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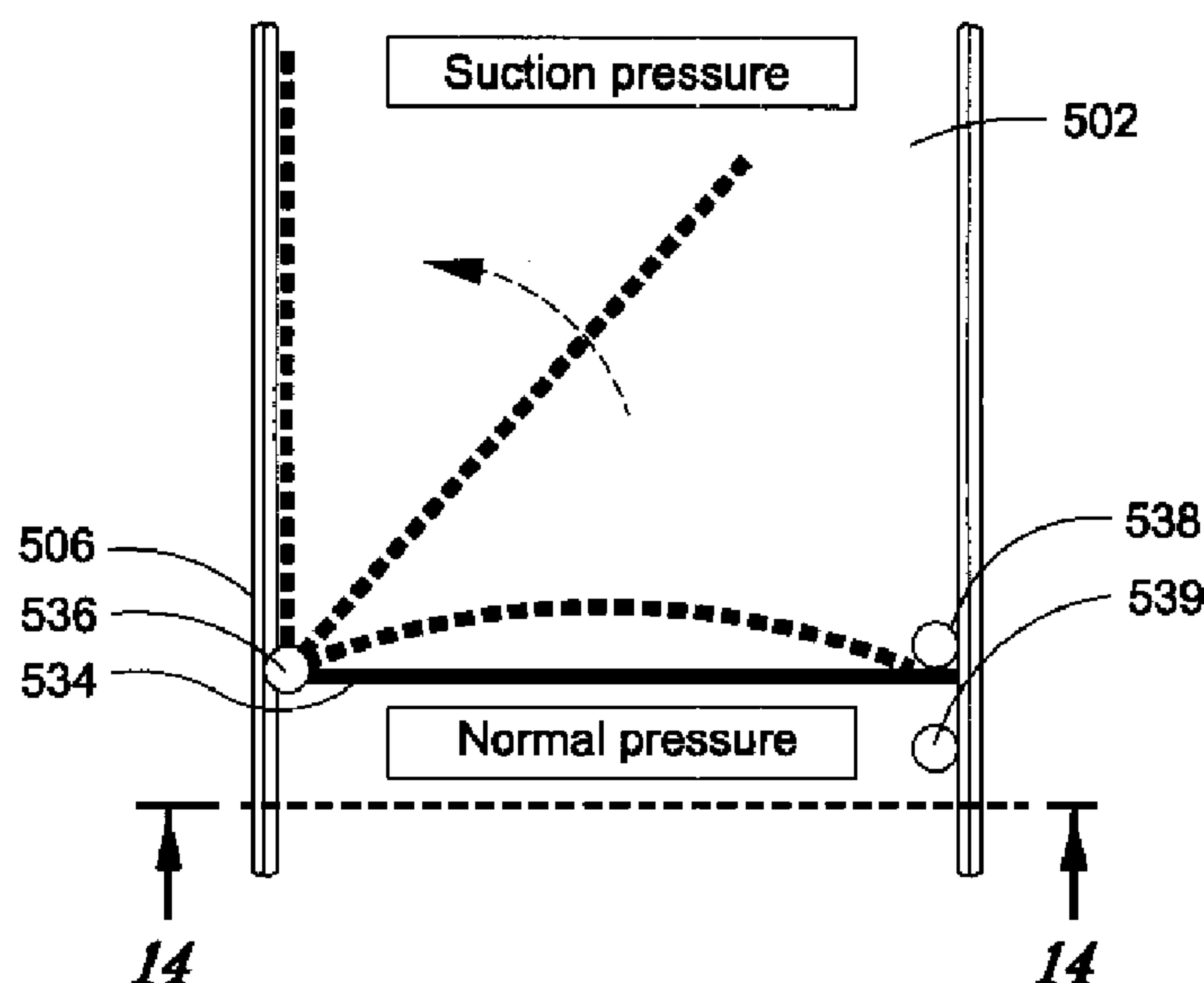
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(54) Title: INCREASED EFFICIENCY STRAINER SYSTEM



*Fig. 13*

(57) Abrégé/Abstract:

In accordance with the present invention, there is provided a strainer system comprising a plurality of strainer modules, each of which comprises multiple cassettes or cartridges assembled together in a prescribed arrangement. In the strainer system constructed in accordance with the present invention, the "clean" sides of the strainer modules are fluidly connected to each other by a plenum duct which also has a suction pump fluidly coupled thereto. Integrated into the plenum duct is a pressure released membrane (PRM) which is positioned so as to effectively isolate one of the strainer modules from the remaining active strainer modules included in the strainer system. The pressure released membrane is uniquely configured so as to facilitate the activation of the isolated strainer module when pressure across the plenum duct increases beyond a prescribed threshold.

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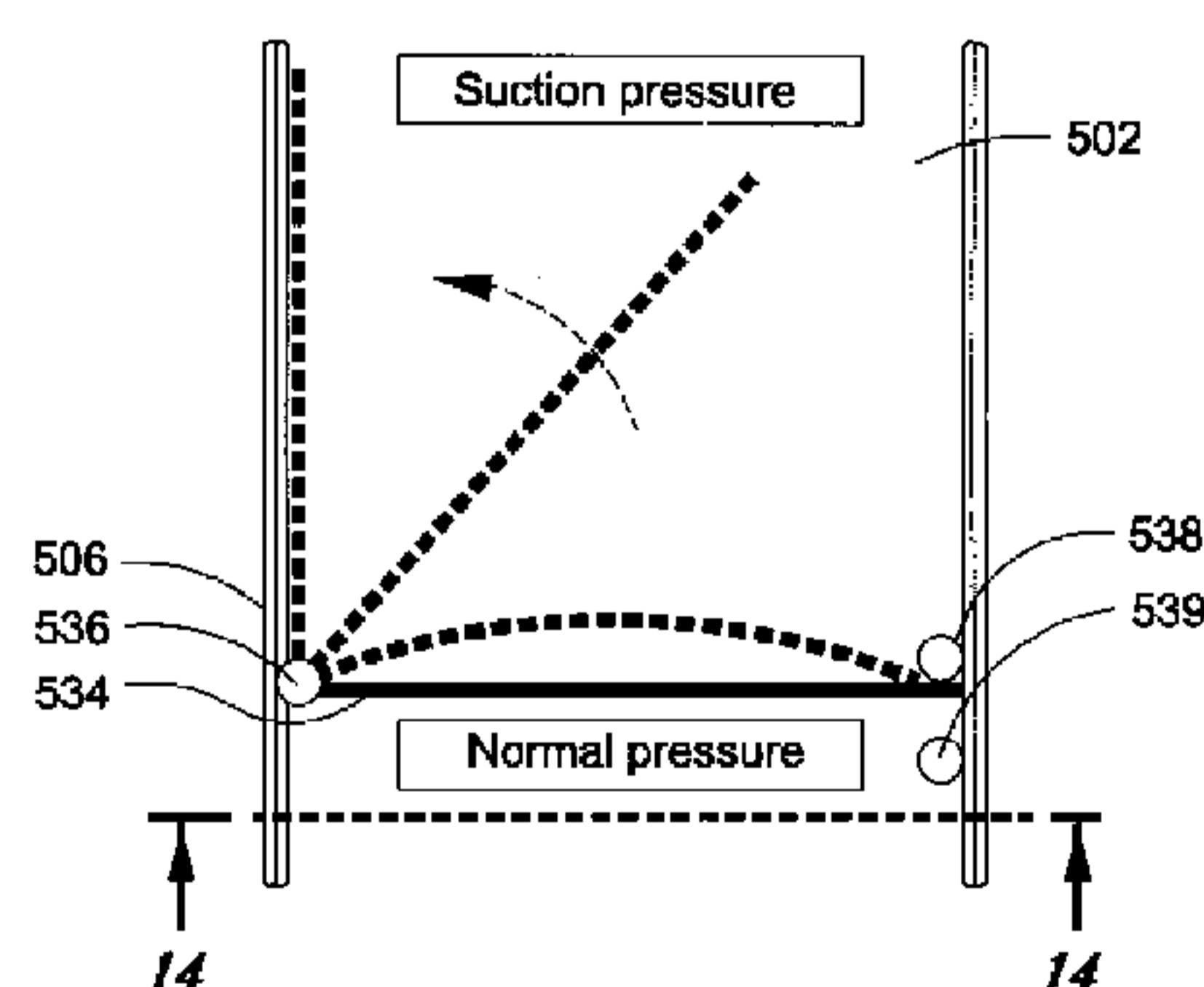


Fig. 13

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(57) Abstract: In accordance with the present invention, there is provided a strainer system comprising a plurality of strainer modules, each of which comprises multiple cassettes or cartridges assembled together in a prescribed arrangement. In the strainer system constructed in accordance with the present invention, the "clean" sides of the strainer modules are fluidly connected to each other by a plenum duct which also has a suction pump fluidly coupled thereto. Integrated into the plenum duct is a pressure released membrane (PRM) which is positioned so as to effectively isolate one of the strainer modules from the remaining active strainer modules included in the strainer system. The pressure released membrane is uniquely configured so as to facilitate the activation of the isolated strainer module when pressure across the plenum duct increases beyond a prescribed threshold.

## INCREASED EFFICIENCY STRAINER SYSTEM

### CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a continuation-in-part of U.S. Patent Application 5 Serial No. 12/578,413 entitled INCREASED EFFICIENCY STRAINER SYSTEM filed October 13, 2009, the disclosure of which is incorporated herein by reference.

### STATEMENT RE: FEDERALLY SPONSORED RESEARCH/DEVELOPMENT

Not Applicable

10

### BACKGROUND OF THE INVENTION

#### 1. Technical Field of the Invention:

15 The present invention relates generally to strainer devices and, more particularly, to a strainer system wherein a pressure released membrane is integrated into the plenum duct at the “clean” side of multiple strainer modules. The pressure released membrane is operative to isolate one of the strainer modules of the strainer system from the remaining active strainer modules thereof, and to effectively activate the isolated strainer module when pressure across the plenum duct increases beyond a 20 prescribed threshold as a result of a head loss increase across the originally active strainer modules attributable to precipitate formation thereon.

#### 2. Description of the Related Art

25 A nuclear power plant typically includes an emergency core cooling system that circulates large quantities of cooling water to critical reactor areas in the event of accidents. A boiling water reactor or BWR commonly draws water from one or more reservoirs, known as suppression pools, in the event of a loss of coolant accident. More particularly, water is pumped from the suppression pool to the reactor core and 30 then circulated back to the suppression pool in a closed loop. A loss of coolant accident can involve the failure of reactor components that introduce large quantities of solid matter into the cooling water, which entrains the solids and carries them back to the suppression pool. For example, if a loss of coolant accident results from the

rupture of a high pressure pipe, quantities of thermal insulation, concrete, paint chips and other debris can be entrained in the cooling water.

In contrast to a BWR, a pressurized water reactor or PWR, after a loss of coolant accident, typically draws cooling water from a reactor water storage tank and, after a signal, shuts off the flow from the storage tank and recirculates this water through the reactor. In this regard, the pressurized water reactor has a containment area that is dry until it is flooded by the occurrence of an accident, with the emergency core cooling system using a pump connected to a sump in the containment area to circulate the water through the reactor. Nevertheless, the water that is pumped in the event of an accident will also usually contain entrained solids that typically include insulation, paint chips, and particulates. Thus, in both types of reactors (i.e., boiling water reactors and pressurized water reactors), cooling water is drawn from a reservoir and pumped to the reactor core, with entrained solids or debris potentially impairing cooling and damaging the emergency core cooling system pumps if permitted to circulate with the water.

In recognition of the potential problems which can occur as a result of the presence of entrained solids or debris in the coolant water of the emergency core cooling system, it is known in the prior art to place strainers in the coolant flow path upstream of the pumps, usually by immersing them in the cooling water reservoir. It is critical that these strainers be able to remove unacceptably large solids without unduly retarding the flow of coolant. In this regard, the pressure (head) loss across the strainer must be kept to a minimum. Strainers are commonly mounted to pipes that are part of the emergency core cooling system and that extend into the suppression pool or sump, with the emergency core cooling system pumps drawing water through the strainers and introducing the water to the reactor core. There has been considerable effort expended in the prior art in relation to the design of strainers to decrease head loss across the strainer for the desired coolant flow. Existing strainers often include a series of stacked perforated hollow discs or flat perforated plates and a central core through which water is drawn by the emergency core cooling system pump. The perforated discs or plates prevent debris larger than a given size from passing the strainer perforations and reaching the pumps.

As is apparent from the foregoing, large amounts of fibrous material can enter the circulating coolant water in the event of a reactor accident. This fibrous material,

which often originates with reactor pipe or component insulation that is damaged and enters the emergency core cooling system coolant stream in the event of a loss of coolant accidents indicated above, typically accumulates on the strainer surfaces and captures fine particulate matter in the flow. The resulting fibrous debris bed on the strainer surfaces can quickly block the flow through the strainer, even though the trapped particulates may be small enough to pass through the strainer perforations. More particularly, the debris accumulates in a fluffy density in and on the strainer until the strainer becomes completely covered with a fiber and particulate debris bed. Once this occurs, the strainer loses its complex geometric surface advantages and becomes a simple strainer. Hours to days later, some debris typically dissolves into solution and interacts with chemicals present in the containment. At the same time, containment temperatures are trending down. This phenomenon causes certain chemical precipitates to form which eventually make their way to the strainer. Once they reach the strainer surface, the pressure drop across the strainer typically dramatically increases.

The prior art has attempted to address the above-described flow blockage effect by making the strainer larger, the goal being to distribute the trapped debris over more area, reducing the velocity through the debris bed, and further reducing the head loss across the strainer as a whole. This solution, however, is often undesirable since the available space in a reactor for a suction strainer is usually limited, and further because larger strainers are typically more costly. As a result, the situation sometimes arises wherein the expected debris load after a loss of coolant accident can dictate a need for strainers that are too large for the space allotted for them in the containment area. Moreover, large strainers are often more difficult work with and thus more costly to install. In addition, prior art emergency core cooling system strainers have been constructed in ways that make them somewhat expensive to fabricate.

The present invention addresses the aforementioned needs and overcomes many of the deficiencies associated with existing nuclear power plant strainer designs providing a strainer system design which is specifically suited to reduce the differential pressure experienced across the strainer in nuclear power plants with medium to high fiber loads after chemical precipitate formation. Various features and advantages of the present invention will be described in more detail below.

## SUMMARY OF THE INVENTION

In accordance with the present invention, there is provided an increased efficiency strainer system which is particularly suited for use in the emergency core cooling system of a nuclear power plant. In certain embodiments of the present invention, the strainer system includes one or more strainer cassettes or cartridges, with each such cassette or cartridge including a plurality of strainer pockets disposed in side-by-side relation to each other. Multiple cassettes or cartridges may be assembled together to form a strainer module of the strainer system.

