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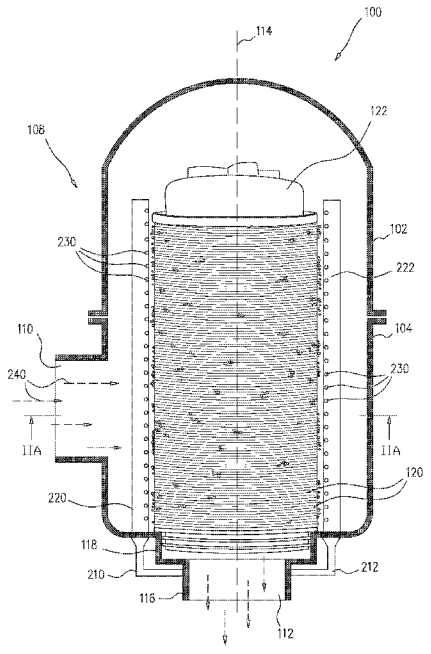
(54) Title: DISC FILTERS

FIG. 1A



(57) Abstract: A disc filter including a stack of apertured filter discs arranged about an axis, the stack having an outer surface and an inner surface and being mounted such that during backflush, individual discs are rotatable relative to adjacent discs about the axis and a disc cleaning assembly operative to rotate at least some of the discs about the axis relative to others of the discs, the disc cleaning assembly including at least one first fluid conduit for producing at least one outer liquid jet directed generally tangentially into engagement with the outer surface of the stack for rotationally driving the at least some of the discs about the axis relative to others of the discs and at least one second fluid conduit for producing at least one inner backflushing liquid jet directed into engagement with the inner surface of the stack.

DISC FILTERS

FIELD OF THE INVENTION

The present invention relates to fluid filters generally and more particularly to backflushable disc filters.

BACKGROUND OF THE INVENTON

Various types of backflushable disc filters are known.

SUMMARY OF THE INVENTION

The present invention seeks to provide an improved backflushable disc filter.

There is thus provided in accordance with a preferred embodiment of the present invention a disc filter including at least one stack of apertured filter discs arranged about an axis, the at least one stack having an outer surface and an inner surface and being mounted such that during backflush, individual discs are rotatable relative to adjacent discs about the axis and a disc cleaning assembly operative to rotate at least some of the discs in the at least one stack about the axis relative to others of the discs in the at least one stack, the disc cleaning assembly including at least one first fluid conduit for producing at least one outer liquid jet directed generally tangentially into engagement with the outer surface of the at least one stack for rotationally driving the at least some of the discs in the at least one stack about the axis relative to others of the discs in the at least one stack and at least one second fluid conduit for producing at least one inner backflushing liquid jet directed into engagement with the inner surface of the at least one stack.

Preferably, the at least one stack of apertured filter discs is arranged in a compressed stacked disc operative orientation during filtering operation and arranged in a non-compressed disc operative orientation during backflushing operation.

In accordance with a preferred embodiment of the present invention the disc filter also includes a core element lying interiorly of and nearly touching each of the at least one stack of apertured filter discs. Additionally, the core element includes a central vertical conduit. Alternatively or additionally, the core element includes at least one peripheral vertical conduit. Additionally or alternatively, at least one of the at least one peripheral vertical conduit is formed with a vertical array of outwardly directed backflush water outlet apertures.

Preferably, the disc filter also includes a first piston assembly disposed within the core element and a second piston assembly disposed within the core element. In accordance with a preferred embodiment of the present invention in a filtering operative orientation, the first piston assembly is in an open state and the second piston

assembly is in a closed state and in a backflushing operative orientation, the first piston assembly is in a closed state and the second piston assembly is in an open state.

In accordance with a preferred embodiment of the present invention in the filtering operative orientation, the first piston assembly is operative to allow filtered water to flow therethrough from an inlet opening to an outlet opening.

Preferably, the first piston assembly includes a piston element including a throughgoing bore. Additionally, the throughgoing bore allows water flow therethrough even when the first piston assembly is in the closed state.

In accordance with a preferred embodiment of the present invention the disc cleaning assembly includes at least one upstanding backflow water conduit including a generally vertical array of backflow water outlet apertures. Additionally, the at least one upstanding backflow water conduit communicates with a liquid flow opening of the filter.

