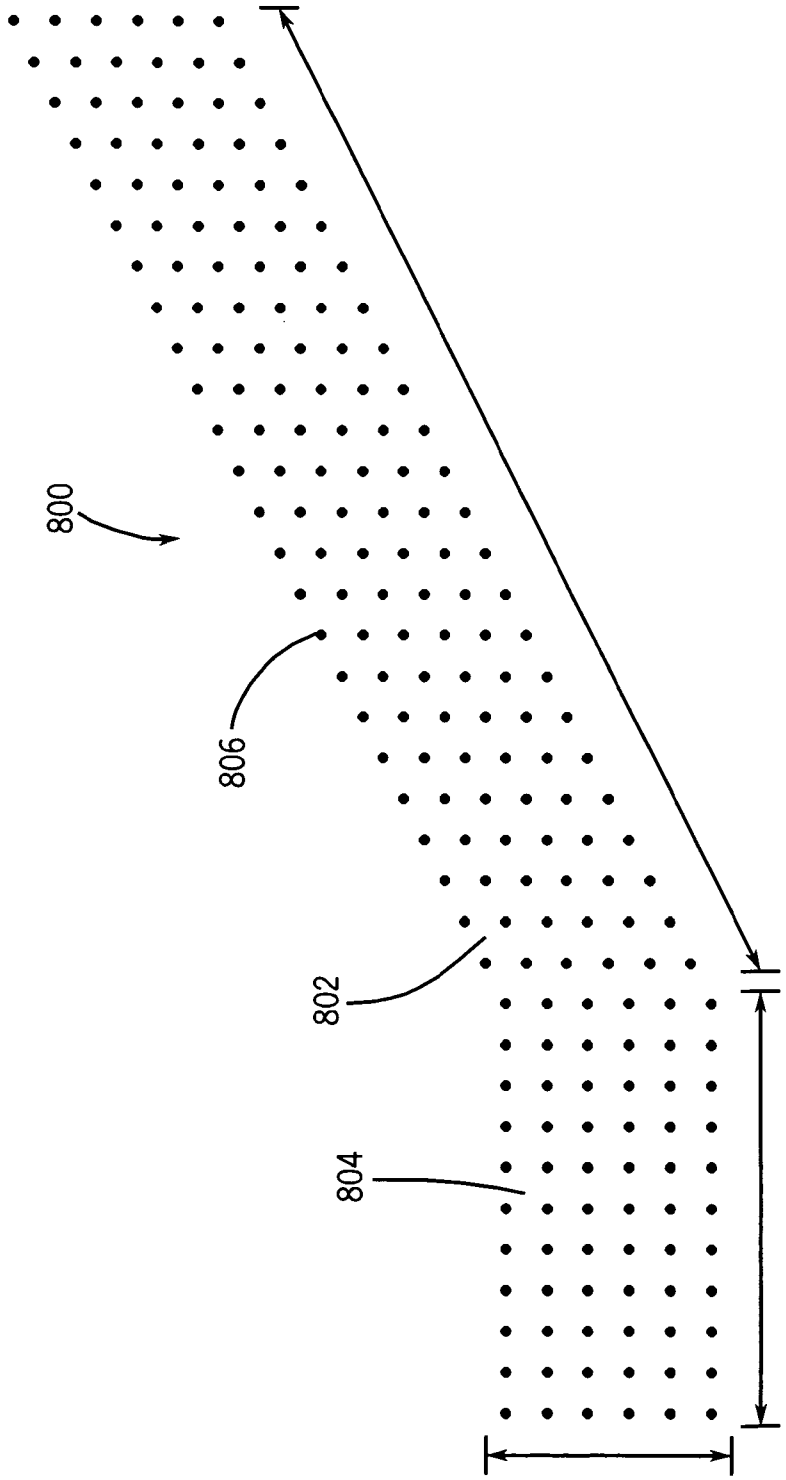



FIG. 14

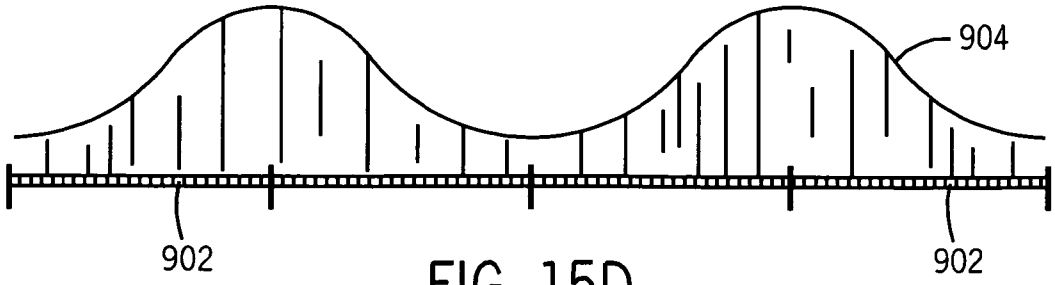



FIG. 15D

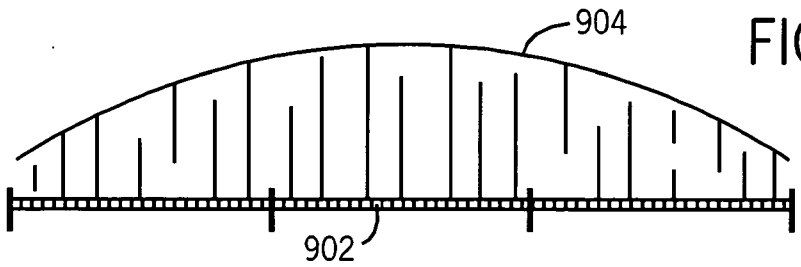



FIG. 15C

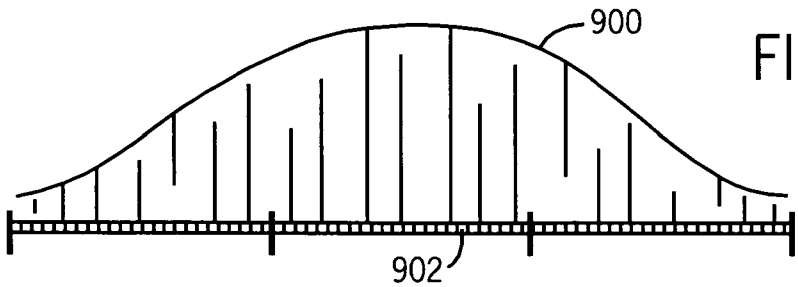



FIG. 15B

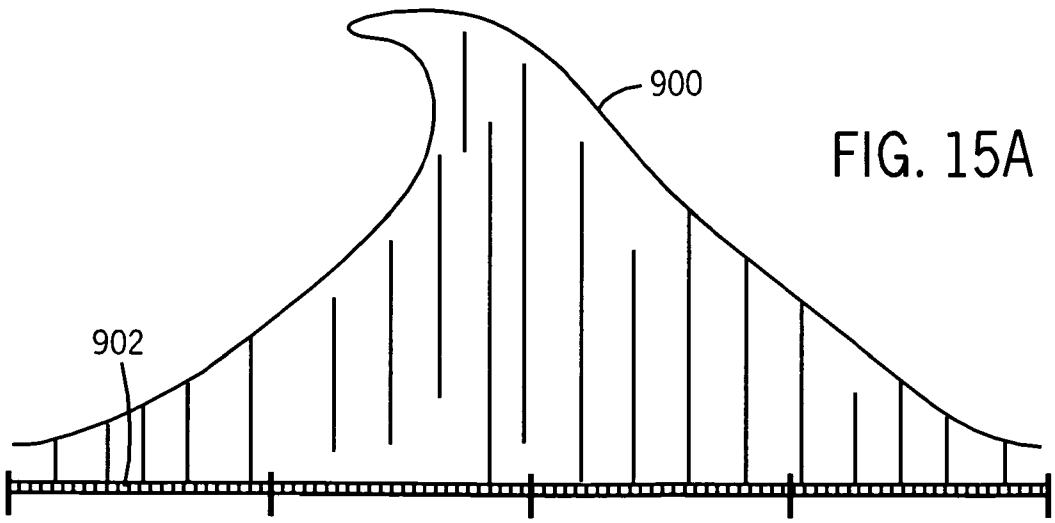



FIG. 15A

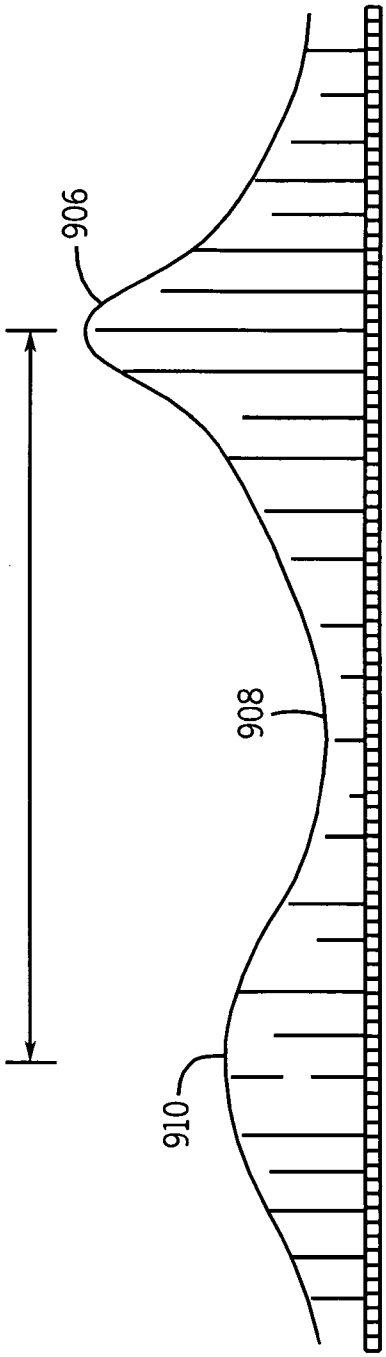