More particularly, in one embodiment of the present invention, each cartridge has a generally quadrangular configuration, as do the individual strainer pockets included therein. In this particular embodiment, the strainer pockets of the cartridge each define an inflow end, with the inflow ends of the strainer pockets of the cartridge facing in a common direction. Within the cartridge, or the module including multiple cartridges, the inflow ends of one or more of the strainer pockets may be enclosed by an elastic metal membrane. When in a closed position, the membrane prevents liquid flow into the corresponding strainer pocket via the inflow end thereof. The membrane remains closed when only a low pressure load is exerted thereon, but is deflected or deformed into an open position when a high pressure load is exerted thereon. The movement of the membrane to its open position effectively opens the corresponding strainer pocket, thus allowing for the flow of liquid into the interior of the strainer pocket via the inflow end thereof.

In accordance with another aspect of the present invention, it is contemplated that the above-described strainer cartridge(s) included in a strainer module of the strainer system may include flat, non-perforated face plates which extend from a surface of the cartridge(s) adjacent the inflow ends of the strainer pockets thereof. The non-perforated extended face plates cause the edges of a fiber and particulate debris bed forming at the inflow ends of the strainer pockets to compress and slowly curl in from an originally flush relationship to the face plates, which results in the creation of small flow paths between the face plates and debris bed as differential pressure continues to rise, thus allowing flow into the strainer and reducing head loss. As the strainer area affected by the flow receives more debris, fiber, particulate and chemical precipitate, the head loss increases until another flow path is opened into

another area of the strainer. The creation of the flow paths, as caused by the optional inclusion of the extended face plates with the strainer cartridge(s), effectively reduces the maximum differential pressure experienced across the strainer and provides a way to potentially reduce required strainer surface area necessary to satisfy a particular containment recirculation net positive suction head requirement.

In accordance with another embodiment of the present invention, the strainer cassette or cartridge has a generally circular configuration, with the strainer pockets thereof being arranged in side-by-side relation to each other in a generally circular pattern. In this particular embodiment, one or more of the strainer pockets of the strainer cartridge may be outfitted with the aforementioned elastic metal membrane. Additionally, if a strainer module is constructed including multiple circularly configured strainer cartridges disposed in stacked relation to each other, it is contemplated that all of the strainer pockets of one or more of the strainer cartridges included in the module may be outfitted with an elastic metal membrane.

In accordance with another embodiment of the present invention, the strainer system comprises a plurality of cylindrically configured, tubular primary strainer elements. Each of the primary strainer elements defines an inflow end, and comprises concentrically positioned inner and outer walls which are each fabricated from a perforated metal material. The inflow end is typically defined solely by the inner wall of the primary strainer element. The inflow end of one or more of the primary strainer elements included in the strainer system may be covered by a rupture disc or segmented membrane which mirrors the functionality of the above-described elastic metal membrane. In this regard, the rupture disc or segmented membrane covering the inflow end of one or more of the primary strainer elements is operative to move from a normally closed position to an open position allowing direct liquid flow into the interior of the inner wall of the primary strainer element via the inflow end defined thereby when such rupture disc or segmented membrane is subjected to a high pressure load.

In this particular embodiment of the strainer system, it is also contemplated that one or more of the primary strainer elements may include a secondary strainer element concentrically positioned within the inner wall of the primary strainer element, thus creating a double cylinder strainer construction as opposed to the single cylinder strainer construction provided by a primary strainer element standing alone.

The secondary strainer element, if included with a primary strainer element, has a construction mirroring that of the surrounding primary strainer element, with the inflow end defined by the inner wall of the secondary strainer element optionally being covered by the above-described rupture disc or segmented membrane. In the 5 double cylinder strainer construction, no rupture disc or segmented membrane is provided on the inflow end defined by the inner wall of the primary strainer element due to the concentric positioning of the secondary strainer element therein.

In accordance with yet another embodiment of the present invention, there is provided a strainer system comprising a plurality of strainer modules, each of which 10 comprises multiple cassettes or cartridges assembled together in a prescribed arrangement. Each cassette or cartridge of each strainer module comprises a plurality of strainer pockets disposed in side-by-side relation to each other, each of the strainer pockets having the structural attributes described above, though none of the strainer pockets is enclosed by one of the aforementioned elastic metal membranes. In the 15 strainer system constructed in accordance with this particular embodiment of the present invention, the “clean” sides of the strainer modules are fluidly connected to each other by a plenum duct which also has a suction pump fluidly coupled thereto. Integrated into the plenum duct is a pressure released membrane (PRM) which is positioned so as to effectively isolate one of the strainer modules from the remaining 20 active strainer modules included in the strainer system. The pressure released membrane is uniquely configured so as to facilitate the activation of the isolated strainer module when pressure across the plenum duct increases beyond a prescribed threshold. Such pressure increase within the plenum duct typically occurs as a result 25 of a head loss across the originally active strainer modules of the strainer system, such head loss increase being attributable to precipitate formation on such strainer modules.

In the embodiment of the strainer system including the pressure released membrane in the plenum duct, the activation of the originally isolated strainer module is facilitated by the movement of the pressure released membrane from an original 30 closed position, to an open position. When the pressure released membrane is in its closed position, it effectively blocks that portion of the plenum duct fluidly communicating with the isolated strainer module from the remainder of the plenum duct which is fluidly coupled to the originally active strainer modules and the suction

5 pump. As indicated above, an increase in the suction pressure level within that portion of the plenum duct fluidly communicating with the originally active strainer modules beyond a prescribed threshold facilitates the movement of the pressure released membrane from its closed position to its open position, thus placing that portion of the plenum duct in fluid communication with the originally inactive strainer module into fluid communication with the remainder of the plenum duct. Such fluid communication in turn allows the operating suction pump to effectively draw fluid through the previously isolated and now active strainer module of the strainer system.

10 The present invention is best understood by reference to the following detailed description when read in conjunction with the accompanying drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

These, as well as other features of the present invention, will become more apparent upon reference to the drawings wherein:

15 Figure 1 is a front perspective view of a prior art strainer cassette or cartridge;

Figure 2 is a rear perspective view of the prior art strainer cartridge shown in Figure 1;

20 Figure 3 is a front perspective view of a strainer module including multiple strainer cartridges constructed in accordance with a first embodiment of the present invention;

Figure 4 is a cross-sectional view of an exemplary strainer system including an opposed pair of the strainer modules shown in Figure 3;

Figure 5 is an enlargement of the encircled region 5 shown in Figure 4;

25 Figure 6 is a perspective view of a strainer module constructed in accordance with a second embodiment of the present invention;

Figure 7 is a cross-sectional view taken along line 7-7 of Figure 6;

Figure 8 is an enlargement of encircled region 8 shown in Figure 7;

Figure 9 is a perspective view of a strainer module constructed in accordance with a third embodiment of the present invention;

30 Figure 10 is a perspective view of a strainer module constructed in accordance with a fourth embodiment of the present invention;

Figure 11 is an enlargement of the encircled region 11 shown in Figure 10;

Figure 12 is a schematic view of a strainer system constructed in accordance with another embodiment of the present invention, and including a pressure released membrane integrated into a plenum duct thereof;

5 Figure 13 is an enlargement of the encircled region 13 shown in Figure 12, further illustrating in phantom the movement of the pressure released membrane from its closed position to its open position;

Figure 14 is a front elevational view of the pressure released membrane of the strainer system taken along line 14-14 of Figure 13; and

10 Figures 15A-15C are schematic views similar to Figure 12, but depicting the strainer system shown in Figure 12 in various phases of functionality as facilitate the actuation of the pressure released membrane thereof from its closed position to its open position.

Common reference numerals throughout the drawings and detailed description to indicate like elements.

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#### DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings wherein the showings are for purposes of illustrating preferred embodiments of the present invention only, and not for purposes of limiting the same, Figures 1 and 2 illustrate an existing, prior art strainer cassette or 20 cartridge 10. The cartridge 10 has a generally quadrangular configuration. When viewed from the perspective shown in Figures 1 and 2, the cartridge 10 includes an opposed pair of side walls 12 extending in spaced, generally parallel relation to each other, a top wall 14 extending between the top edges of the side walls 12, a bottom wall 16 extending in spaced, generally parallel relation to the top wall 14 between the 25 bottom edges of the side walls 12, and a back wall 18 which extends between the back edges of the side walls 12 and between the back edges of the top and bottom walls 14, 16. In the strainer cartridge 10, the side, top, bottom and back walls 12, 14, 16, 18 are each fabricated from a perforated metal material.

30 The strainer cartridge 10 further comprises a plurality of separator plates 20 which, when viewed from the perspective shown in Figures 1 and 2, are horizontally and vertically oriented between the side, top, bottom and back walls 12, 14, 16, 18 in a prescribed arrangement. More particularly, the separator plates 20 are arranged such that they, along with the side, top, bottom and back walls 12, 14, 16, 18,

5 collectively define a plurality of strainer pockets 22 within the strainer cartridge 10. In the exemplary strainer cartridge 10 shown in Figures 1 and 2, a total of eight (8) strainer pockets 22 are included in the strainer cartridge 10, with the strainer pockets 22 being arranged in two side-by-side vertical columns of four (4) strainer pockets 22 each. Like the side, top, bottom and back walls 12, 14, 16, 18, each of the separator plates 20 is fabricated from a perforated metal material.

10 As is most apparent from Figures 4 and 5, the horizontally oriented separator plates 20 included in the strainer cartridge 10 are preferably formed in a manner which imparts a generally parabolic configuration to each of the strainer pockets 22. In this regard, each of the strainer pockets 22 includes an open inflow end 24 at the front edges of the side, top, bottom and back walls 12, 14, 16, 18 and the front edges of the separator plates 20. In addition to the inflow end 24, each strainer pocket 22 includes an arcuate, concave back end 26 which is disposed proximate the back wall 18 of the strainer cartridge 10.

15 As will be discussed in more detail below, in accordance with the present invention, the strainer cartridge 10 is provided with additional structural features which enhance the functionality thereof, and hence the functionality of a strainer module assembled to include one or more enhanced strainer cartridges. Figure 3 depicts an exemplary strainer module 28 assembled by placing multiple strainer 20 cartridges in side-by-side relation to each other. In the exemplary strainer module 28 shown in Figure 3, a total of seven (7) strainer cartridges are included therein, with three (3) of the strainer cartridges being "enhanced." For purposes of clarity, the "enhanced" strainer cartridges constructed in accordance with the present invention are labeled with the reference number "10a" in Figures 3 and 4 to differentiate the 25 same from the prior art strainer cartridges 10. The remaining four (4) strainer cartridges included in the strainer module 28 are the prior art, non-enhanced strainer cartridges 10 described above. Those of ordinary skill in the art will recognize that the strainer module 28 may be assembled to include one or more enhanced strainer cartridges 10a and one or more standard strainer cartridges 10 in any combination, the aforementioned arrangement of three strainer cartridges 10a and four strainer 30 cartridges 10 being exemplary only.

When assembled to form the strainer module 28 shown in Figure 3, the strainer cartridges 10, 10a are arranged such that the inflow ends 24 defined by the

strainer pockets 22 thereof face in a common direction. When the strainer module 28 is integrated into a strainer system, a suction plenum is defined between the back wall of the strainer module 28 collectively defined by the back walls 18 of the strainer cartridges 10, 10a thereof. The suction plenum is fluidly coupled to a pump which, 5 when activated, creates suction in the suction plenum as results in a differential pressure condition which causes liquid to be drawn into the inflow ends 24 of the strainer pockets 22 of the strainer cartridges 10, 10a, and thereafter through the strainer pockets 22 of the strainer cartridges 10, 10a into the suction plenum. As will be recognized, flow through the strainer cartridges 10, 10a of the strainer module 28 is 10 achieved as a result of the fabrication of the strainer cartridges 10, 10a from the perforated metal material described above.

Figure 4 depicts an exemplary strainer system 30 which includes the strainer module 28 shown in Figure 3 as paired with a second strainer module 29. The strainer module 29 is virtually identical to the strainer module 28, with the sole 15 distinction being that is assembled with only the standard strainer cartridges 10 (i.e., a total of seven (7) of the cartridges 10 in side-by-side relation to each other). In the exemplary strainer system 30, the strainer modules 28, 29 are oriented in spaced, back-to-back relation to each other, with a suction plenum 32 being defined between the back walls of the strainer modules 28, 29. As will be recognized, in the 20 exemplary strainer system 30, the activation of a pump fluidly coupled to the suction plenum 32 effectively draws liquid into the inflow ends 24 of the strainer pockets 22 of the strainer cartridges 10, 10a within each of the opposed strainer modules 28, 29, such liquid ultimately passing through the strainer cartridges 10, 10a and into the suction plenum 32. Again, the configuration of the strainer module 28 shown in 25 Figure 3 and the configuration of the strainer system 30 shown in Figure 4 are intended to be exemplary only, with the present invention being directed in large measure toward the structural features added to the strainer cartridge 10 which facilitate the creation of the enhanced strainer cartridge 10a. These structural features or enhancements will now be described with particular regard to Figures 4 and 5.

30 Referring now to Figures 4 and 5, in accordance with the present invention, it is contemplated that one or more of the strainer pockets 22 of each of the strainer cartridges 10a included in the exemplary strainer module 28 may be outfitted with a membrane 34 which is selectively moveable between a closed position and an open

position. In the exemplary strainer system 30 shown in Figure 4, a prescribed number of the strainer pockets 22 of the strainer module 28 included in the strainer system 30 are each outfitted with a membrane 34. Each membrane 34 is preferably fabricated from an elastic metal material and is pivotally connected to a corresponding strainer pocket 32 at a joint 36. Each membrane 34 is positioned at the inflow end 24 of the corresponding strainer pocket 22, and is sized so as to substantially cover such inflow end 24. Additionally, as is seen in Figure 5, each strainer pocket 22 outfitted with a membrane 34 further preferably includes a membrane stopper 38 mounted thereto in opposed relation to the joint 36. In this regard, that edge of the membrane 34 disposed furthest from the joint 36 is normally abutted against the corresponding membrane stopper 38 when the membrane 34 is in its closed position.

As indicated above, within one or more of the strainer cartridges 10a of the strainer module 28, the inflow end(s) 24 of one or more of the strainer pockets 22 may be enclosed by an elastic metal membrane 34. When in the closed position shown in Figures 4 and 5, the membrane 34 substantially prevents liquid flow into the corresponding strainer pocket 22 via the inflow end 24 thereof. The membrane 34 is normally maintained in its closed position by the abutment of one edge thereof against the corresponding membrane stopper 38, and remains in such closed position when only a low pressure load is exerted thereon. However, the exertion of a high pressure load on the membrane 34 effectively facilitates the deflection of deformation thereof into the open position in the manner shown by the phantom lines included in Figure 5. As is apparent from Figure 5, the level of flexion or deformation of the membrane 34 must be sufficient to cause the same to move beyond and thus be effectively disengaged from corresponding membrane stopper 38. Once the membrane 34 disengages the corresponding membrane stopper 38, such membrane 34 is free to rotate or pivot about the joint 36 to its fully open position. The movement of the membrane 34 to its open position effectively opens the corresponding strainer pocket 22, thus allowing for the flow of liquid into the interior of such strainer pocket 22 via the now unobstructed inflow end 24 thereof. Those strainer pockets 22 outfitted with the membranes 34 may be referred to as pressure controlled pockets or PCP's.