In accordance with a preferred embodiment of the present invention the at least one stack of apertured filter discs includes a plurality of stacks of apertured filter discs and the disc cleaning assembly includes at least one upstanding backflow water conduit including a plurality of generally vertical arrays of backflow water outlet apertures, the plurality of generally vertical arrays providing a plurality of outer located liquid jets directed generally tangentially into engagement with different ones of the plurality of stacks.

Preferably, the apertured filter discs include generally radially grooved filter discs.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood and appreciated more fully from the following detailed description, taken in conjunction with the drawings in which:

Figs. 1A & 1B are simplified partially cut away illustrations of the operation of a backflushable disc filter constructed and operative in accordance with a preferred embodiment of the present invention in respective filtering and backflushing modes of operation;

Figs. 2A & 2B are simplified sectional illustrations of the operation of the backflushable disc filter of Figs. 1A and 1B, taken along respective lines IIA - IIA and IIB - IIB in respective Figs. 1A & 1B;

Figs. 3A & 3B are simplified sectional illustrations of the operation of the backflushable disc filter of Figs. 1A - 2B in respective filtering and backflushing modes of operation, taken along respective lines IIIA - IIIA and IIIB - IIIB in respective Figs. 2A & 2B;

Fig. 4 is a simplified exploded view illustration of a portion of the backflushable disc filter of Figs. 1A - 3B;

Figs. 5A and 5B are simplified illustrations of a core, forming part of the backflushable disc filter of Figs. 1A - 4; and

Figs. 6A & 6B are simplified sectional illustrations of the operation of a backflushable disc filter constructed and operative in accordance with another preferred embodiment of the present invention in respective filtering and backflushing modes of operation.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Reference is now made to Figs. 1A & 1B, which are simplified partially cut away illustrations of the operation of a backflushable disc filter 100 constructed and operative in accordance with a preferred embodiment of the present invention in respective filtering and backflushing modes of operation, to Figs. 2A & 2B, which are simplified sectional illustrations of the operation of backflushable disc filter 100, and to Figs. 3A & 3B, which are simplified sectional illustrations of the operation of the backflushable disc filter 100.

As seen in Figs. 1A - 3B, filter 100 preferably includes a top housing portion 102 and a bottom housing portion 104 which are preferably sealingly clamped together to define a water tight housing enclosure, generally designated by reference numeral 108. Bottom housing portion 104 defines an inlet opening 110 for water to be filtered and a bottom outlet opening 112 for filtered water. Enclosure 108 has a general axis of symmetry designated by reference numeral 114. Throughout this description, the terms "vertical", "upper" and "lower" and similar terms are defined with respect to axis 114, as seen in Figs. 1A - 3B, it being appreciated that the filter 100 and its axis 114 may be in any desired orientation.

Bottom housing portion 104 preferably includes a generally cylindrical portion 116, which defines bottom outlet opening 112, and an inwardly threaded broadened cylindrical portion 118.

Disposed within enclosure 108 there is provided a stack of generally radially grooved filter discs 120, which are maintained in a desired mutually stacked, overall generally cylindrical orientation by means of a core element 122, which is described below in greater detail with reference to Figs. 4 - 5B and which preferably lies interiorly of and nearly touching the stack of discs 120.

Referring now additionally to Figs. 4 - 5B, it is seen that core element 122 is preferably an integrally formed element, injection molded of plastic, and has a generally cylindrical overall configuration. Core element 122 preferably includes a generally circular base plate portion 130 having a central aperture 132 and typically four apertures 134, 136, 138 and 140, all disposed outside of and separated from central

aperture 132.

A lower piston housing portion 142 extends upwardly from base plate portion 130 at central aperture 132 and a center vertical conduit 144 extends upwardly from lower piston housing portion 142 to an upper piston housing portion 146. A plurality of water flow apertures 148 are formed preferably on a top facing surface of lower piston housing portion 142.

Four peripheral vertical conduits 154, 156, 158 and 160 extend upwardly from base plate portion 130 at respective apertures 134, 136, 138 and 140. One or more of vertical conduits 154, 156, 158 and 160 are formed with a vertical array of outwardly directed backflush water outlet apertures 162. Apertures 162 are preferably directed at an angle which is between a radial direction and a tangential direction. Preferably a plurality of lateral mechanical supports 164 extend between each of vertical conduits 154, 156, 158 and 160 and central vertical conduit 144.