FIG. 16A

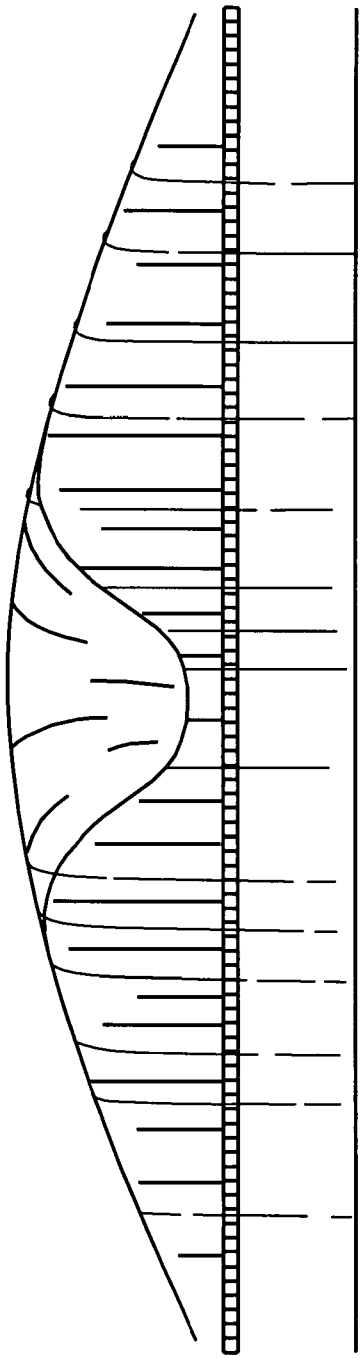


FIG. 16B

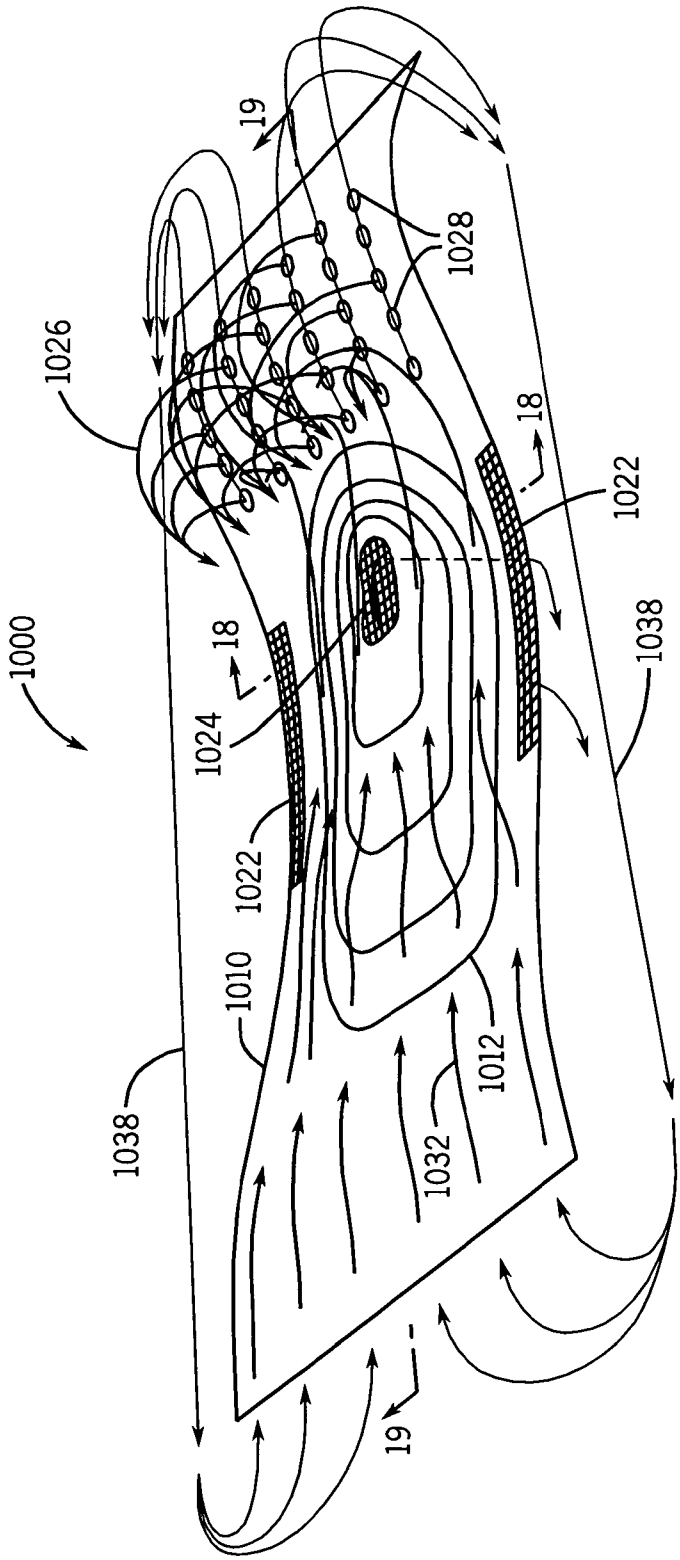

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FIG. 17

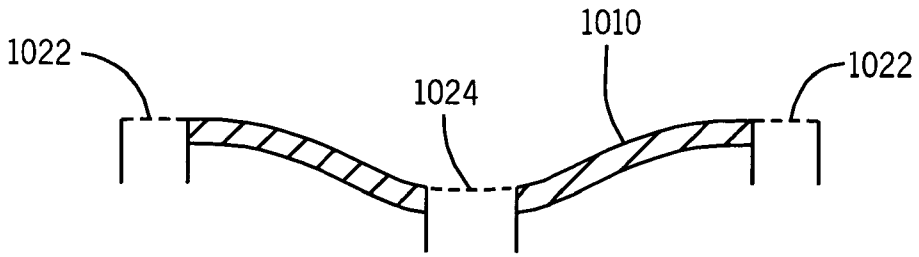
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FIG. 18