Within the exemplary strainer module 28 including the strainer cartridges 10a, it is contemplated that approximately five percent (5%) of the strainer pockets 22 included in the strainer cartridges 10a will each be outfitted with a membrane 34 and

thus function as a PCP. As a result, approximately ninety-five percent (95%) of the strainer pockets 22 included in the strainer cartridges 10a of the strainer module 28 will be open without membranes 34. With regard to the distribution of those strainer pockets 22 including membranes 34, it is also contemplated that such PCP's should be kept "clean" during the phase of debris coming on the strainer module 28 in the case of an accident. Accordingly, it is desirable that the strainer pockets 22 outfitted with membranes 34 be installed or located in a dead water zone of the strainer module 28 within the overall strainer system. Typically, this dead water zone may be in the middle of the strainer module 28 and/or at the opposite location of where debris 5 typically enters into the containment. When the strainer module 28 is in use upon the occurrence of an accident, it is contemplated that the strainer pockets 22 outfitted with the membranes 34 will not open simultaneously, but rather will open sequentially as needed to cope with chemical effects in the debris laden water circulating through the strainer module 28. The sequential opening of the PCP's, as will usually occur when 10 the pressure load exerted thereagainst by the debris field forming on the strainer module 28 exceeds the above-described high pressure threshold, facilitates an effective, controlled reduction in head loss, and further avoids any head loss "jump" 15 due to clogging.

As is further shown in Figures 3 and 4, the functional advantages to the 20 exemplary strainer module 28 as a result of the inclusion of one or more PCP's in each of the strainer cartridges 10a may be further enhanced by additionally outfitting the strainer module 28 with flat, non-perforated face plates 40 which extend from prescribed surfaces of the strainer module 28 adjacent the inflow ends 24 of the strainer pockets 22 defined by the strainer cartridges 10, 10a thereof. More 25 particularly, as is best seen in Figure 3, the exemplary strainer module 28 includes a multiplicity of the extended face plates 40 which are attached to the front edges of corresponding ones of the top and bottom walls 14, 16 and separator plates 20 of the strainer cartridges 10, 10a included in the strainer module 28. The face plates 40 are arranged so as to define two generally quadrangular (e.g., rectangular) frames. As is 30 seen in Figure 3, the two quadrangular frames defined by the face plates 40 extend in spaced, generally parallel relation to each other. Since the face plates 40 are attached to the front edges of the top and bottom walls 14, 16 and separator plates 20, the frames defined thereby effectively circumvent the inflow ends 24 of a prescribed

number of the strainer pockets 22, one or more of which may be outfitted with a membrane 34 so as to function as an above-described PCP. Those of ordinary skill in the art will recognize that the particular arrangement of the face plates 40 as shown in Figure 3 is exemplary only, and that the number, size and arrangement of the face plates 40 may be selectively varied as needed to provide the functionality enhancements described below based on the particular environment or configuration of the strainer system in which the strainer module 28 outfitted with the face plates 40 is to be integrated.

As indicated above, the face plates 40 extend forwardly from the strainer module 28 such that the two quadrangular frames defined by the face plates 40 effectively circumvent the inflow ends 24 of a prescribed number of the strainer pockets 22. As shown in Figure 4, in the exemplary strainer system 30, though the strainer module 29 is not assembled to include the enhanced strainer cartridges 10a, such strainer module 29 is still outfitted with the above-described face plates 40 which are arranged on the strainer module 29 in the same pattern described above in relation to the strainer module 28. In this regard, the functional advantages attributable to the inclusion of the face plates 40 on the strainer module 28 are equally applicable to the strainer module 29, despite the absence therein of any of the PCP's. When included with the strainer module 29, the face plates 40 protrude forwardly from the strainer module 29 such that the spaced, generally parallel pair of quadrangular frames defined thereby circumvent the inflow ends 24 of a prescribed number of the strainer pockets 22 of the strainer module 29.

As is further apparent from Figure 4, the face plates 40 included with the strainer modules 28, 29 cause the edges of a fiber and particulate debris bed 42 which may form at the inflow ends of the strainer pockets 22 to compress and slowly curl in from an originally flush relationship to the inner surfaces of the face plates 40. This curling in of the debris bed 42 results in the creation of small flow paths between the inner surfaces of the face plates 40 and the debris bed 42 as differential pressure continues to rise, thus promoting liquid flow through the strainer modules 28, 29 and reducing head loss. The creation of these flow paths, as caused by the inclusion of the face plates 40 with the strainer modules 28, 29, effectively reduces the maximum differential pressure experienced across the strainer modules 28, 29. Those of ordinary skill in the art will recognize that the face plates 40 may be included on one,

both or neither of the face plates 40. In this regard, the inclusion of the face plates 40 with one or both of the strainer modules 28, 29 is purely optional.

Referring now to Figures 6-8, there is shown a strainer module 100 constructed in accordance with a second embodiment of the present invention. The strainer module 100 comprises a generally cylindrical, tubular main body section 102 which defines a section plenum 104 extending axially therethrough. Extending radially from the outer surface of the main body section 102 in spaced, generally parallel relation to each other are a plurality of circularly configured separator plates 106. Though not shown in Figure 6, the main body section 102 includes openings formed therein which allow liquid flowing between the separator plates 106 to be drawn into the suction plenum 104 via such openings upon the creation of a pressure differential condition attributable to the activation of a pump fluidly coupled to the suction plenum 104.

The strainer module 100 further comprises at least one circularly configured strainer cartridge 108 which is positioned between a prescribed adjacent pair of the separator plates 106. The strainer cartridge 108 comprises a multiplicity of wall members 110 which are arranged and attached to each other so as to collectively define a plurality of strainer pockets 112 of the strainer cartridge 108. In the strainer cartridge 108 shown in Figures 6 and 7, a total of ten (10) strainer pockets 112 are included in the strainer cartridge 108, with the strainer pockets 112 being arranged in a circularly configured array. The wall members 110 of the strainer cartridge 108 are each preferably fabricated from a perforated metal material.

In the strainer cartridge 108 included in the strainer module 100, each of the strainer pockets 112 includes an open inflow end 114 which is defined by the peripheral edges of corresponding wall members 110. Thus, as seen in Figures 6 and 7, the inflow ends 114 of the strainer pockets 112 are directed or face radially outwardly relative to the suction plenum 104 defined by the main body section 102. In the strainer cartridge 108, each of the strainer pockets 112 is preferably outfitted with a membrane 116 which mimics the functionality of the above-described membrane 34. In this regard, each membrane 116 is preferably fabricated from an elastic metal material and is pivotally connected to a corresponding strainer pocket 112 at a joint 118. Each membrane 116 is positioned at the inflow end 114 of the corresponding strainer pocket 112, and is sized so as to substantially cover such

inflow end 114. As is best seen in Figure 7, each strainer pocket 112 is further outfitted with a membrane stopper 120 which is mounted thereto in opposed relation to the joint 118. In this regard, that edge of the membrane 116 disposed furthest from the joint 118 is normally abutted against the corresponding membrane stopper 120 when the membrane 116 is in its closed position.

In the strainer cartridge 108, each membrane 116, when in its closed position, substantially prevents liquid flow into the corresponding strainer pocket 112 via the inflow end 114 thereof. Each membrane 116 is normally maintained in its closed position by the abutment of one edge thereof against the corresponding membrane stopper 120, and remains in such closed position when only a low pressure load is exerted thereon. However, the exertion of a high pressure load on the membrane 116 effectively facilitates the flexion or deformation thereof into the open position in the manner shown by the phantom lines included in Figure 8. As is apparent from Figure 8, the level of flexion or deformation of the membrane 116 must be sufficient to cause the same to move beyond and thus be effectively disengaged from the corresponding membrane stopper 120. Once the membrane 116 disengages the corresponding membrane stopper 120, such membrane 116 is free to rotate or pivot about the joint 118 to its fully open position. The movement of the membrane 116 to its open position effectively opens the corresponding strainer pocket 112, thus allowing for the flow of liquid into the interior of such strainer pocket 112 via the now unobstructed inflow end 114 thereof.

Though, in Figure 7, each of the strainer pockets 112 included in the strainer cartridge 108 is shown as being outfitted with a membrane 116, those of ordinary skill in the art will recognize that any number of the strainer pockets 112 less than the entire number thereof may be outfitted with a membrane 116 in any distribution or arrangement. Further, the strainer cartridge 108 may be assembled to include greater or fewer than ten strainer pockets 112 without departing from the spirit and scope of the present invention. Additionally, though the strainer module 100 is shown as including only one strainer cartridge 108 between one adjacent pair of the separator plates 106, those of ordinary skill in the art will also recognize that one or more additional strainer cartridges 108 may be included in the strainer module 100 between one or more other adjacent pairs of the separator plates 106. Within the strainer cartridge 108, it is contemplated that the strainer pockets 112 outfitted with the

membranes 116 will not open simultaneously, but rather will open sequentially as needed to cope with chemical effects in debris laden water circulating through the strainer module 100. The sequential opening of the membranes 116 will usually occur when the pressure load exerted thereagainst by the debris field forming on the strainer module 100 exceeds a prescribed high pressure threshold as described above in relation to the strainer module 28.

Referring now to Figure 9, there is shown a strainer module 200 constructed in accordance with a third embodiment of the present invention. The sole distinction between the strainer modules 100, 200 lies in the separator plates 206 included in the strainer module 200 each having a generally quadrangular (e.g. square) configuration, as opposed to the circular configuration of the above-described separator plates 106 included in the strainer module 100.

Referring now to Figures 10 and 11, there is shown a strainer module 400 constructed in accordance with a fourth embodiment of the present invention. The strainer module 400 comprises a main body section 402 which has a generally quadrangular cross-sectional configuration and defines a suction plenum 404. Attached to a common wall of the main body section 402 and protruding therefrom in spaced, generally parallel relation to each other are a plurality of (e.g., four) cylindrically configured, tubular primary strainer elements 406 which each fluidly communicate with the suction plenum 404. Each of the primary strainer elements 406 defines an inflow end 408, and comprises concentrically positioned outer and inner walls 410, 412. The outer and inner walls 410, 412 are each fabricated from a perforated metal, mesh-like material. The inflow end 408 is typically defined solely by the inner wall 412 of the primary strainer element 406.

In the exemplary strainer module 400, the inflow end 408 of one of the primary strainer elements 406 is covered by a rupture disk or segmented membrane 414 which mirrors the functionality of the above-described membranes 34, 116. In this regard, the segmented membrane 414 is operative to move from a normally closed position (as shown in Figures 10 and 11) to an open position allowing direct liquid flow into the interior of the inner wall 412 of the corresponding primary strainer element 406 via the inflow end 408 defined thereby when such segmented membrane 414 is subjected to a high pressure load beyond a prescribed threshold.

The segmented membrane 414 has a generally circular configuration and defines four (4) membrane quadrants which are individually movable relative to each other.

In the strainer module 400 shown in Figures 10 and 11, it is also contemplated that one or more of the primary strainer elements 406 may include a secondary strainer element 416 concentrically positioned within the inner wall 412 of the primary strainer element 406, thus creating a double cylinder strainer construction as opposed to the single cylinder strainer construction provided by any primary strainer element 406 standing alone. The secondary strainer elements 416 defines an inflow end 418, and comprises concentrically positioned outer and inner walls 420, 422. The outer and inner walls 420, 422 are each fabricated from a perforated metal, mesh-like material. The inflow end 418 is typically defined solely by the inner wall 420 of the secondary strainer element 416.

In the secondary strainer module 416, the inflow end 418 is covered by a rupture disk or segmented membrane 424 which mirrors the functionality of the above-described segmented membrane 414. In this regard, the segmented membrane 424 is operative to move from a normally closed position (as shown in Figures 10 and 11) to an open position allowing direct liquid flow into the interior of the inner wall 422 of the secondary strainer element 416 via the inflow end 418 defined thereby when such segmented membrane 424 is subjected to a high pressure load beyond a prescribed threshold. The segmented membrane 424 also has a generally circular configuration and defines four (4) membrane quadrants which are individually movable relative to each other.

When the exemplary strainer module 400 is integrated into a strainer system, the creation of a pressure differential condition attributable to the activation of a pump fluidly coupled to the suction plenum 404 causes liquid to be drawn through the primary strainer elements 406 and the sole secondary strainer element 416 into the suction plenum 404. Within the strainer module 400, it is contemplated that the segmented membranes 414, 424 will not open simultaneously, but rather will open sequentially as needed to cope with chemical effects in debris laden water circulating through the strainer module 400. As described above in relation to the strainer module 28, the sequential opening of the segmented membranes 414, 424 will usually occur when the pressure load exerted thereagainst by a debris field forming of the strainer module 400 exceeds a prescribed high pressure threshold.

Those of ordinary skill in the art will recognize that greater or fewer than four primary strainer elements 406 may be included in the strainer module 400 without departing from the spirit and scope of the present invention. Along these lines, more than one primary strainer element 406 may be outfitted with a segmented membrane 414, or with the above-described secondary strainer element 416 including its own segmented membrane 424. Further, no primary strainer module 406 need necessarily be outfitted with a secondary strainer element 416.

Referring now to Figures 12-15C, there is shown a strainer system 500 constructed in accordance with another embodiment of the present invention. The strainer system 500 comprises a plurality of strainer modules 528 positioned in a prescribed arrangement. In the strainer system 500, each of the strainer modules 528 comprises a plurality of the above-described strainer cartridges 10 disposed in side-by-side relation to each other. More particularly, in each strainer module 528 shown in Figure 12, a total of nine (9) strainer cartridges 10 are included therein. However, those of ordinary skill in the art will recognize that each strainer module 528 may be assembled to include more or less than nine (9) strainer cartridges 10 without departing from the spirit and scope of the present invention. In the strainer system 500, it is contemplated that none of the strainer modules 528 included therein will include any of the above-described enhanced strainer cartridges 10a. Rather, as indicated above, it is contemplated that each of the strainer modules 528 will be assembled to include only the above-described, non-enhanced strainer cartridges 10.

When viewed from the perspective shown in Figures 12 and 15A-15C, in the strainer system 500, the strainer modules 528 are arranged in two (2) spaced, generally parallel rows of four (4), for a total of eight (8) strainer modules 528. More particularly, the back wall of each strainer module 528 in each row thereof is oriented in spaced, back-to-back relation to the back wall of a corresponding one of the strainer modules 528 included in the remaining row thereof, creating a total of four (4) opposed pairs of the strainer modules 528. In addition, the strainer modules 528 are arranged such that the inflow ends 24 of the strainer pockets 22 of the strainer cartridge 10 included in one row or set thereof face in a common first direction D1, while the inflow ends 24 of the strainer pockets 22 of the strainer cartridges 10 of the remaining row or set thereof face in a common direction D2 which is opposite or opposed to the direction D1. Though the strainer system 500 is shown as including a

total of eight (8) strainer modules 528, those of ordinary skill in the art will further recognize that this total is exemplary only, and may be increased or decreased without departing from the spirit and scope of the present invention.