Disposed below base plate portion 130 is an outwardly threaded cylindrical water flow portion 166 which is preferably threadably engageable with inwardly threaded broadened cylindrical portion 118 (Figs. 1A, 1B, 3A & 3B).

Disposed within lower piston housing portion 142 is a spring loaded lower piston assembly 170, preferably including a piston element 172, a spring seat 174 and a compression spring 176. As seen in Fig. 3A, lower piston assembly 170 is in an open operative orientation during normal filtering operation and, as seen in Fig. 3B, lower piston assembly 170 is in a closed operative orientation during backflushing. As seen in sectional drawing A in Fig. 4, piston element 172 is formed with a throughgoing bore 178, which permits limited water flow therethrough even when lower piston assembly 170 is in a closed state.

Disposed within upper piston housing portion 146 is a spring loaded upper piston assembly 190, preferably including a piston plate 192, a spring seat 194, a compression spring 196, a stacked disc compression plate 198, a side apertured, top and bottom threaded conduit element 200 and a tightening nut 202. Upper piston assembly 190 is in a closed stacked disc compressing operative orientation during normal filtering operation, as seen in Fig. 3A, and in an open, non stacked disc compression operative orientation during backflushing, as seen in Fig. 3B.

Returning now to Figs. 1A - 3B, it is seen that at least one and preferably

two backflow water conduits 210 and 212 communicate between the interior of generally cylindrical portion 116, which defines bottom outlet opening 112, and a pair of upstanding backflow water conduits 220 and 222, via respective one way check valves 224 and 226. It is a particular feature of the present invention that, as seen in Figs. 1A & 1B, upstanding backflow water conduits 220 and 222 are provided with a generally vertical array of backflow water outlet apertures 230 which are directed tangentially so as to produce jets of water tangentially impinging onto outer surfaces 232 of the stack of generally radially grooved filter discs 120 during backflow operation of the filter 100, when the discs 120 are not compressed and are thus able to individually rotate.

Preferably but not necessarily, during backflushing, water jets from apertures 230 of upstanding conduits 220 and 222 impinge onto the outer surfaces 232 of the discs 120 at the same time and in the same rotational direction as the water flow from apertures 162 of peripheral vertical conduits 154, 156, 158 and 160, it being appreciated that a radial angular component of the water flow from apertures 230 is directed in a direction opposite to a radial component of the water flow from apertures 162 of peripheral vertical conduits 154, 156, 158 and 160.

The operation of the backflushable disc filter 100 constructed and operative in accordance with a preferred embodiment of the present invention will now be described with reference to Figs. 1A - 3B.

During normal filtering operation, as seen in Figs. 1A, 2A and 3A, pressurized water to be filtered is supplied to the backflushable disc filter 100 at inlet opening 110, as indicated by arrows 240. The upper piston assembly 190 is closed, by the action of spring 196 and by the positive pressure differential acting on stacked disc compression plate 198, thus tightly compressing the stack of discs 120 along axis 114. The resulting compression of the stack of discs 120 is indicated schematically by arrows 242.

During normal filtering operation, as seen in Figs. 1A, 2A and 3A, the lower piston assembly 170 is open, by the pressure differential between the interior of lower piston housing 142 and the interior of bottom outlet opening 112, which overcomes the urging of spring 176.

During normal filtering operation, water to be filtered passes through the

vertically compressed stack of discs 120 from the outside surface thereof inwardly therethrough, as indicated by arrows 244, leaving particulate matter on the outer surfaces 232 of the stack of discs 120 and in the grooves of the discs 120. The filtered water passes into the volume interior of the stack of discs 120, as indicated by arrows 246, and passes through apertures 148, as indicated by arrows 248, into lower piston housing 142 and therethrough out through bottom outlet opening 112 as indicated by arrows 250.

During normal backflushing operation, as seen in Figs. 1B, 2B and 3B, pressurized backflushing water is supplied to the backflushable disc filter 100 at outlet opening 112, as indicated by arrows 260, and inlet opening 110 is at atmospheric pressure. The lower piston assembly 170 is closed, by the pressure differential between interior of bottom outlet opening 112 and the interior of lower piston housing 142 and by the urging of spring 176.