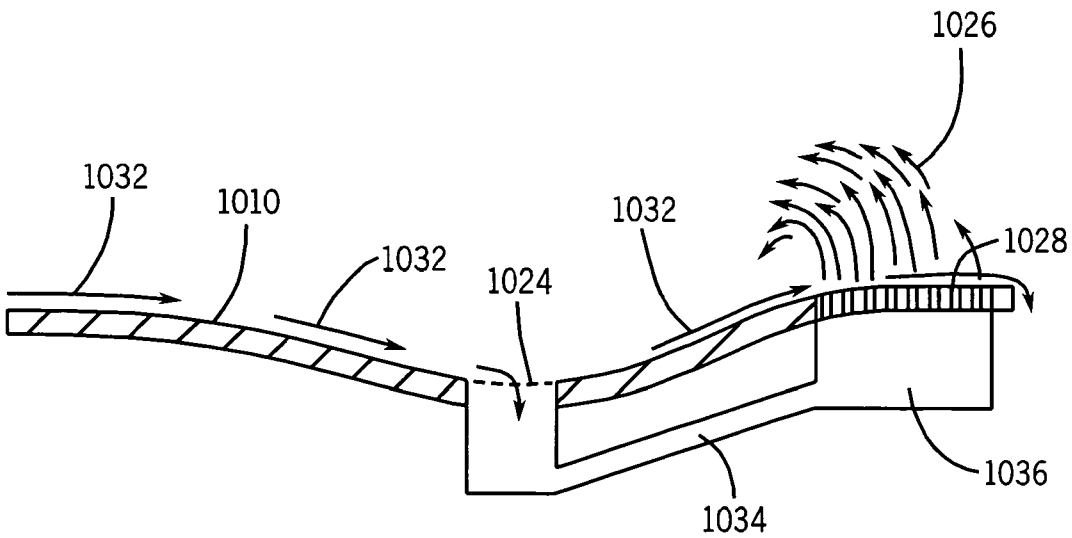
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FIG. 19