As further seen in Figure 12, due to the manner in which the two rows or sets 5 of the strainer cartridges 528 are arranged within the strainer system 500, an elongate suction plenum duct 502 is partially defined by the back walls of the strainer modules 528 (which are collectively defined by the back walls 18 of the strainer cartridges 10 thereof). In addition to being partially defined by the back walls of the strainer modules 528, the plenum duct 502 is also partially defined by various segments or 10 sections of a duct wall 506. Thus, in the strainer system 500, the back walls 18 of the strainer cartridges 10 of each of the strainer modules 528 fluidly communicate with the plenum duct 502. The plenum duct 502 is also fluidly coupled to a suction pump 504. When activated, the suction pump 504 creates suction in the plenum duct 502 as 15 results in a differential pressure condition which causes liquid to be drawn into the inflow ends 24 of the strainer pockets 22 of the strainer cartridges 10 included in the strainer modules 528, and thereafter through the strainer pockets 22 into the plenum duct 502.

As best seen in Figures 12-14, it is contemplated that one opposed pair of the strainer modules 528 will originally be “isolated” from the three remaining opposed 20 pairs of the “active” strainer modules 528 included in the strainer system 500. When viewed from the perspective shown in Figures 12 and 15A-15C, the isolated pair of the strainer modules 528 is that pair which is disposed at the back end of the train of strainer modules 528 included in the strainer system 500. However, those of ordinary skill in the art will recognize that the isolated pair of strainer modules 528 could 25 alternatively be that pair located at the opposite, front end of the train of strainer modules 528 included in the strainer system 500.

In the strainer system 500, the isolation of one pair of strainer modules 528 from the remaining active pairs of the strainer modules 528 is facilitated by the integration of a pressure released membrane or PRM 534 within a prescribed location 30 in the interior of the plenum duct 502. As seen in Figure 12, the PRM 534 is positioned in that section of the plenum duct 502 located between the pair of strainer modules 528 at the back end of the train thereof and those strainer modules 528 comprising the remainder of the strainer system 500. The PRM 534 is selectively

movable between a closed position (shown in solid lines in Figure 13) and an open position (shown in phantom lines in Figure 13). The PRM 534 is preferably fabricated from an elastic metal material, and is pivotally connected to the duct wall 506 which, as indicated above, partially defines the plenum duct 502. More 5 particularly, the PRM 534 is pivotally connected to the duct wall 506 at a hinge joint 536. The PRM 534 is sized so as to completely span the cross-sectional area of the plenum duct 502 at the location wherein the PRM 534 is positioned therein. Thus, when the PRM 534 is in its closed position, the plenum duct 502 is effectively segregated into a first section which extends between the back walls of the active 10 strainer modules 528 and fluidly communicates with the suction pump 504, and a second section which extends between the back walls of the isolated strainer modules 528.

As further seen in Figure 13, also attached to the duct wall 506 is a first 15 membrane stopper bar 538 which is disposed in generally opposed relation to the joint 536. In this regard, that edge of the PRM 534 disposed furthest from the joint 536 is normally abutted against the stopper bar 538 when the PRM 534 is in its original, closed position. Thus, the stopper bar 538 is disposed in the aforementioned non-isolated first section of the plenum duct 502. Also attached to the duct wall 506 in close proximity to the stopper bar 538 is a second membrane stopper bar 539 which 20 extends in spaced, generally parallel relation to the stopper bar 538. However, as seen in Figure 13, the stopper bar 539 is disposed in the isolated second section of the plenum duct 502, i.e., the stopper bars 538, 539 are disposed at opposite sides of the PRM 534 when the same is in its closed position.

Having thus described the structural features of the strainer system 500 of the 25 present invention, the functionality thereof will now be described with specific reference to Figures 15A, 15B and 15C. Referring now to Figure 15A, at the beginning of a postulated loss of coolant accident, fibers and particulates laden coolant will come into contact with the strainer modules 528 of the strainer system 500. This debris, however, will only be deposited on the active strainer modules 528 30 of the strainer system 500. In this regard, despite the activation of the suction pump 504, no fluid will be drawn through the isolated strainer modules 528 while the PRM 534 is in its original, closed position. Stated another way, without the opening of the PRM 534, there is no flow through the isolated strainer modules 528 due to the

absence of any suction pressure within the second section of the plenum duct 502 extending between the back walls thereof.

Referring now to Figure 15B, as time cools the cooling water, the above-described chemical effect begins. In this regard, if the coolant is cold enough, precipitates are formed, with such precipitates being deposited as a compact layer on the active strainer modules 528. As previously explained, these precipitate deposits lead to a significant increase in head loss across the active strainer modules 528, with the fibers and the particulates being compressed into the strainer pockets 22 of the strainer cartridges 10 of the active strainer modules 528.

Referring now to Figure 15C, as a result of the compression of fibers and particulates into the strainer pockets 22, the pressure in the non-isolated first section of the plenum duct 502 will continue to grow, and eventually reach the trigger point for the PRM 534. At this trigger point, the PRM 534 is actuated or flexed from its original closed position to its open position. As a result of the opening of the PRM 534, the previously isolated modules 528 are now free and become active. The cooling water as laden with precipitates is filtered through the previously isolated and now released strainer modules 528. Such flow causes the pressure in the plenum duct 502 to decrease rapidly to a low value due to the absence of fibers on the newly activated modules 528 with which the precipitates may react to form a dense bed. In the strainer system 500, the aforementioned first membrane stopper bar 538 is sized and configured to normally maintain the PRM 534 in the closed position and to permit the PRM 534 to flex to the open position upon the application of the prescribed suction load thereto. The second membrane stopper bar 539 is used to prevent the PRM 534 from assuming an open position as a result of a seismic event.

Various potential modifications to the strainer system 500 described above are contemplated to be within the spirit and scope of the present invention. For example, any one of the strainer modules 528, whether originally active or isolated, may optionally be outfitted with one or more of the above-described enhanced strainer cartridges 10a as an alternative to the sole inclusion of the non-enhanced strainer cartridges 10 therein. Similarly, it is also contemplated that any one of the strainer modules 528, whether originally active or isolated, may optionally be outfitted with the above-described face plates 40. Moreover, though the originally isolated strainer modules 528 are shown in Figures 12 and 15A-15C as being disposed in relative close

proximity to the originally active strainer modules 528, it is contemplated that the originally isolated strainer modules 528 may be placed a greater distance from the originally active strainer modules 528. Still further, though only one pair of the strainer modules 528 at one end of the train thereof included in the strainer system 500 is shown as being originally isolated, it is contemplated that those pairs of strainer modules 528 disposed at each of the two opposed ends of the train included in the strainer system 500 may be originally isolated, i.e., two (2) PRM's 534 would originally be integrated into the plenum duct 502 of the strainer system 500. Finally, it is contemplated that the above-described PRM 534 may be substituted with a 10 rupture disk or segmented membrane which mirrors the functionality of the above-described segmented membrane 414.

This disclosure provides exemplary embodiments of the present invention. The scope of the present invention is not limited by these exemplary embodiments. Numerous variations, whether explicitly provided for by the specification or implied 15 by the specification, such as variations in structure, dimension, type of material and manufacturing process may be implemented by one of skill in the art in view of this disclosure.

## WHAT IS CLAIMED IS:

1. A strainer system, comprising:
  - at least two strainer modules fluidly connected to each other by a plenum duct;
  - a suction pump fluidly coupled to the plenum duct; and
  - at least one membrane disposed within the plenum duct;
  - the membrane being selectively transitionable from a closed position wherein at least one of the strainer modules is substantially fluidly isolated from the suction pump, to an open position wherein each of the strainer modules fluidly communicates with the suction pump via the plenum duct.
2. The strainer system of Claim 1 wherein the membrane is fabricated in elastic material adapted to flex upon the application of a prescribed suction load thereto, and the movement of the membrane from the closed position to the open position is facilitated by the flexion thereof.
3. The strainer system of Claim 2 wherein the membrane is fabricated in non-perforated elastic metal material.
4. The strainer system of Claim 2 further comprising:
  - at least one membrane stopper disposed within the plenum duct adjacent the membrane;
  - the membrane stopper being sized and configured to normally maintain the membrane in the closed position and to permit the membrane to flex to the open position upon the application of the prescribed suction load thereto.
5. The strainer system of Claim 4 wherein the membrane is pivotally attached to the plenum duct at a joint which is disposed in generally opposed relation to the membrane stopper.
6. The strainer system of Claim 4 comprising first and second membrane stoppers disposed within the plenum duct adjacent respective ones of opposed sides of the membrane, the first membrane stopper being sized and configured to normally maintain the membrane in the closed position and to permit the membrane to flex to the open position upon the application of the prescribed suction load thereto, and the second membrane stopper being used to prevent the membrane from assuming the open position as a result of a seismic event.

7. The strainer system of Claim 1 comprising a plurality of strainer modules arranged in at least two adjacent rows defining multiple opposed pairs which extend in back to back relation to each other with a portion of the plenum duct extending therebetween, the membrane being positioned to fluidly isolate one of the opposed pairs of the strainer modules from the suction pump when in the closed position.

8. A strainer system, comprising:

at least two strainer modules fluidly connected to a plenum duct; and  
at least one membrane disposed within the plenum duct;

the membrane being selectively transitionable from a closed position wherein the strainer modules are substantially fluidly isolated from each, to an open position wherein the strainer modules fluidly communicate with each other via the plenum duct.

9. The strainer system of Claim 8 wherein the membrane is fabricated from an elastic material adapted to flex upon the application of a prescribed suction load thereto, and the movement of the membrane from the closed position to the open position is facilitated by the flexion thereof.

10. The strainer system of Claim 9 wherein the membrane is fabricated from a non-perforated elastic metal material.

11. The strainer system of Claim 9 further comprising:

at least one membrane stopper disposed within the plenum duct adjacent the membrane;

the membrane stopper being sized and configured to normally maintain the membrane in the closed position and to permit the membrane to flex to the open position upon the application of the prescribed suction load thereto.

12. The strainer system of Claim 11 wherein the membrane is pivotally connected to the plenum duct at a joint which is disposed in generally opposed relation to the membrane stopper.

13. The strainer system of Claim 11 comprising first and second membrane stoppers disposed within the plenum duct adjacent respective ones of opposed sides of the membrane, the first membrane stopper being sized and configured to normally maintain the membrane in the closed position and to permit the membrane to flex to the open position upon the application of the prescribed

suction load thereto, and the second membrane stopper being used to prevent the membrane from assuming the open position as a result of a seismic event.

14. The strainer system of Claim 8 comprising a plurality of strainer modules arranged in at least two adjacent rows defining multiple opposed pairs which extend in back to back relation to each other with a portion of the plenum duct extending therebetween, the membrane being positioned to fluidly isolate one of the opposed pairs of the strainer modules from the remaining opposed pairs thereof when in the closed position.

15. A strainer system, comprising:

10 a plurality of strainer modules arranged to define multiple opposed pairs which extend in back to back relation to each other, each of the opposed pairs of the strainer modules being fluidly connected to each other by a plenum duct;

15 a suction pump fluidly coupled to the plenum duct; and

15 at least one membrane disposed within the plenum duct;

20 the membrane being selectively transitionable from a closed position wherein at least one of the opposed pairs of the strainer modules is substantially fluidly isolated from the suction pump, to an open position wherein each of the opposed pairs of the strainer modules fluidly communicates with the suction pump via the plenum duct.

16. The strainer system of Claim 15 wherein the membrane is fabricated from an elastic material adapted to flex upon the application of a prescribed suction load thereto, and the movement of the membrane from the closed position to the open position is facilitated by the flexion thereof.

25 17. The strainer system of Claim 16 wherein the membrane is fabricated from a non-perforated elastic metal material.

18. The strainer system of Claim 16 further comprising:

25 at least one membrane stopper disposed within the plenum duct adjacent the membrane;

30 the membrane stopper being sized and configured to normally maintain the membrane in the closed position and to permit the membrane to flex to the open position upon the application of the prescribed suction load thereto.

19. The strainer system of Claim 18 wherein the membrane is pivotally connected to the plenum duct at a joint which is disposed in generally opposed relation to the membrane stopper.

20. The strainer system of Claim 18 comprising first and second membrane stoppers disposed within the plenum duct adjacent respective ones of opposed sides of the membrane, the first membrane stopper being sized and configured to normally maintain the membrane in the closed position and to permit the membrane to flex to the open position upon the application of the prescribed suction load thereto, and the second membrane stopper being used to prevent the membrane from assuming the open position as a result of a seismic event.

10 21. A strainer cartridge, comprising:

5 a plurality of strainer pockets, each of the strainer pockets defining an open inflow end; and

15 at least one membrane attached to the strainer cartridge in a manner substantially covering the inflow end of a corresponding one of the strainer pockets;

20 the membrane being selectively transitionable from a closed position wherein the inflow end is substantially covered thereby, to an open position wherein the inflow end is at least partially unobstructed allowing for the flow of a fluid into the strainer pocket.

22. The strainer cartridge of Claim 21 wherein the membrane is fabricated from an elastic material adapted to flex upon the application of a prescribed pressure load thereto, and the movement of the membrane from the closed position to the open position is facilitated by the flexion thereof.

25 23. The strainer cartridge of Claim 22 wherein the membrane is fabricated from a non-perforated elastic metal material.

24. The strainer cartridge of Claim 22 further comprising:

30 at least one membrane stopper attached to the strainer cartridge adjacent the inflow end of the strainer pocket substantially covered by the membrane;

the membrane stopper being sized and configured to normally maintain the membrane in the closed position, and to permit the membrane to flex to the open position upon the application of the prescribed pressure load thereto.

25. The strainer cartridge of Claim 24 wherein the membrane is pivotally connected to the strainer cartridge at a joint which is disposed adjacent the inflow end of the strainer pocket in opposed relation to the membrane stopper.

5 26. The strainer cartridge of Claim 22 wherein a plurality of the membranes are attached to the strainer cartridge in a manner substantially covering the inflow ends of respective ones of the strainer pockets, the membranes being arranged on the strainer cartridge in a prescribed pattern.

10 27. The strainer cartridge of Claim 21 wherein the strainer pockets are arranged in at least two side-by-side columns which extend in generally parallel relation to each other such that the inflow ends of the strainer pockets face in a common direction.

28. The strainer cartridge of Claim 21 wherein the strainer pockets are arranged in a generally circular array such that the inflow ends thereof are directed radially outward relative to a common axis.

15 29. The strainer cartridge of Claim 28 wherein a plurality of membranes are attached to the strainer cartridge in a manner substantially covering the inflow ends of respective ones of each of the strainer pockets.

20 30. The strainer cartridge of Claim 21 further comprising a plurality of face plates attached to the strainer cartridge in a manner wherein the faceplates collectively define a frame which extends forwardly relative to and at least partially circumvents the inflow ends of at least some of the strainer pockets.

31. A strainer cartridge, comprising:

a plurality of strainer pockets, each of the strainer pockets defining an open inflow end; and

25 a plurality of membranes attached to the strainer cartridge in a manner substantially covering the inflow ends of respective ones of the strainer pockets;

30 each of the membranes being individually transitionable from a closed position wherein the inflow end of the corresponding strainer pocket is substantially covered thereby, and an open position wherein the inflow end of the corresponding strainer pocket is at least partially unobstructed allowing for the flow of a fluid therethrough.