During normal backflushing operation, the upper piston assembly 190 is open against the urging of spring 196 by the positive pressure differential acting on piston plate 192 by pressurized water within central vertical conduit 144, which is coupled via the interior of lower piston housing 142 and throughgoing bore 178 to the pressurized interior of outlet opening 112. It is appreciated that during normal backflushing operation the interior of enclosure 118 outside of the stack of discs 120 communicates with the inlet opening 110 and is thus at atmospheric pressure. The open state of upper piston assembly 190 causes upward displacement of stacked disc compression plate 198, as indicated by arrows 262, thus allowing the discs 120 to rotate somewhat independently of each other about axis 114.

During normal backflushing operation, backflushing water passes through one or more of vertical conduits 154, 156, 158 and 160, as indicated by arrows 264, and out of water outlet apertures 162, as indicated by arrows 266, as jets of backflushing water. The jets of backflushing water impinge on the non-compressed stack of discs 120 at inside surfaces 267 thereof and may cause rotation of at least some of the discs 120 about axis 114, as indicated by arrows 268. The jets of backflushing water cause backflushing water to pass between the non-compressed discs and outwardly therethrough, as indicated by arrows 270, flushing particulate matter from the outer surface of the stack of discs 120 and from the grooves of the discs 120. The

backflushing water, including the flushed particulate matter, passes into the volume interior of enclosure 108 and exterior of the stack of discs 120, as indicated by arrows 266, and passes out of enclosure 108 via inlet opening 110, as indicated by arrows 272.

It is a particular feature of an embodiment of the present invention that during backflushing operation backflushing water also passes through backflow water conduits 210 and 212 from outlet opening 112 to upstanding backflow water conduits 220 and 222, via respective one way check valves 224 and 226, as indicated by arrows 274, and through the generally vertical array of backflow water outlet apertures 230, as indicated by arrows 280, which are directed tangentially so as to produce jets of water tangentially impinging onto the outer surfaces 232 of the stack of generally radially grooved filter discs 120, when the discs 120 are not compressed and are thus able to individually rotate.

It is a particular feature of the present invention that jets of backflushing liquid emanating from the array of backflow water outlet apertures 230 in conduits 220 and 222 both slough off contaminants from outer surfaces 232 and produce rotation of the discs 120 which are loosely held together. It is appreciated that the rotation of the discs 120, produced by the action of the jets, may produce different extents of rotation of mutually adjacent discs 120 in the stack, thus further enhancing sloughing off of contaminants from outer surfaces 232.

Reference is now made to Figs. 6A and 6B, which are simplified sectional illustrations of the operation of a backflushable disc filter 300 constructed and operative in accordance with another preferred embodiment of the present invention in respective filtering and backflushing modes of operation.

As seen in Figs 6A and 6B, backflushable disc filter 300 preferably includes a housing 308, defining an inlet opening 310 and a bottom outlet opening (not shown). Housing 308 has a general axis of symmetry designated by reference numeral 314. Throughout this description, the terms “vertical”, “upper” and “lower” and similar terms are defined with respect to axis 314, as seen in Figs. 6A - 6B, it being appreciated that the filter 300 and axis 314 may be in any desired orientation.

Disposed within housing 308 there is provided a plurality of stacks of generally radially grooved filter discs 120, each stack of discs being maintained in a desired mutually stacked, overall generally cylindrical orientation by means of a core

element 122, described hereinabove with reference to Figs. 4 - 5B, which preferably lies interiorly of and nearly touching the stack of discs 120.

Similar to the embodiment described with reference to Figs. 1A-3B, during normal filtering operation, lower piston assemblies 170 are in an open operative orientation and upper piston assemblies 190 are in a closed stacked disc compressing operative orientation. During backflushing, lower piston assemblies 170 are in a closed operative orientation and upper piston assemblies 190 are in an open, non-stacked disc compression operative orientation.