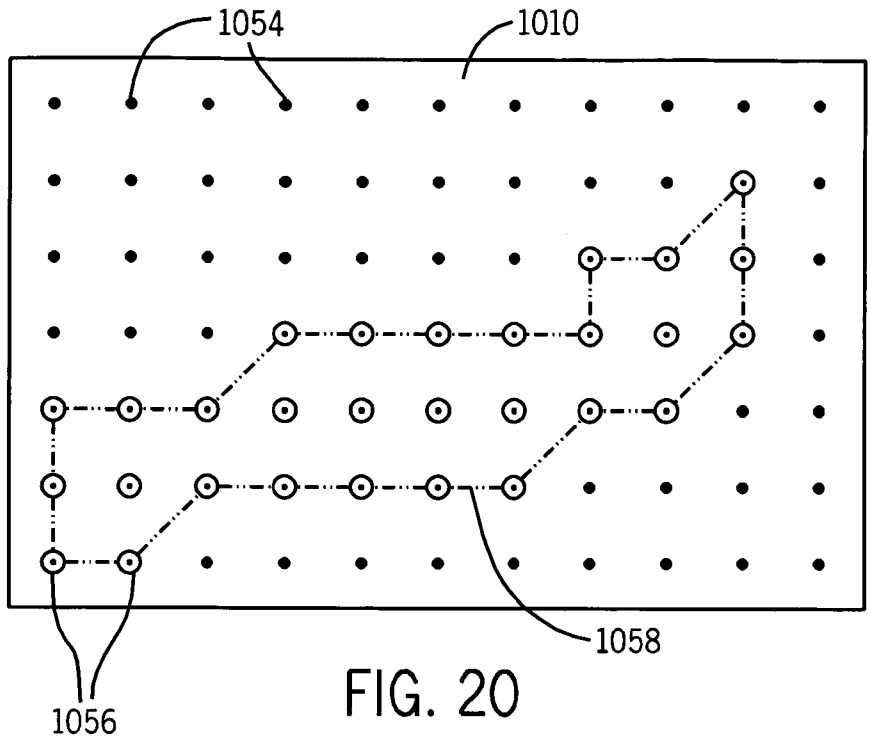


FIG. 20

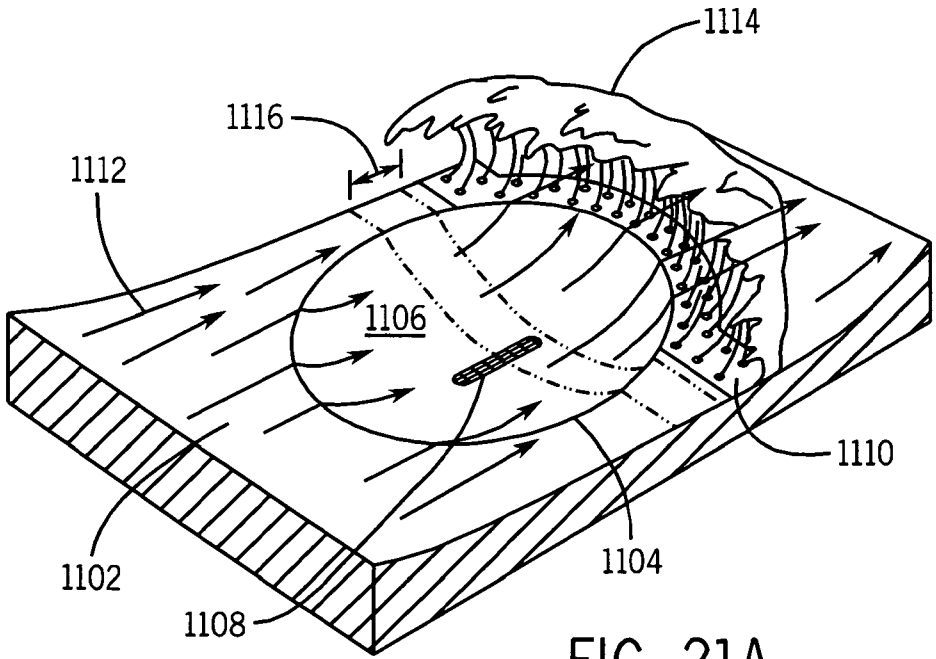


FIG. 21A

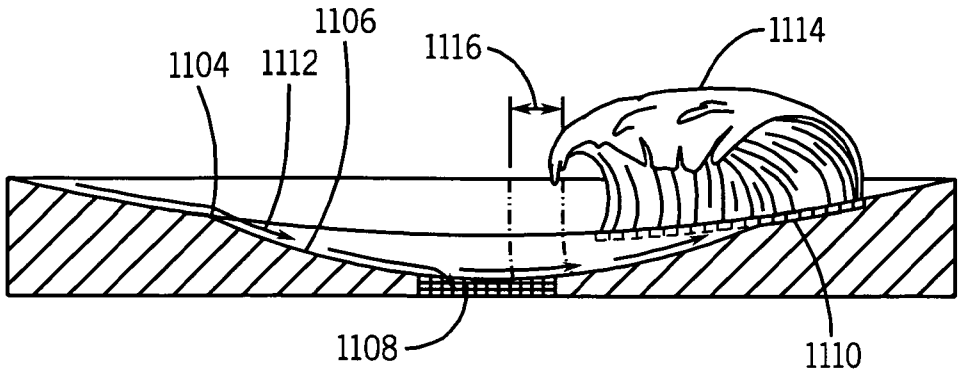


FIG. 21B

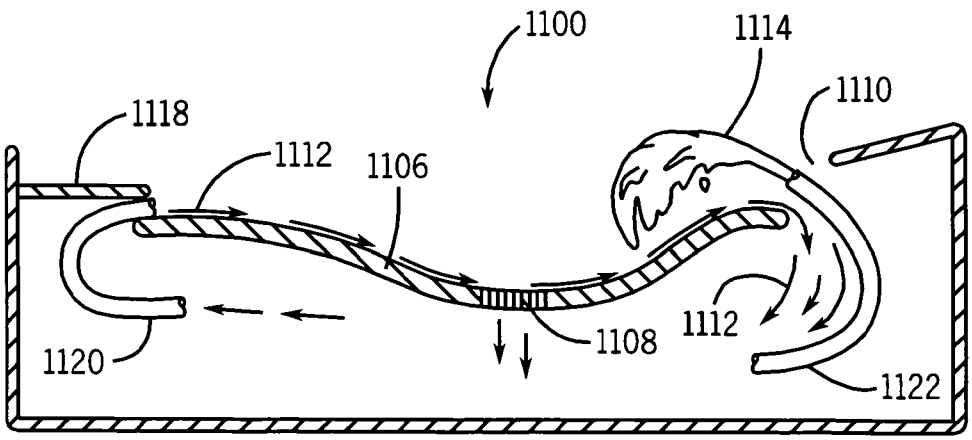


FIG. 22A

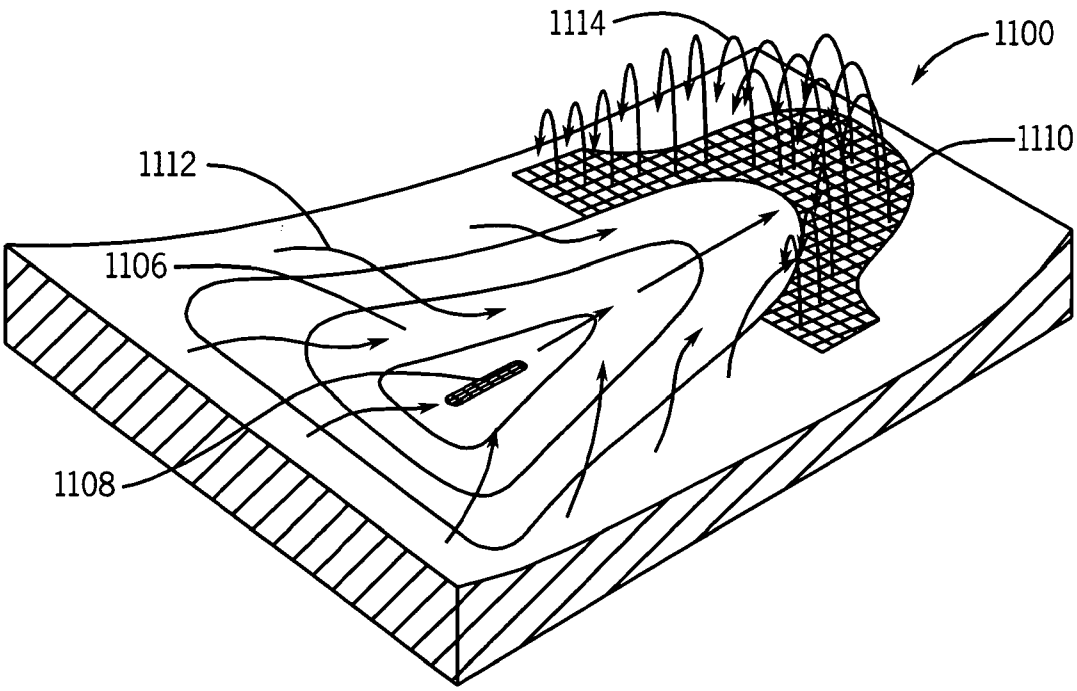


FIG. 22B

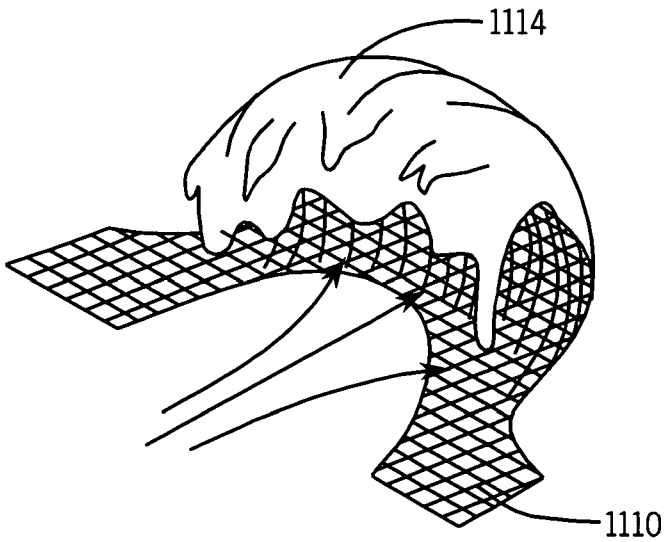


FIG. 22C

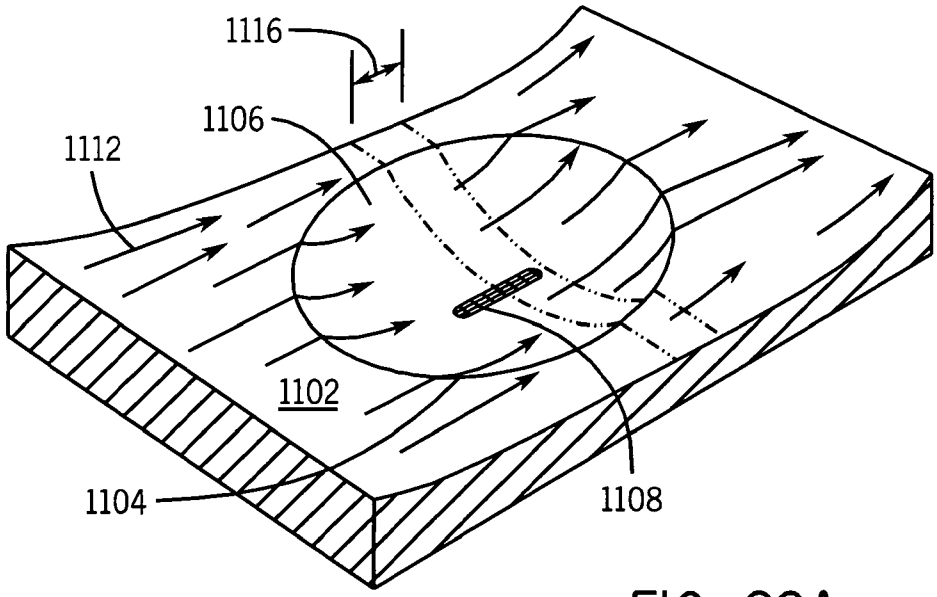


FIG. 23A

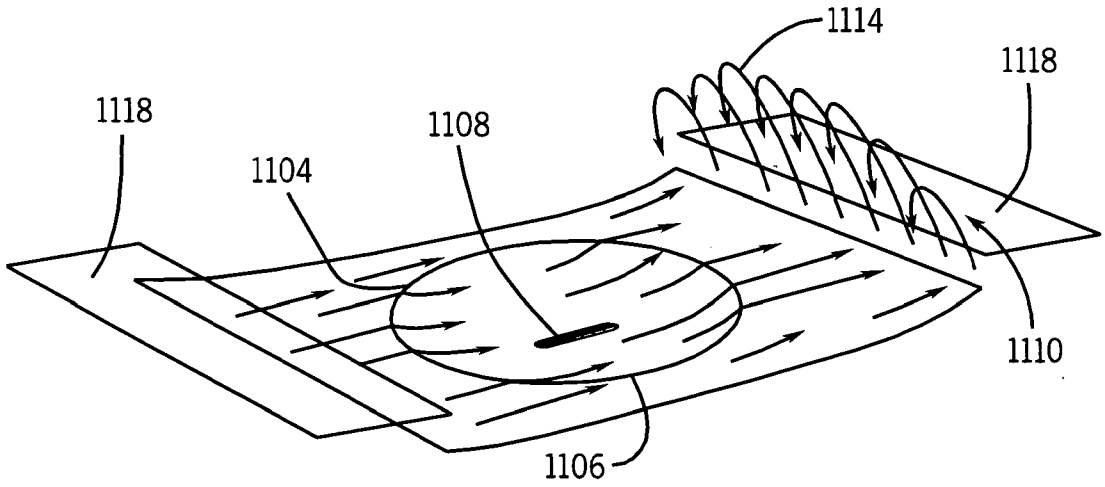