32. The strainer cartridge of Claim 31 wherein each of the membranes is fabricated from an elastic, non-perforated metal material adapted to flex upon the application of a prescribed pressure load thereto, and the movement of each of the membranes from the closed position to the open position is facilitated by the flexion thereof.

5 33. The strainer cartridge of Claim 31 wherein the inflow ends of approximately five percent of the strainer pockets included in the strainer cartridge are at least partially covered by a respective one of the membranes.

10 34. The strainer cartridge of Claim 31 further comprising:

a plurality of membrane stoppers attached to the strainer cartridge adjacent the inflow ends of respective ones of the strainer pockets which are substantially covered by respective ones of the membranes;

15 each of the membrane stoppers being sized and configured to normally maintain a respective one of the membranes in the closed position, and to permit a respective one of the membranes to flex to the open position upon the application of the prescribed pressure load thereto.

20 35. The strainer cartridge of Claim 34 wherein each of the membranes is pivotally connected to the strainer cartridge at a joint which is disposed adjacent the inflow end of a respective one of the strainer pockets in opposed relation to a respective one of the membrane stoppers.

36. The strainer cartridge of Claim 31 wherein the strainer pockets are arranged in a plurality side-by-side columns which extend in generally parallel relation to each other such that the inflow ends of the strainer pockets face in a common direction.

25 37. The strainer cartridge of Claim 31 further comprising a plurality of face plates attached to the strainer cartridge in a manner wherein the faceplates collectively define a frame which extends forwardly relative to and at least partially circumvents the inflow ends of at least some of the strainer pockets.

38. A strainer cartridge, comprising:

30 at least two cylindrically configured, tubular primary strainer elements, each of which includes an inflow end; and

a membrane attached to at least one of the primary strainer elements in a manner covering the inflow end thereof;

the membrane being selectively transitional from a closed position wherein the inflow end is substantially covered thereby, and an open position wherein the inflow end is at least partially unobstructed allowing for the flow of a fluid through the inflow end.

5 39. The strainer cartridge of Claim 38 wherein the membrane has a generally circular, segmented configuration defining four membrane quadrants which are individually moveable relative to each other.

40. The strainer cartridge of Claim 38 further comprising:

10 at least one secondary strainer element concentrically positioned within a corresponding one of the primary strainer elements, the secondary strainer element defining an inflow end and including a membrane attached thereto and covering the inflow end thereof;

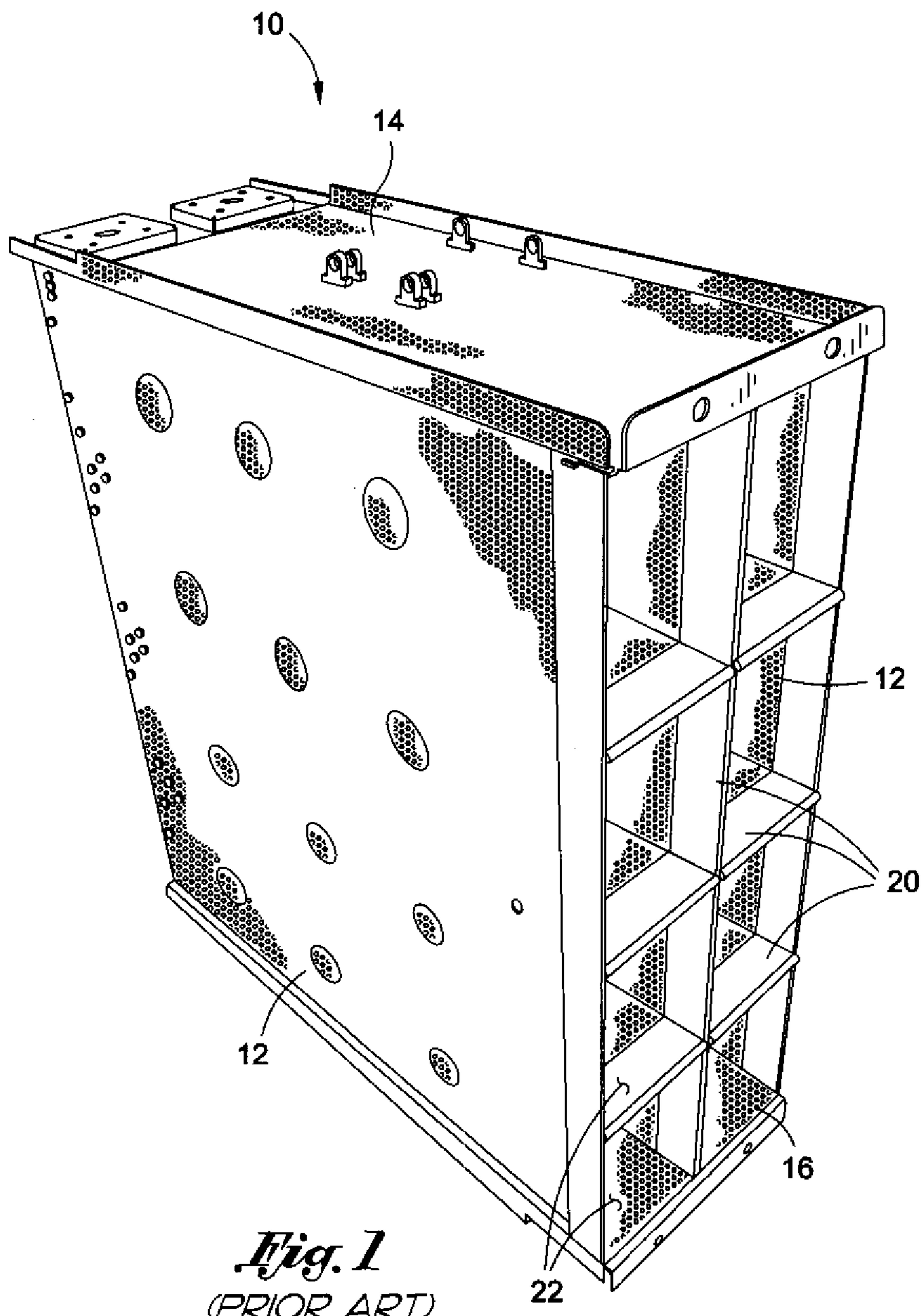
15 the membrane of the secondary strainer element being selectively transitional from a closed position wherein the inflow end of the secondary strainer element is substantially covered thereby, and an open position wherein the inflow end of the secondary strainer element is at least partially unobstructed to allow for the flow of fluid therethrough.

41. A strainer module, comprising:

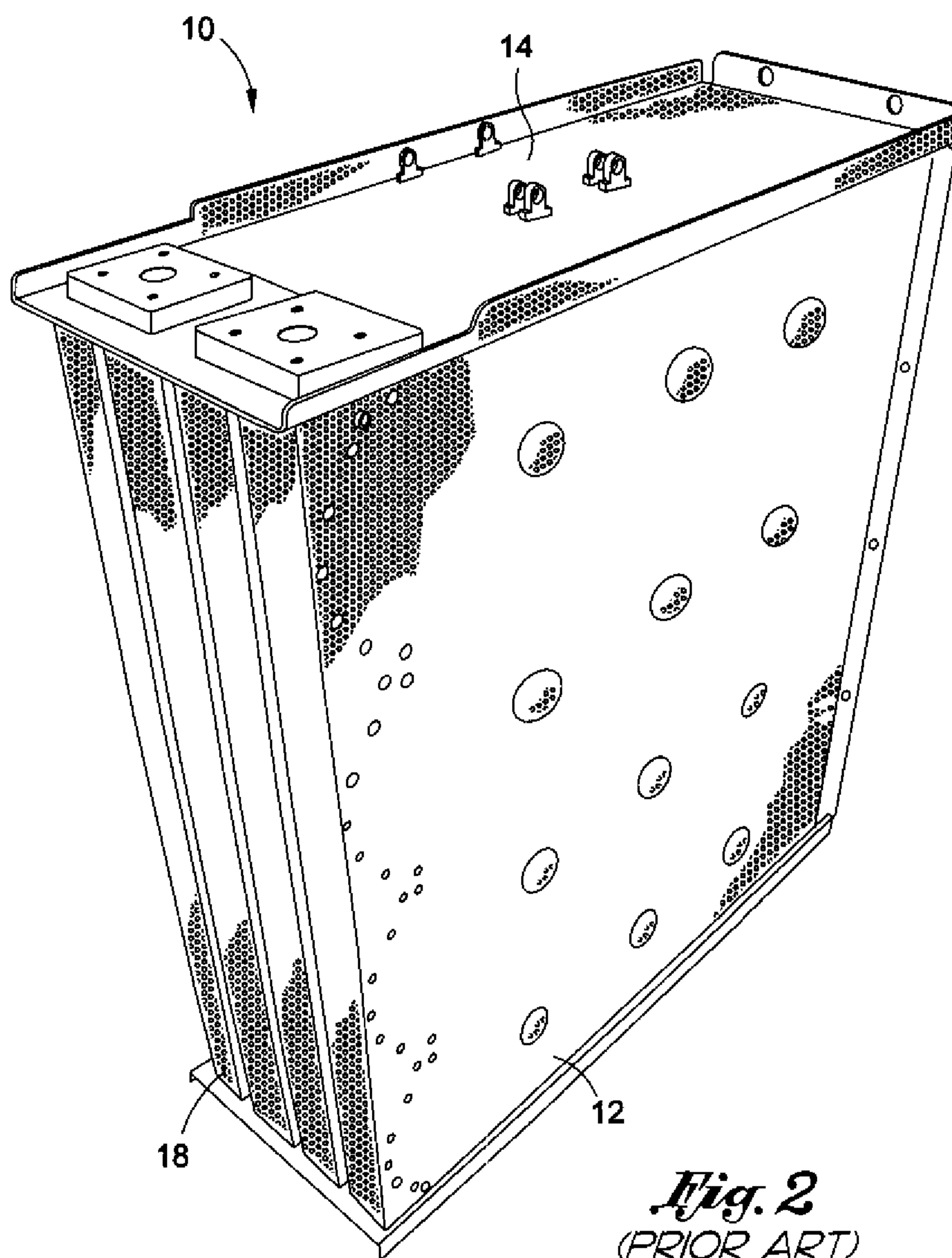
20 at least one strainer cartridge defining at least two of fluid inflow portions;

the strainer cartridge being configured such that at least one of the inflow portions is selectively transitional from a closed state wherein the inflow portion is substantially obstructed, to an open state wherein the inflow portion is at least partially unobstructed to allow for the flow of a fluid therein.

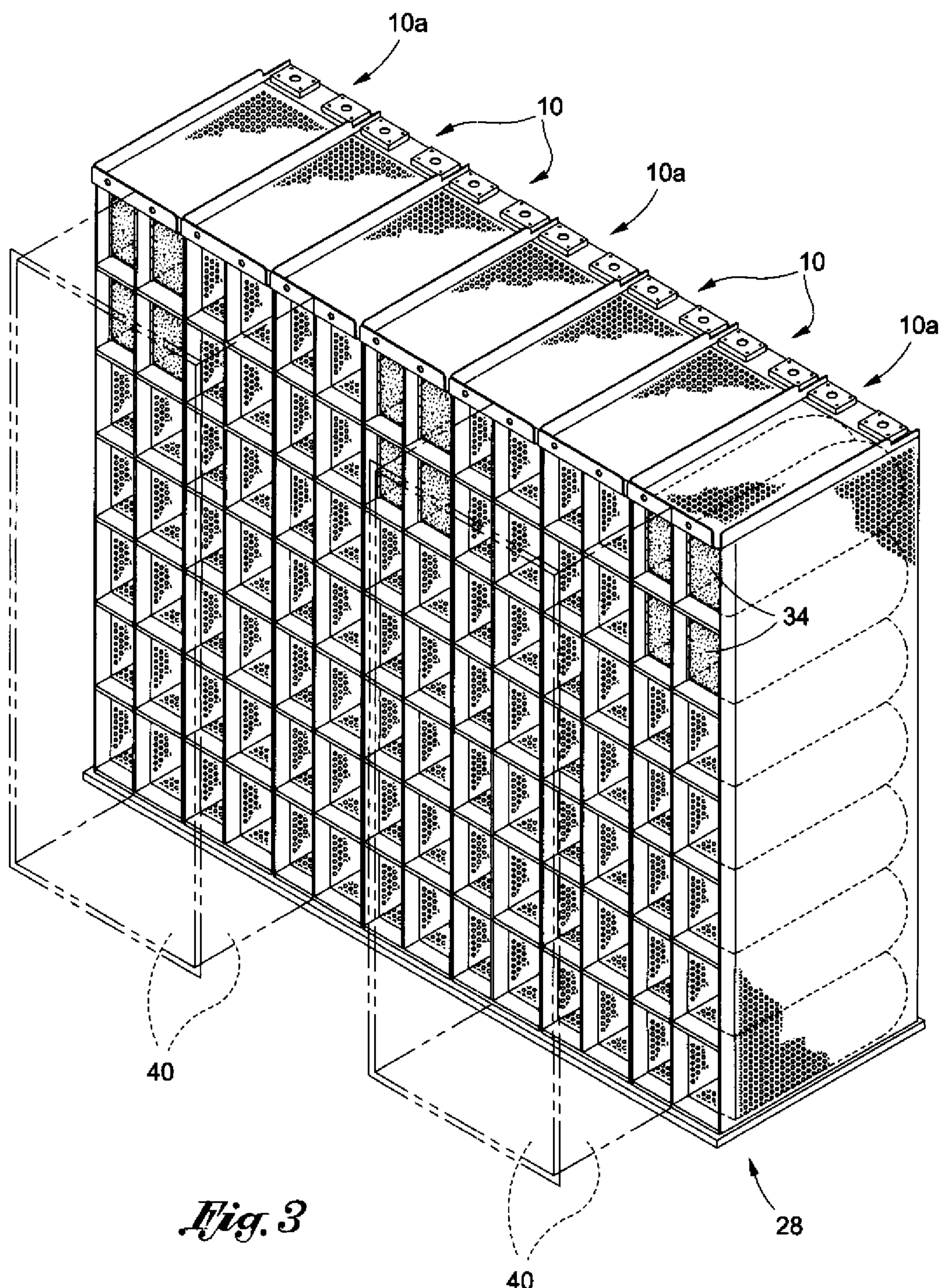
1/11



2/11



3/11



4/11

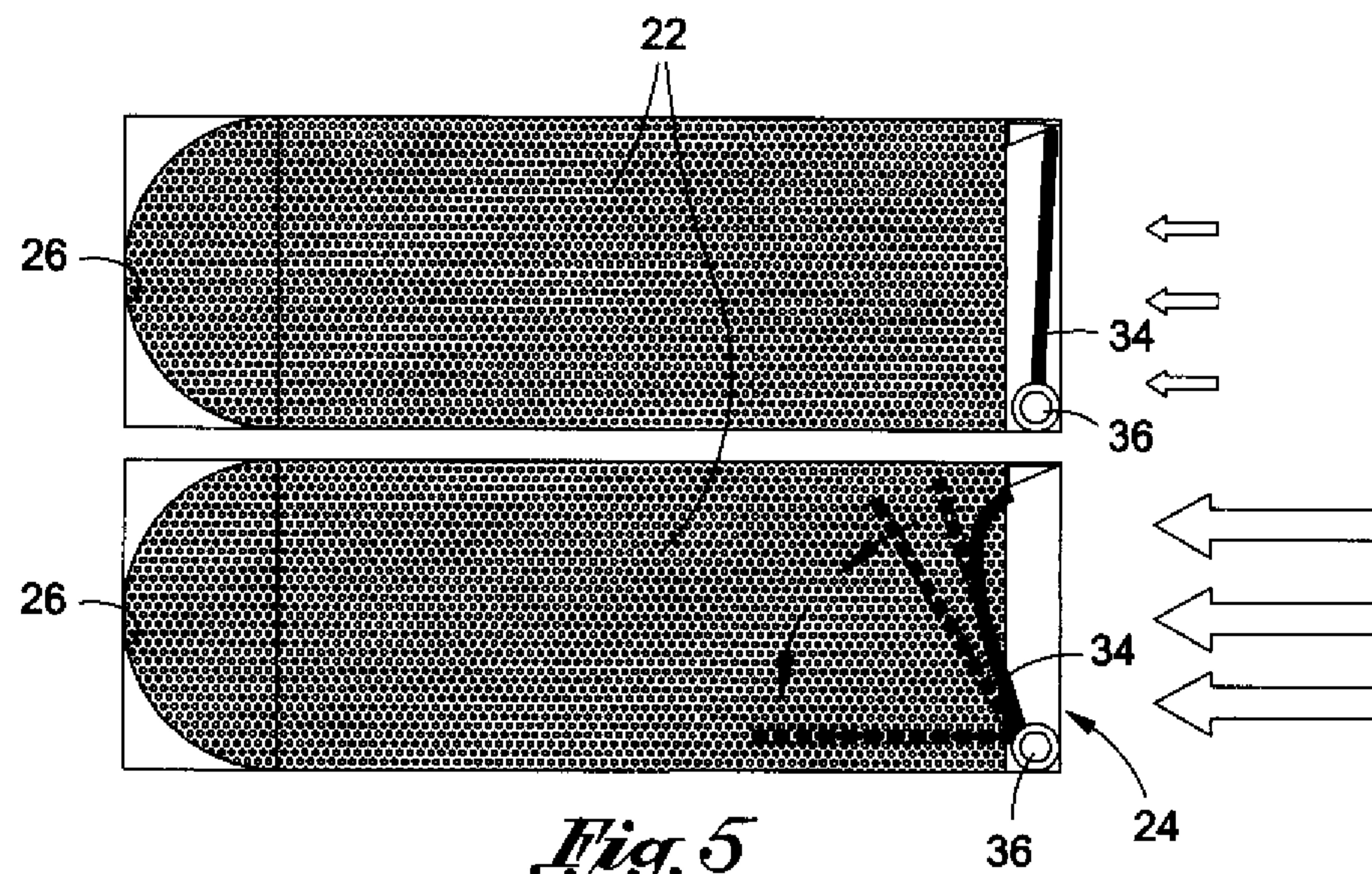


Fig. 5

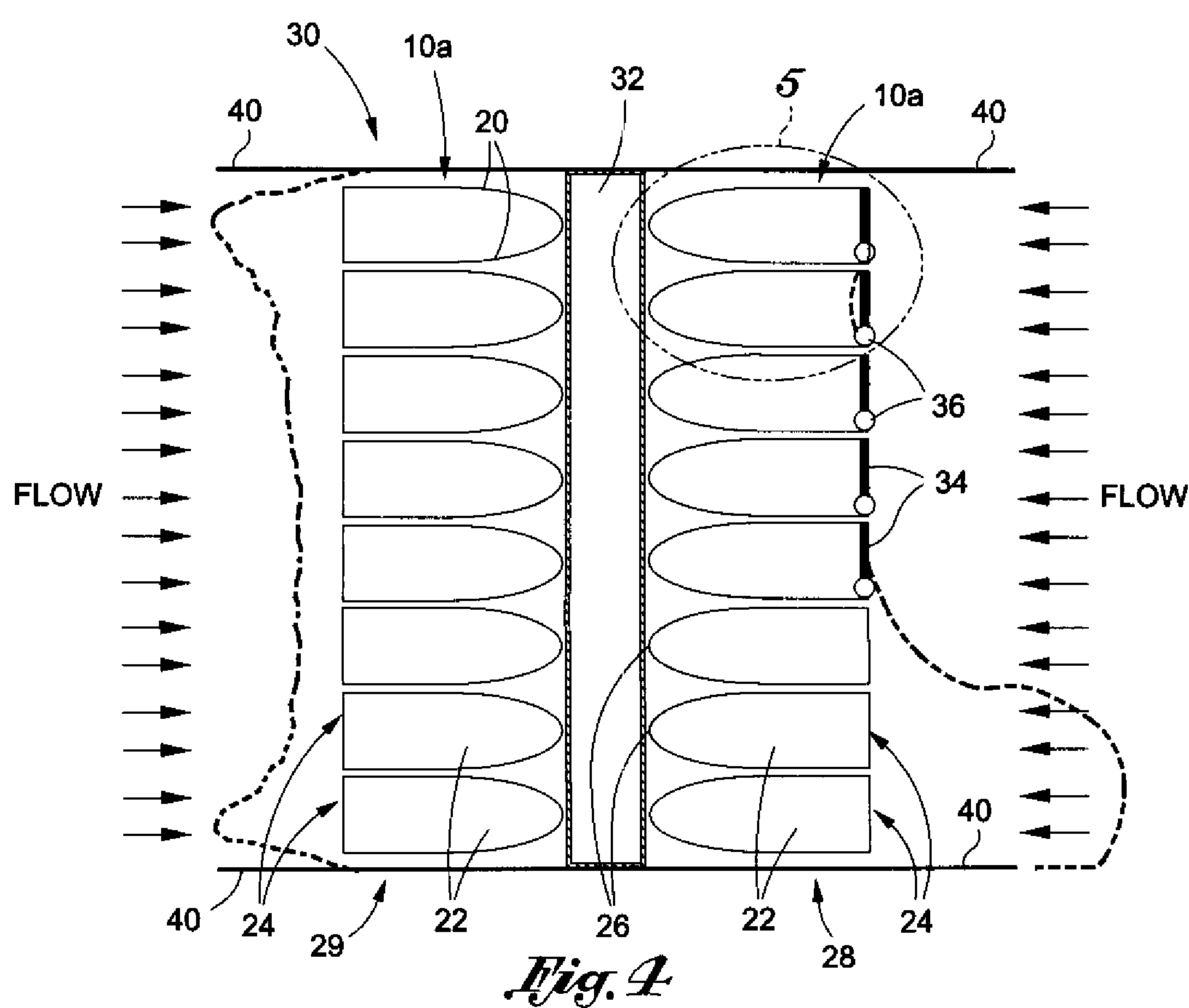
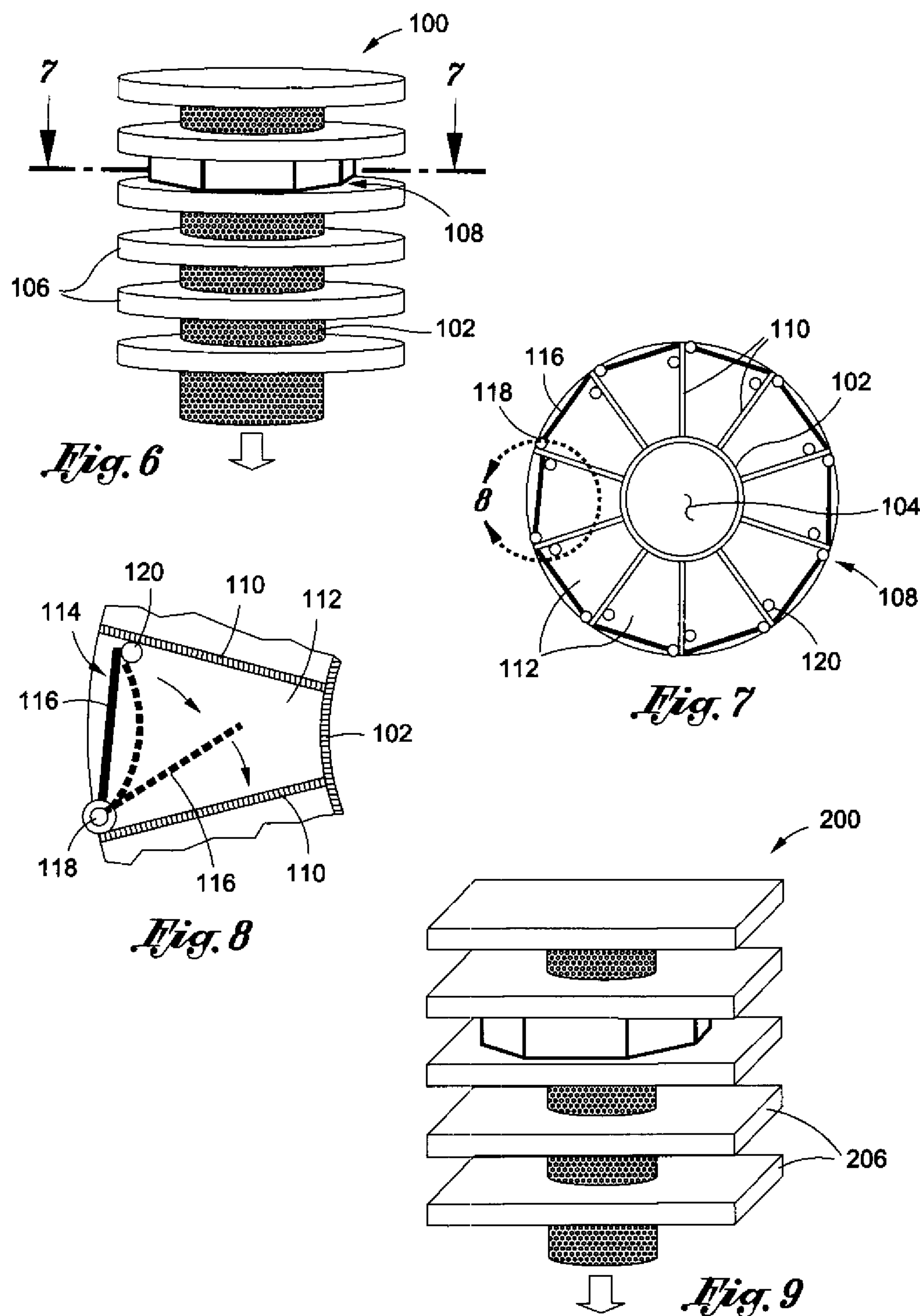
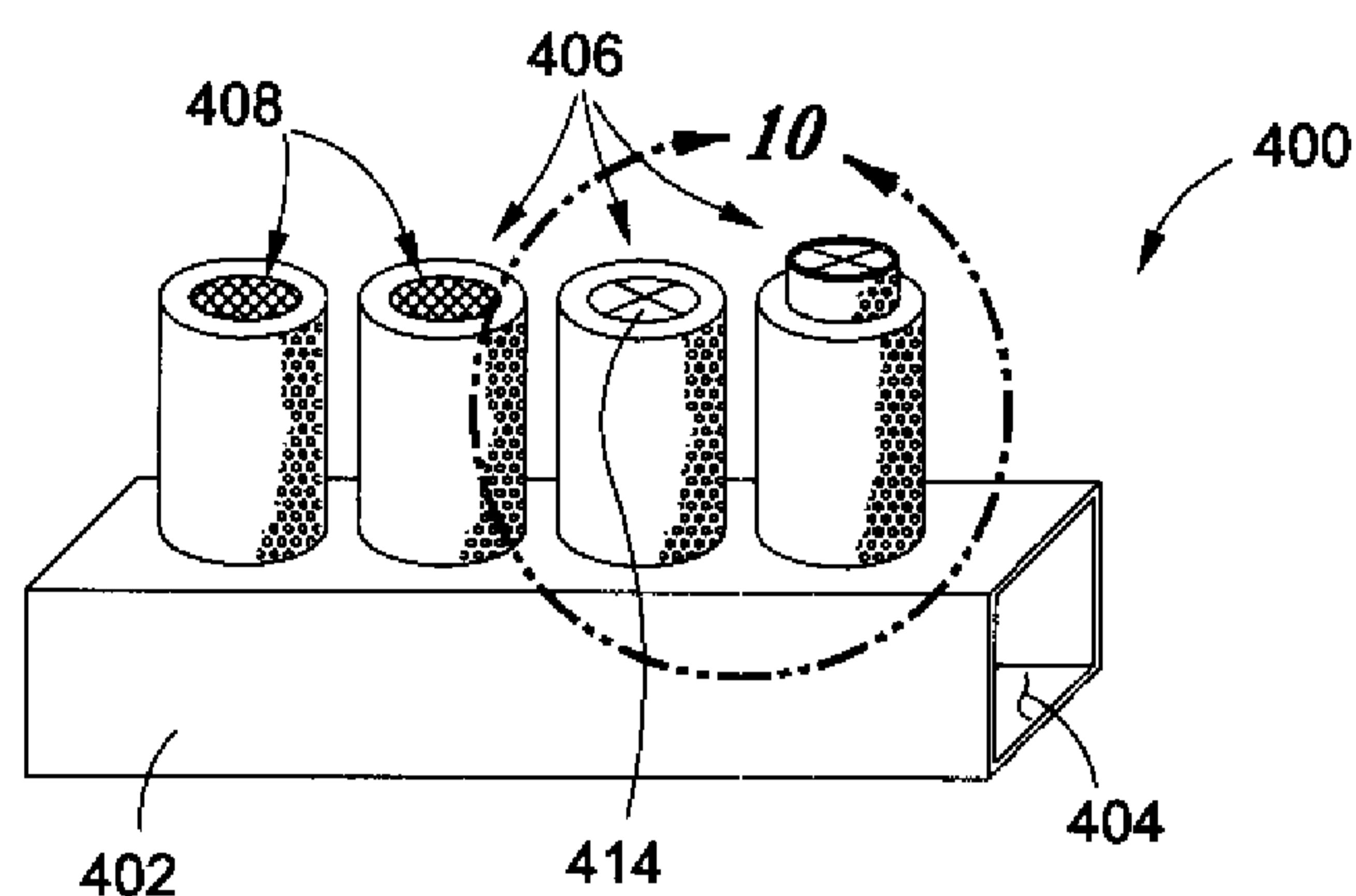
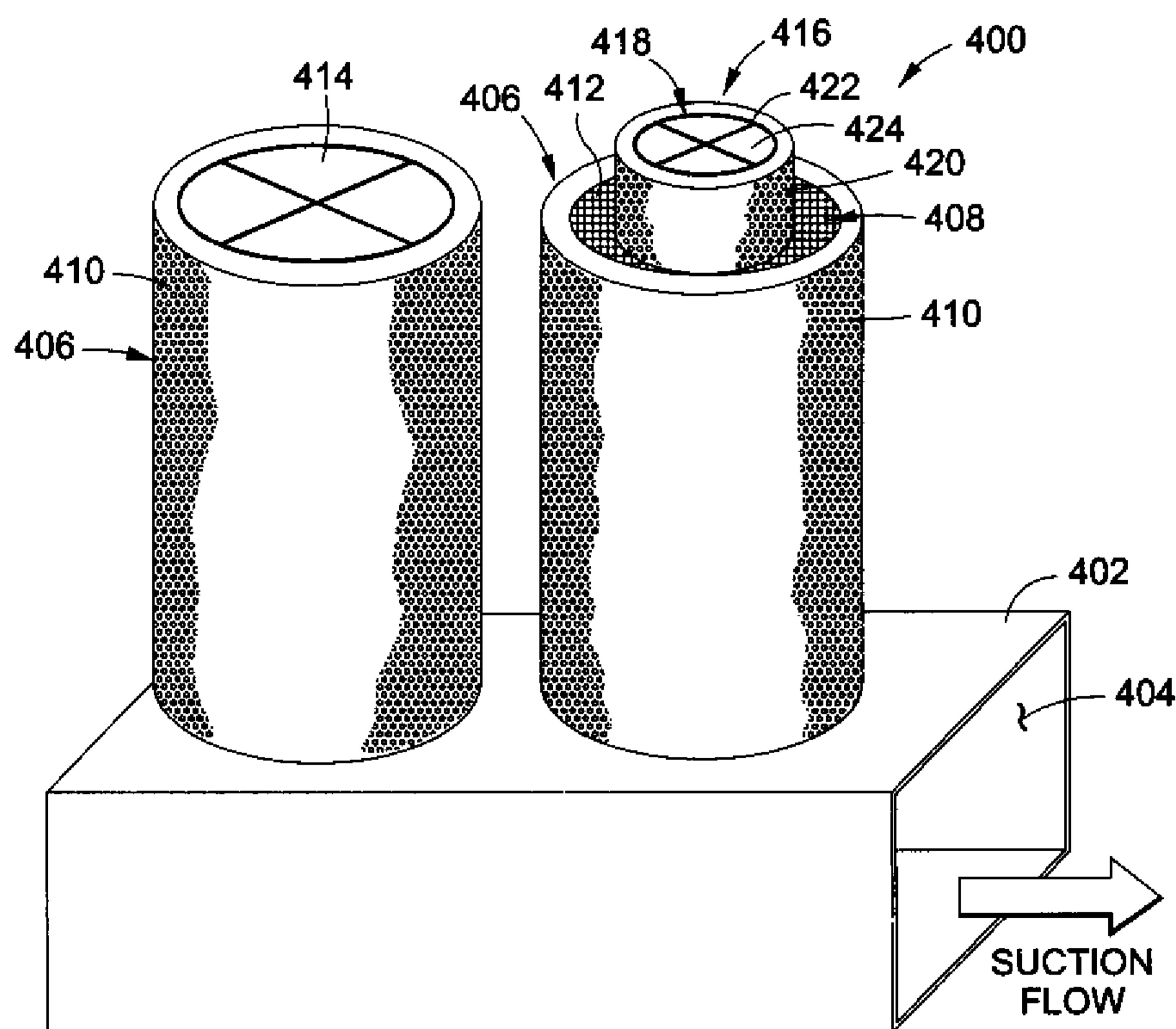