FIG. 23B

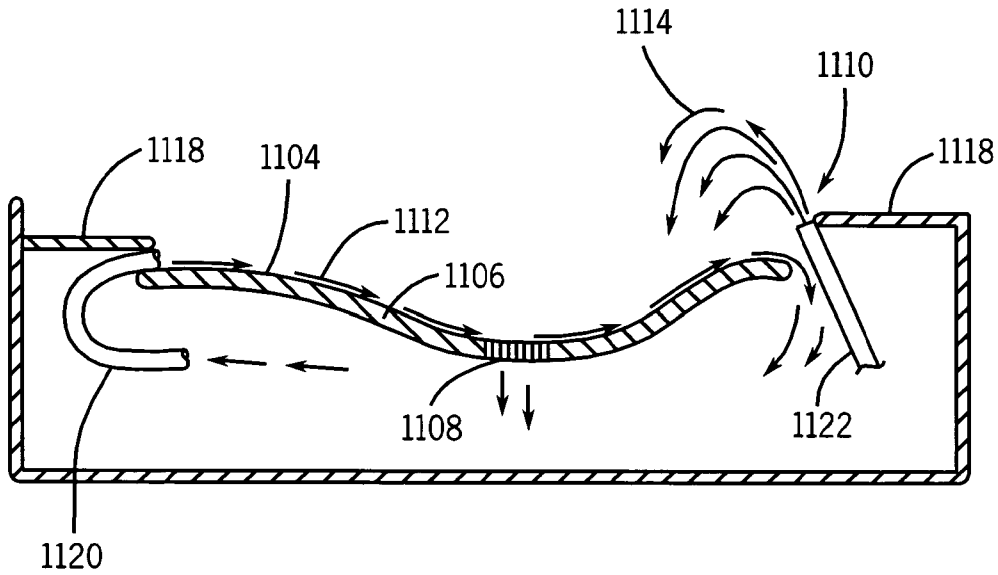


FIG. 23C

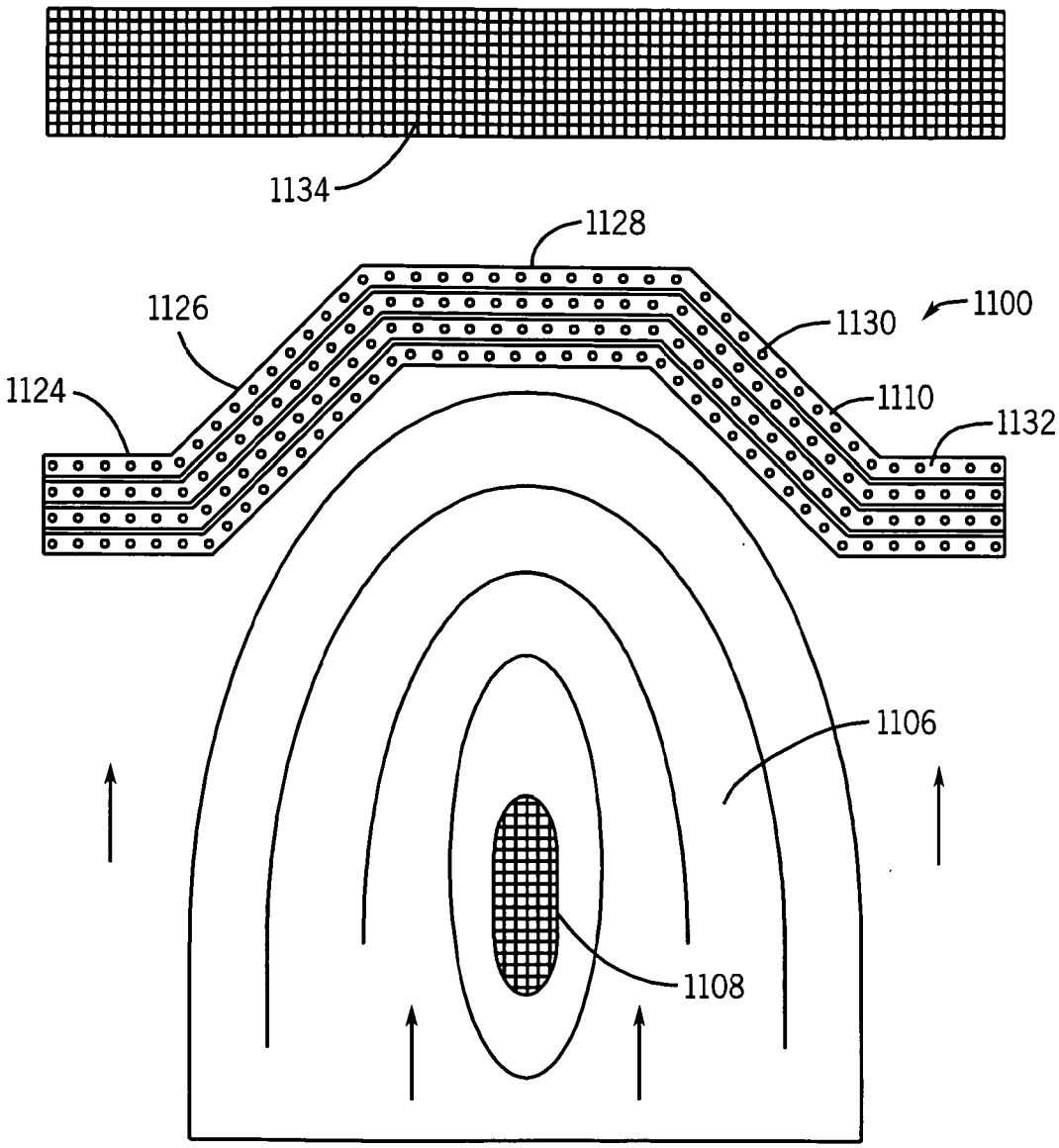


FIG. 24A

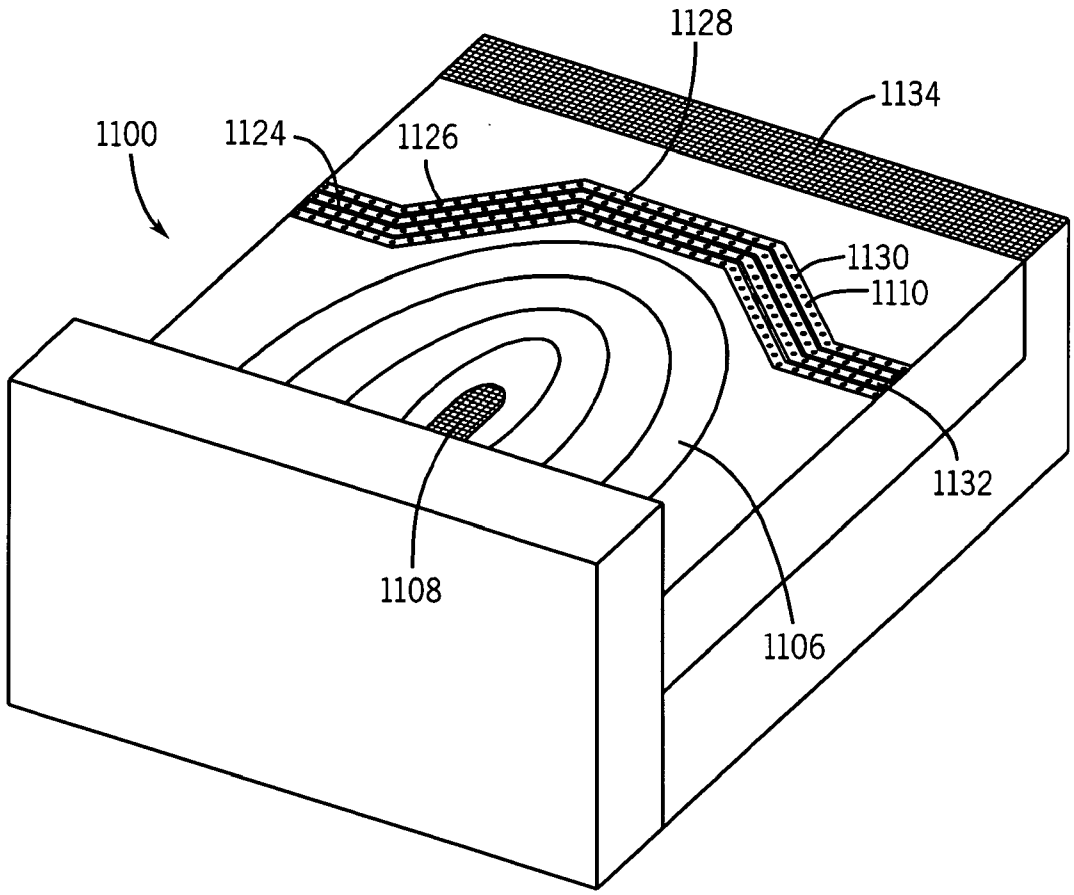


FIG. 24B

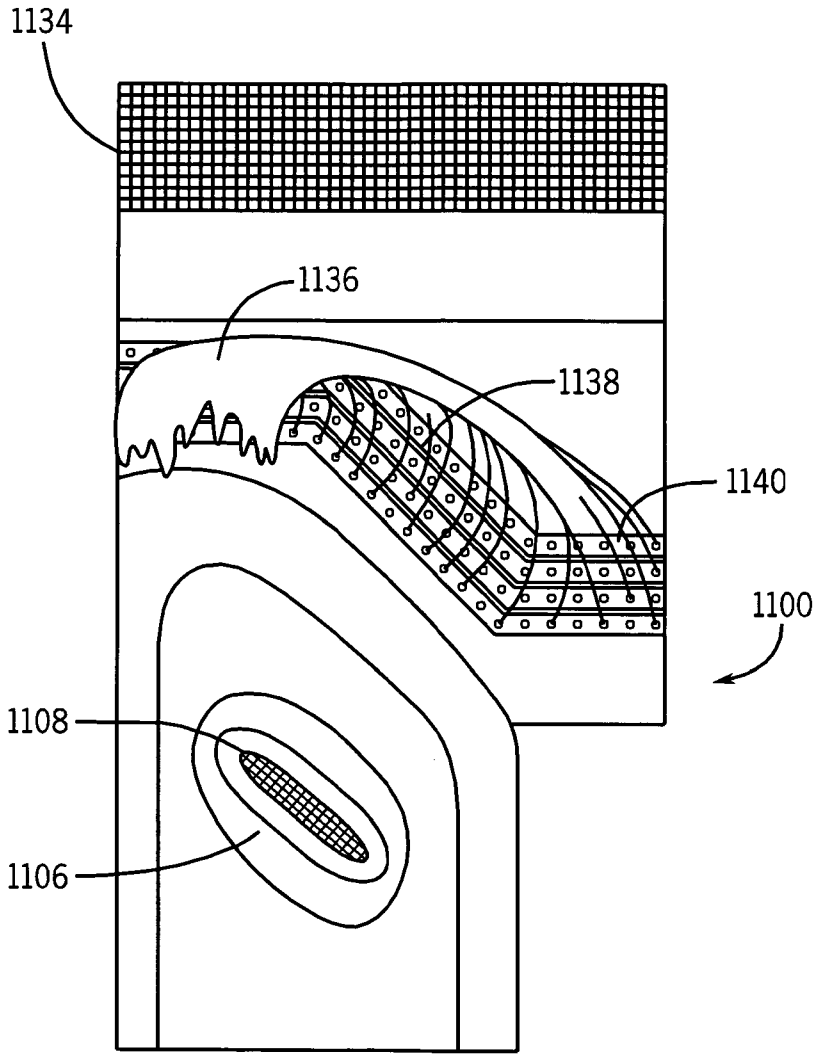


FIG. 25

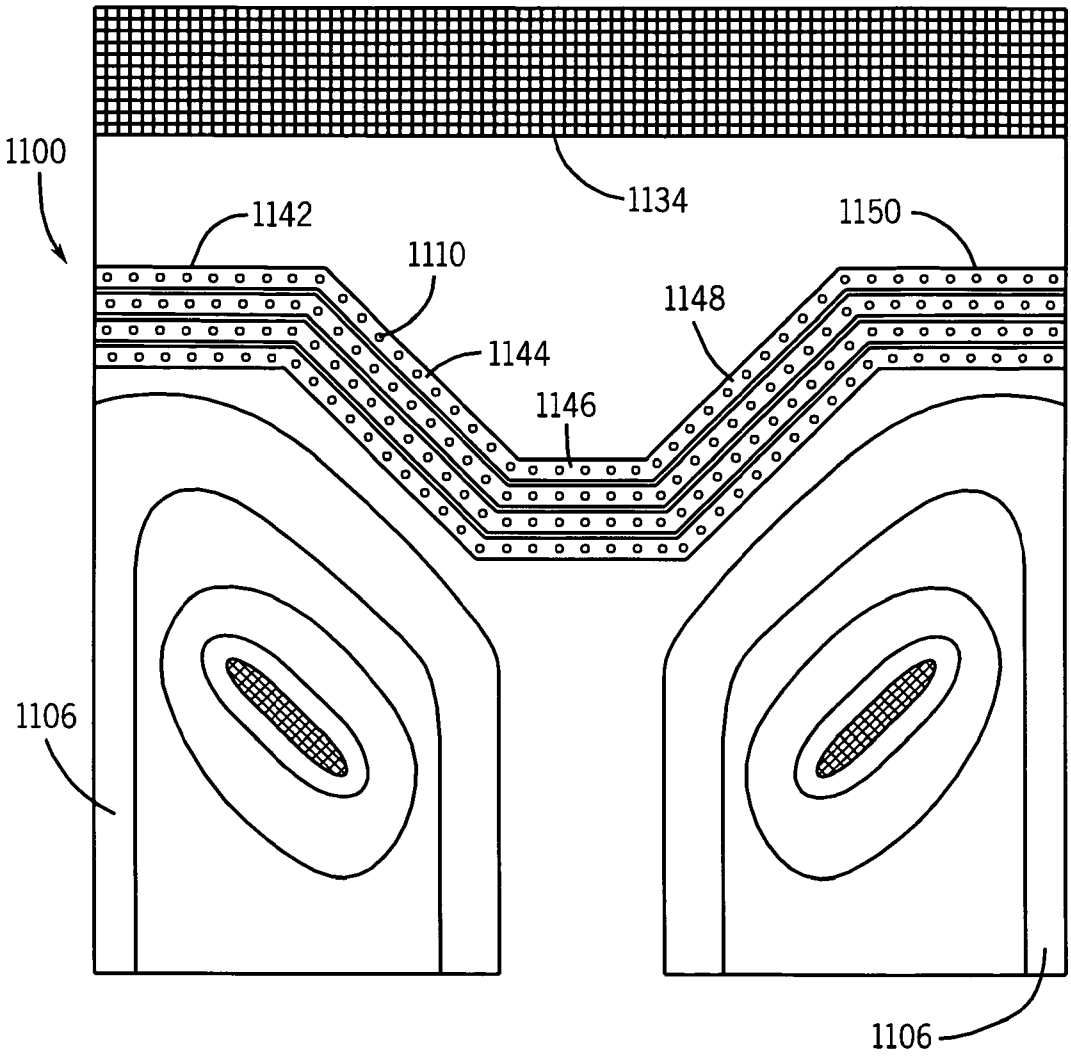


FIG. 26A

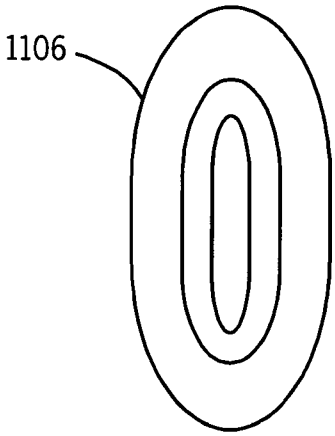


FIG. 26B

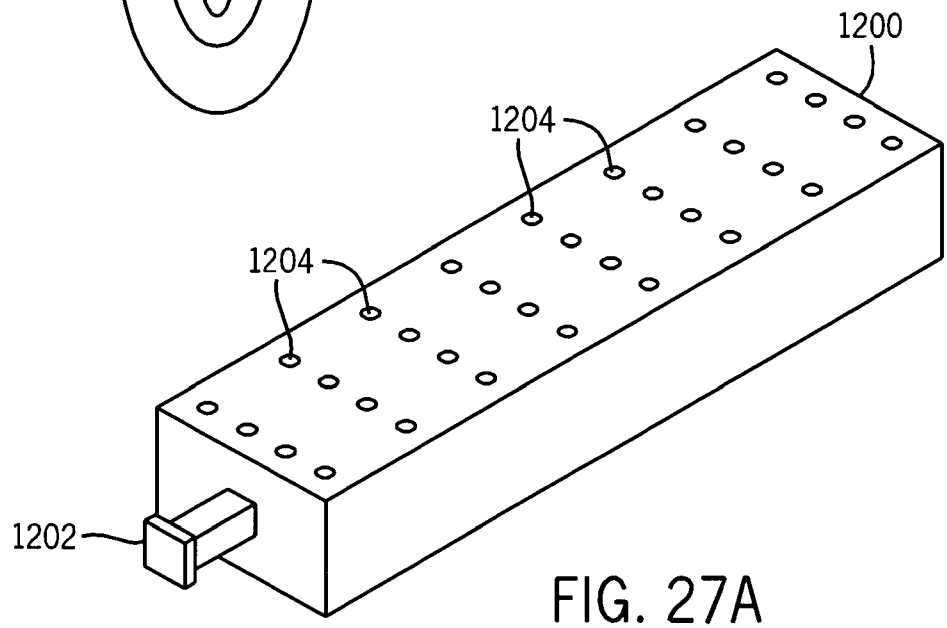


FIG. 27A

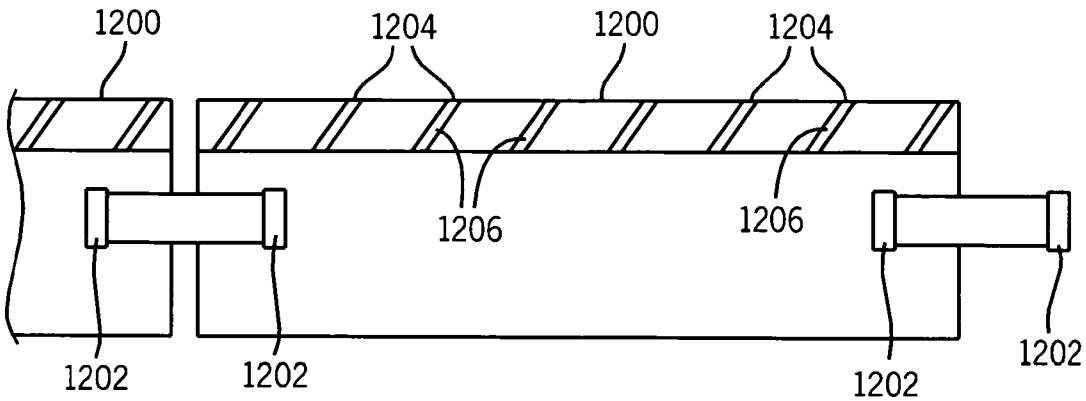