Fig. 4

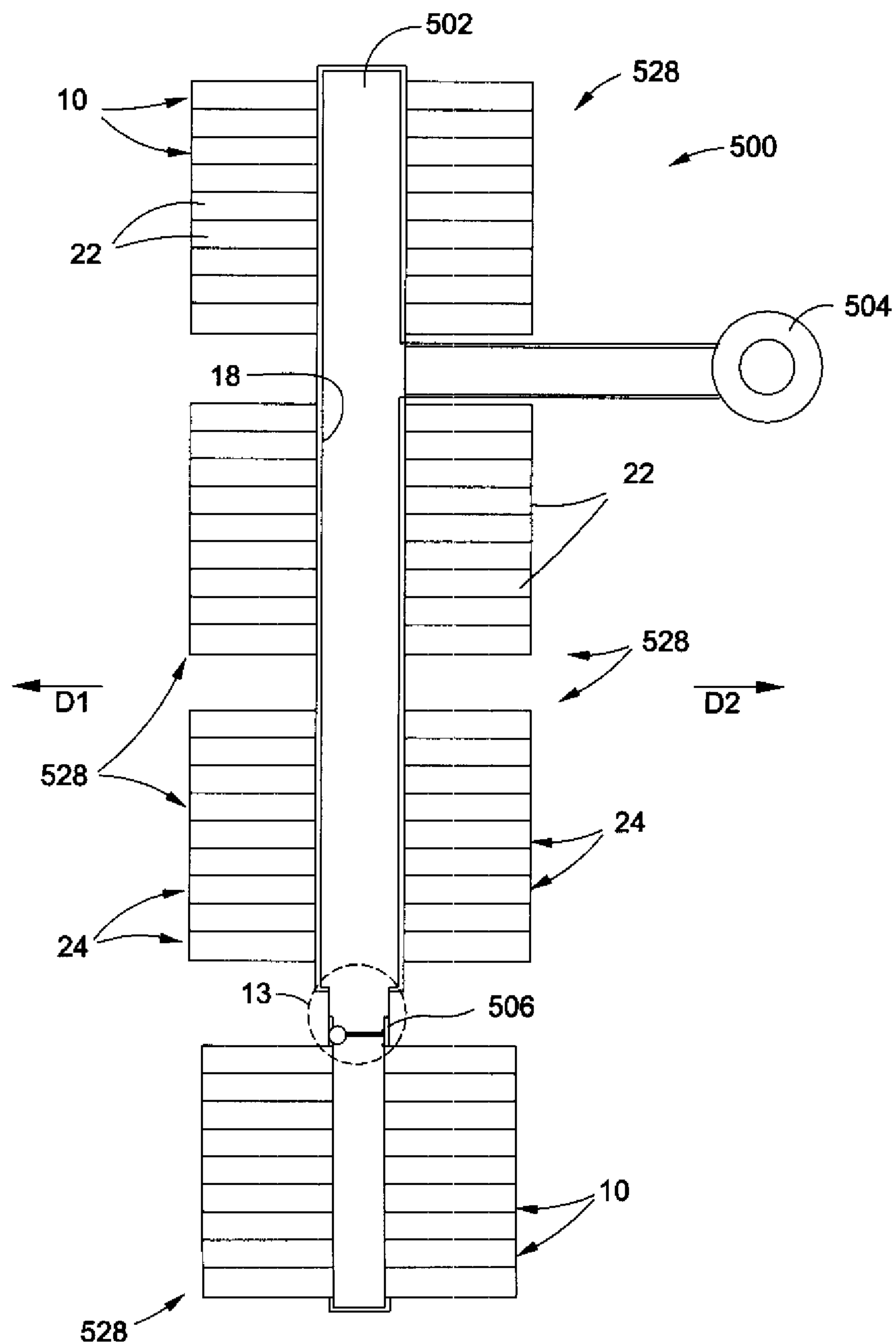
5/11



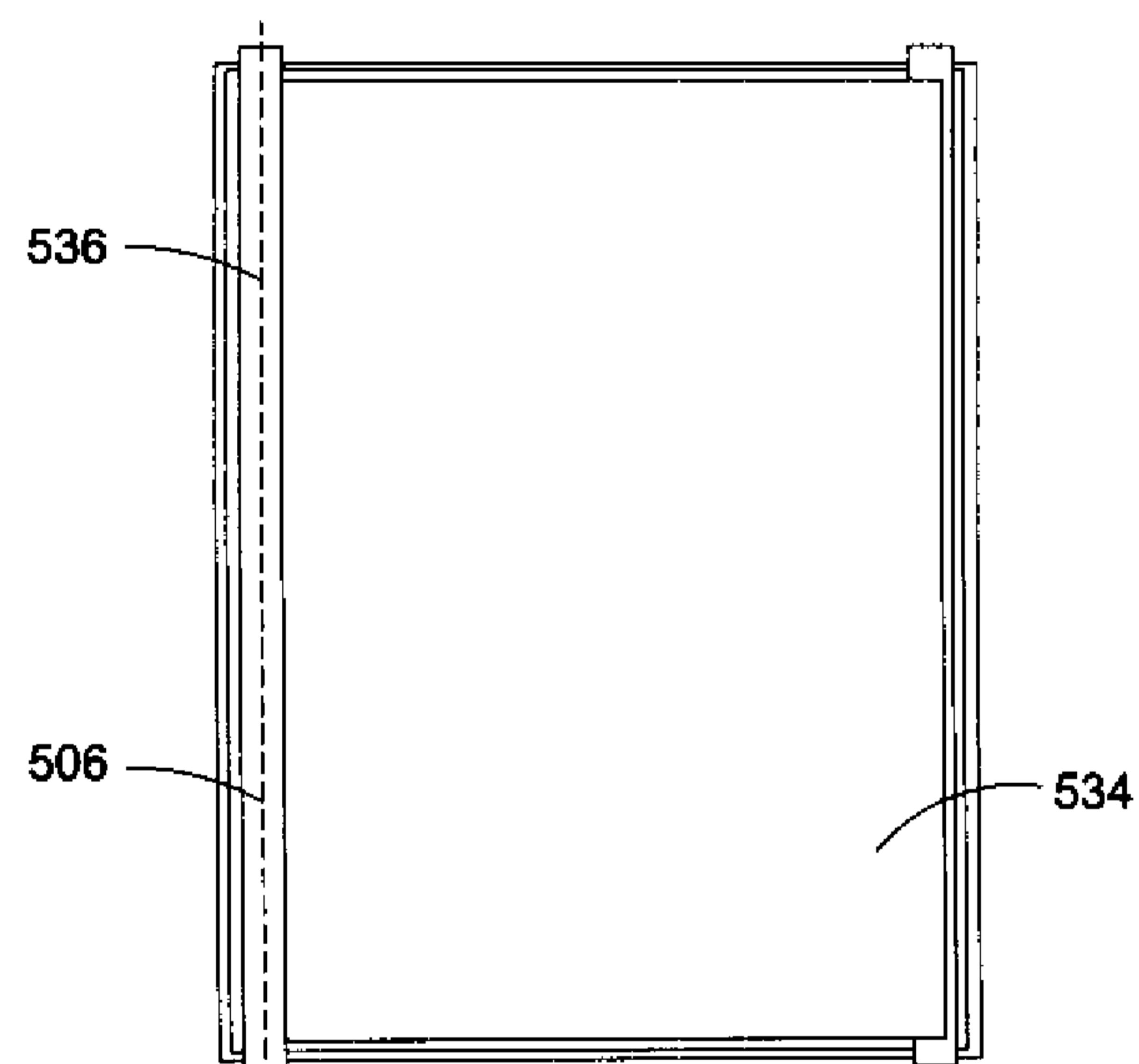
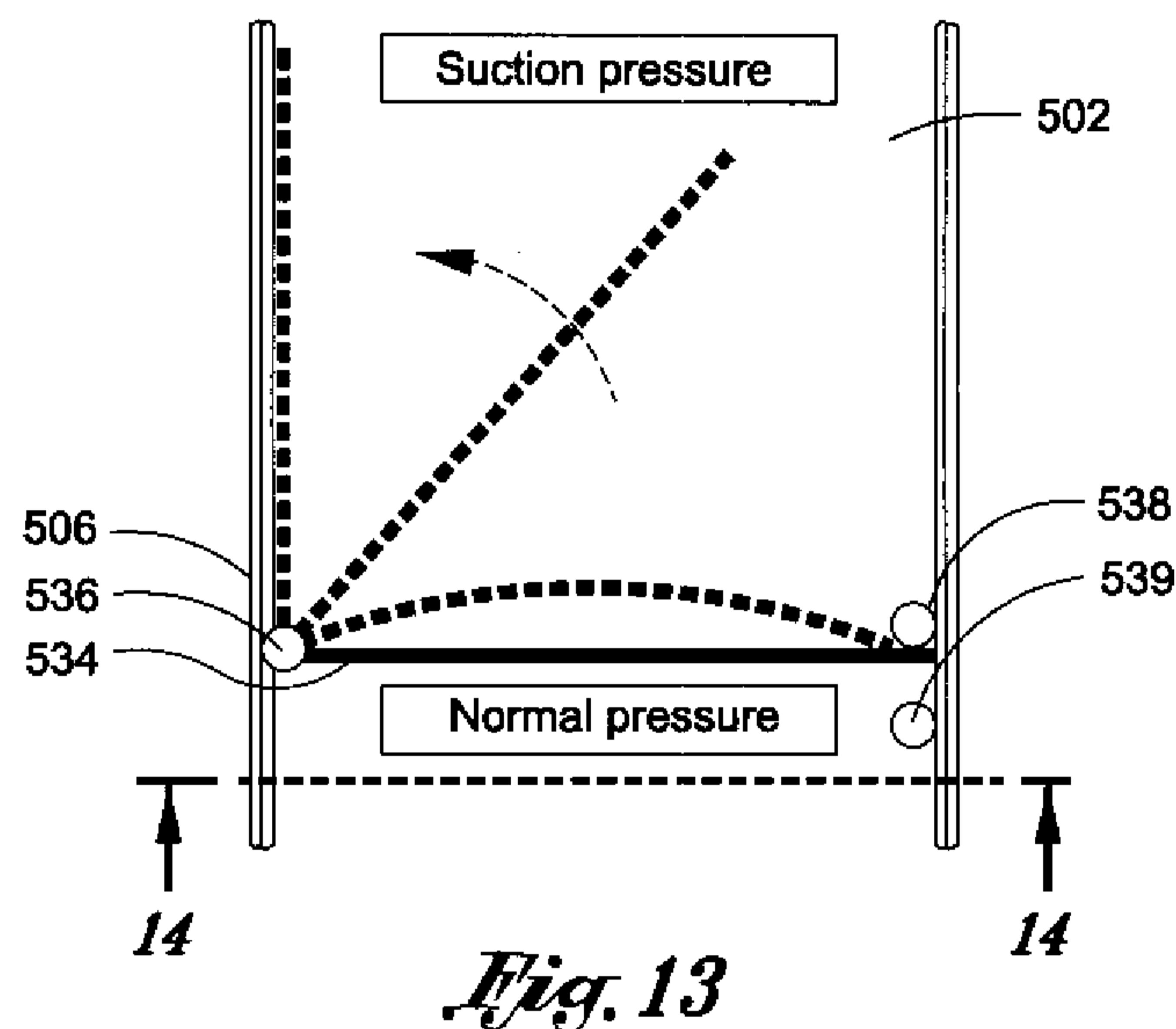
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*Fig. 10**Fig. 11*