FIG. 27B

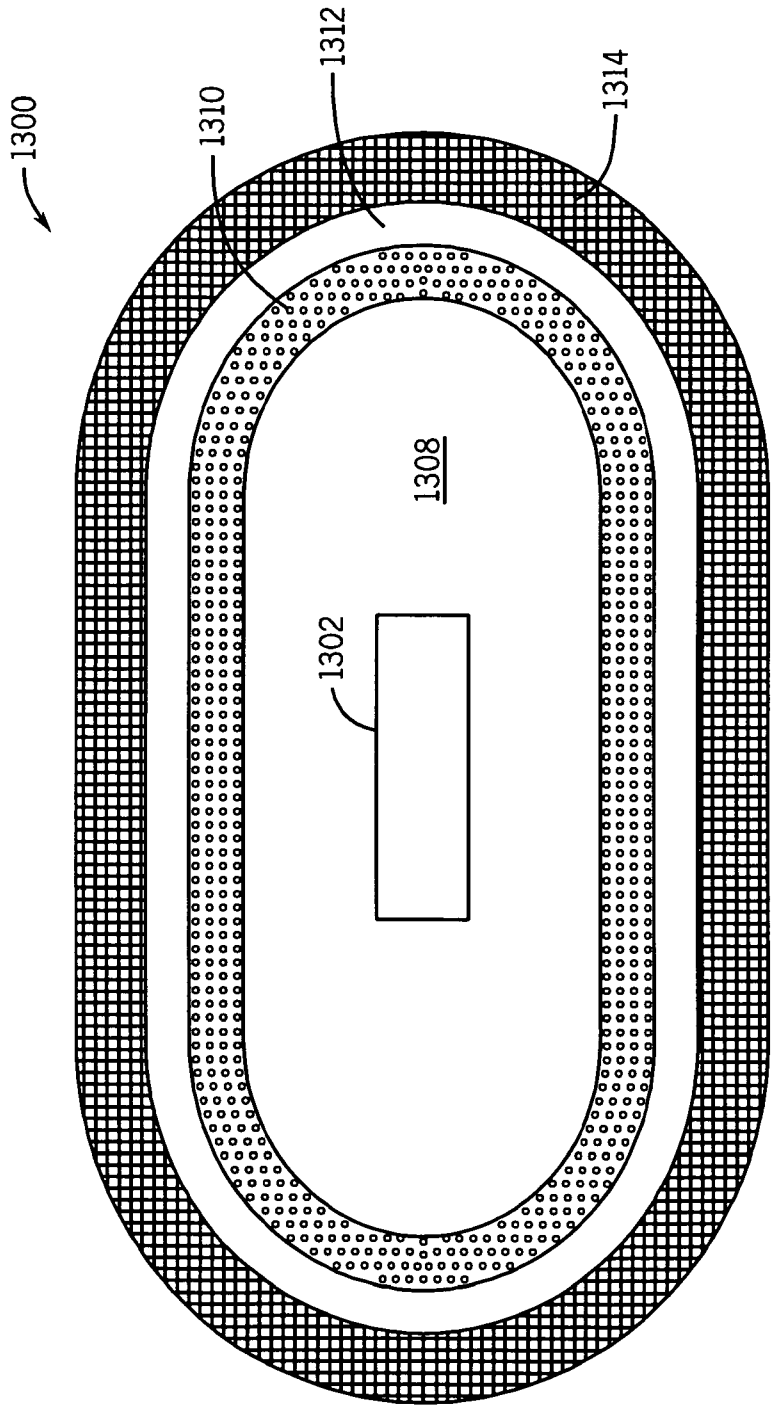


FIG. 28A

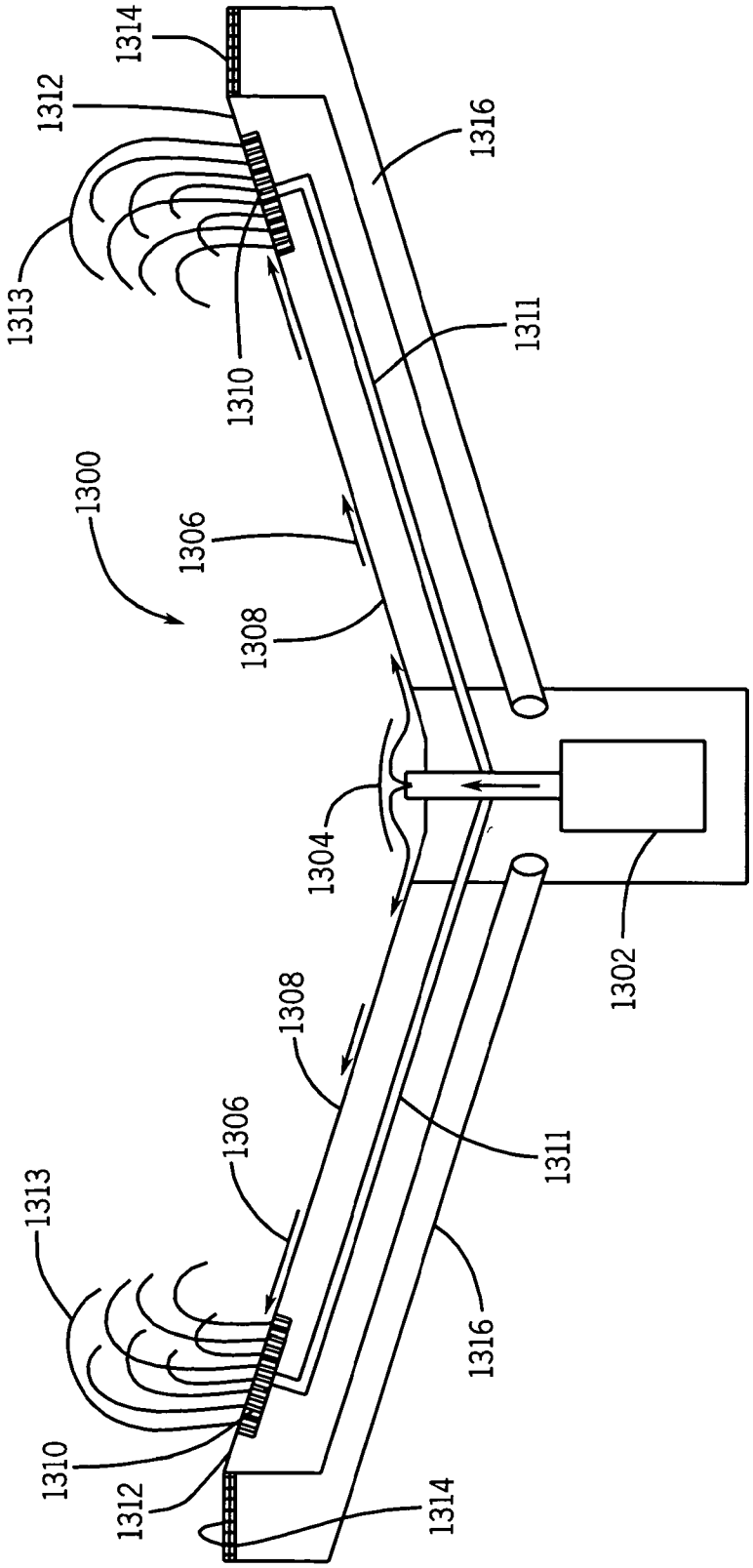
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FIG. 28B

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2008/002974

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - E02B 3/00 (2008.04)
USPC - 405/79
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - E02B 3/00 (2008.04)
USPC - 405/76, 79; 472/117

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | US 6,932,541 B2 (MCFARLAND) 23 August 2005 (23.08.2005) entire document | 1-36 |
| X | US 2006/0026746 A1 (MCFARLAND) 09 February 2006 (09.02.2006) entire document | 37-53 |
| A | US 3,802,697 A (LE MEHAUTE) 09 April 1974 (09.04.1974) entire document | 1-53 |

☐ Further documents are listed in the continuation of Box C. ☐

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 17 June 2008 | 07 JUL 2008 |
| Name and mailing address of the ISA/US<br>Mail Stop PCT, Attn: ISA/US, Commissioner for Patents<br>P.O. Box 1450, Alexandria, Virginia 22313-1450<br>Facsimile No. 571-273-3201 | Authorized officer:<br>Blaine R. Copenheaver<br>PCT Helpdesk: 571-272-4300<br>PCT OSP: 571-272-7774 |

Form PCT/ISA/210 (second sheet) (April 2005)