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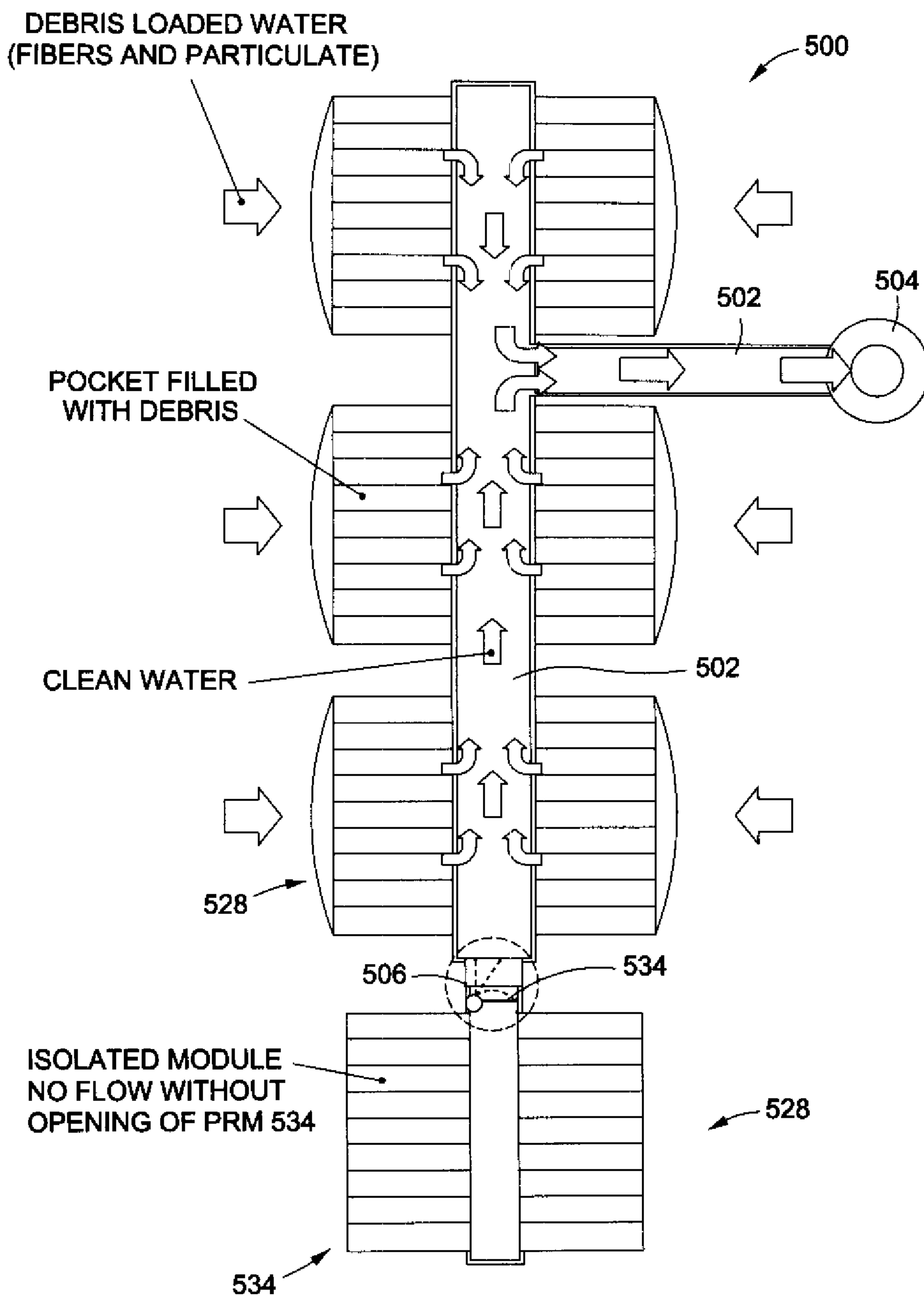
*Fig. 12*

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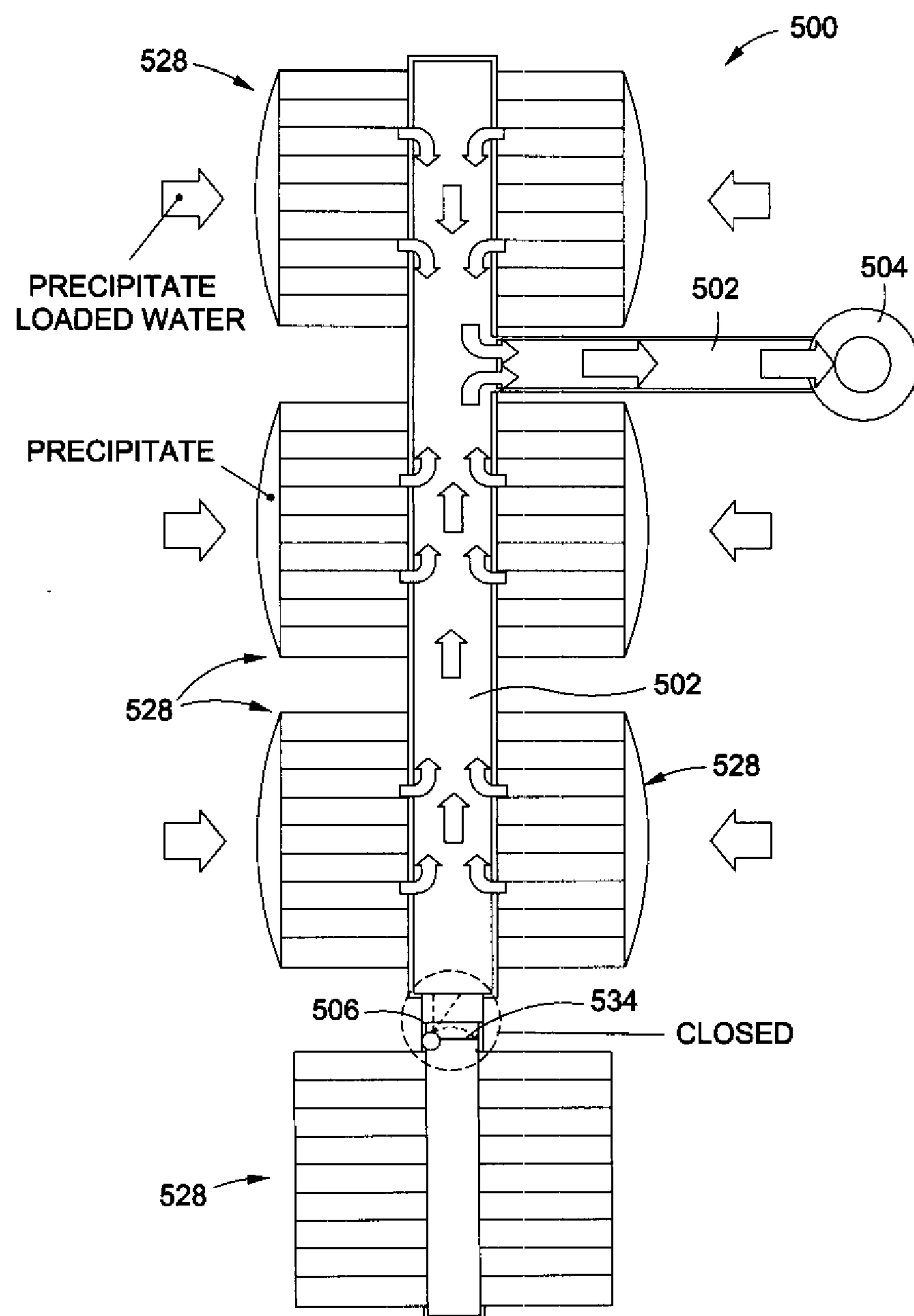


*Fig. 14*

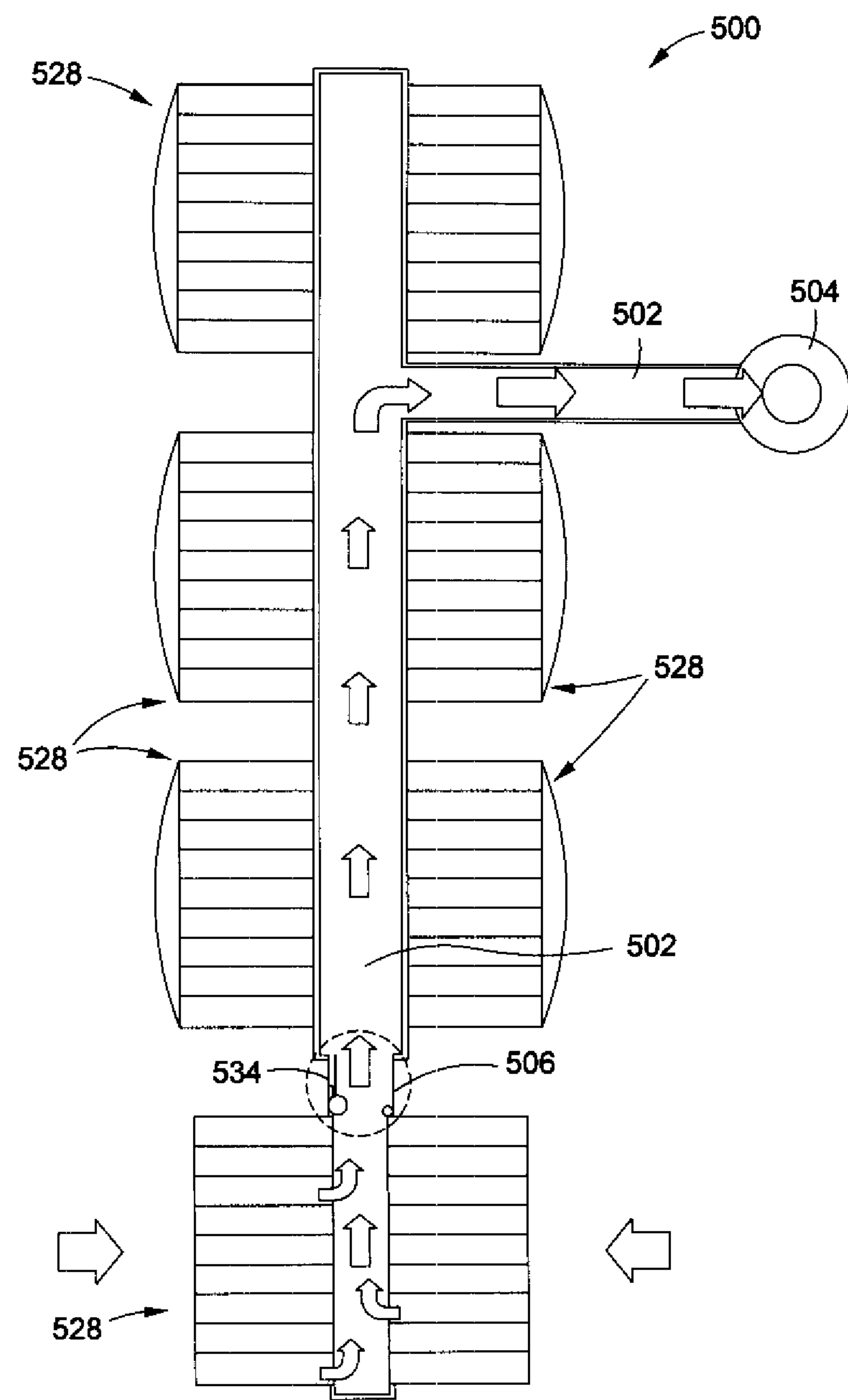
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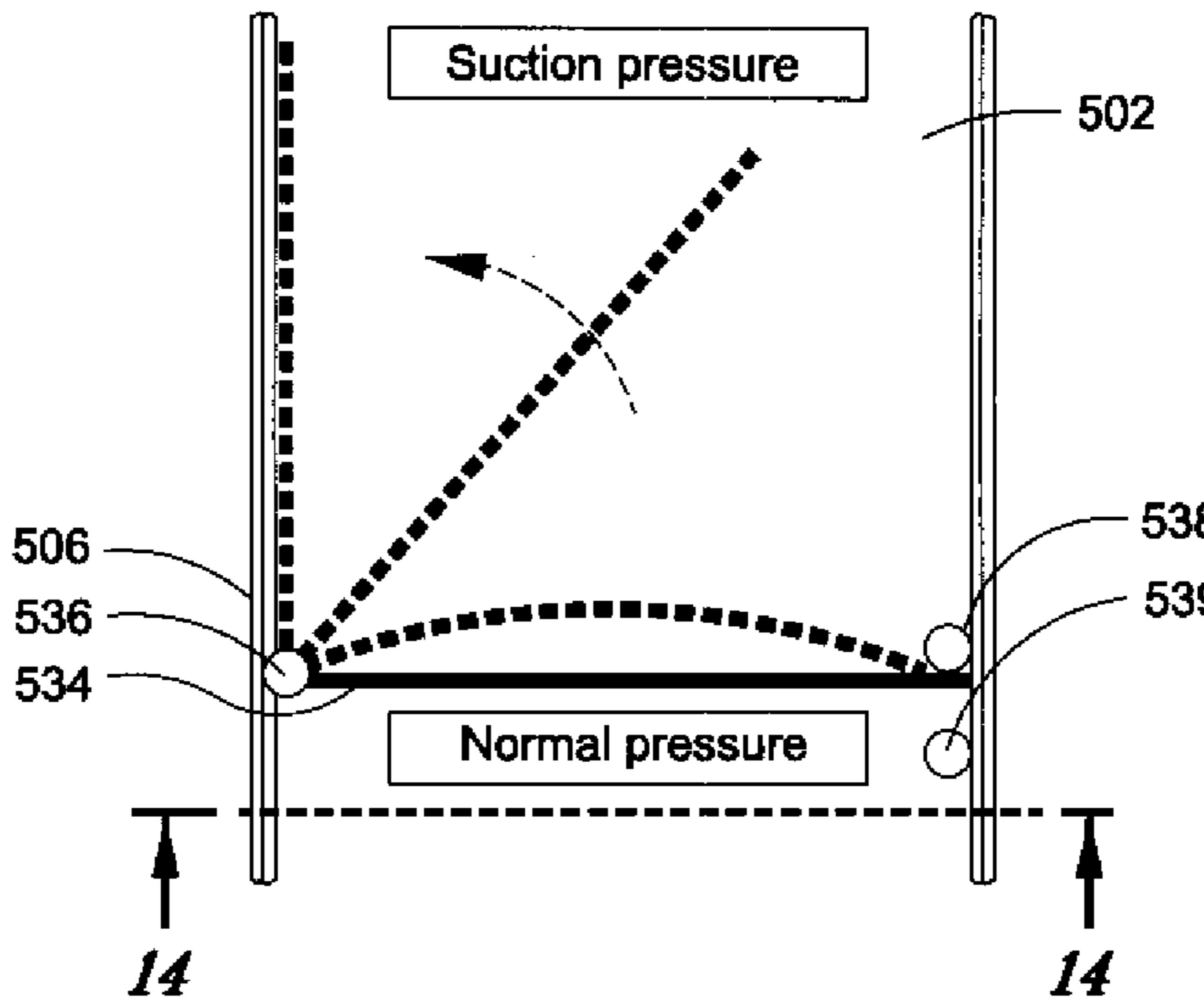
*Fig. 15A*

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*Fig. 15B*

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*Fig. 15C*



*Fig. 13*