In the embodiment of Figs. 6A and 6B filter 300 includes an upstanding backflow water conduit 350 communicating with the bottom outlet opening, preferably via a one way check valve. It is a particular feature of the present invention that upstanding backflow water conduit 350 is provided with a generally vertical arrays of backflow water outlet apertures, similar to apertures 230 of conduits 220 and 222 described hereinabove, which are directed tangentially so as to produce jets of water tangentially impinging onto outer surfaces 232 of each of the plurality of stacks of generally radially grooved filter discs 120 during backflow operation of filter 300, when discs 120 are not compressed and are thus able to individually rotate.

Preferably but not necessarily, during backflushing, water jets from apertures formed in upstanding backflow water conduit 350 impinge onto the outer surfaces 232 of the discs 120 at the same time and in the same rotational direction as the water flow from apertures 162 of vertical conduits 154, 156, 158 and 160, it being appreciated that a radial angular component of the water flow from backflow water outlet apertures of upstanding backflow water conduit 350 is directed in a direction opposite to a radial component of the water flow from the outwardly directed backflush water outlet apertures 162 of vertical conduits 154, 156, 158 and 160.

The operation of the backflushable disc filter 300 will now be described with reference to Figs. 6A - 6B.

During normal filtering operation, as seen in Fig. 6A, pressurized water to be filtered is supplied to the backflushable disc filter 300 at inlet opening 310, as indicated by arrows 400. The upper piston assemblies 190 are closed, by the action of springs 196 and by the positive pressure differential acting on stacked disc compression plates 198, thus tightly compressing the stacks of discs 120 along axes 114. During

normal filtering operation, the lower piston assemblies 170 are open, by the pressure differential between the interior of lower piston housings 142 and the interior of bottom outlet openings, which overcomes the urging of springs 176.

During normal filtering operation, water to be filtered passes through the vertically compressed stacks of discs 120 from the outside surface thereof inwardly therethrough, as indicated by arrows 410, leaving particulate matter on the outer surfaces 232 of the stacks of discs 120 and in the grooves of the discs 120. The filtered water passes into the volume interior of the stack of discs 120, as indicated by arrows 420, and passes through apertures 148 into lower piston housing 142 and therethrough out through bottom outlet opening.

During normal backflushing operation, as seen in Fig. 6B, pressurized backflushing water is supplied to the backflushable disc filter 300 at bottom outlet opening and inlet opening 310 is at atmospheric pressure. The lower piston assemblies 170 are closed, by the pressure differential between interior of bottom outlet opening and the interior of the lower piston housings 142 and by the urging of springs 176.

During normal backflushing operation, the upper piston assemblies 190 are open against the urging of springs 196 by the positive pressure differential acting on piston plates 192 by pressurized water within central vertical conduits 144, which are coupled via the interior of lower piston housings 142 and throughgoing bores 178 to the pressurized interior of the bottom outlet opening. The open state of upper piston assemblies 190 causes upward displacement of stacked disc compression plates 198 thus allowing discs 120 to rotate somewhat independently of each other about axes 114.

During normal backflushing operation, backflushing water passes through one or more of vertical conduits 154, 156, 158 and 160 and out of water outlet apertures 162, as indicated by arrows 450, as jets of backflushing water. The jets of backflushing water impinge on the non-compressed stack of discs 120 at inside surfaces 267 thereof and may cause rotation of at least some of the discs 120 about axes 114, as indicated by arrows 460. The jets of backflushing water cause backflushing water to pass between the non-compressed discs and outwardly therethrough, as indicated by arrows 450, flushing particulate matter from the outer surfaces 232 of the stack of discs 120 and from the grooves of the discs 120. The backflushing water, including the flushed particulate matter, passes into the volume interior of housing 308 and exterior of

the stacks of discs 120, as indicated by arrows 450, and passes out of housing 308 via inlet opening 110, as indicated by arrows 470.

It is a particular feature of an embodiment of the present invention that during backflushing operation backflushing water also passes into upstanding backflow water conduit 350, via the one way check valve and through the generally vertical array of backflow water outlet apertures of upstanding backflow water conduit 350, as indicated by arrows 480, which are directed tangentially so as to produce jets of water tangentially impinging onto the outer surfaces 232 of the stack of generally radially grooved filter discs 120, when the discs 120 are not compressed and are thus able to individually rotate.

It is a particular feature of the present invention that jets of backflushing liquid emanating from the array of backflow water outlet apertures of upstanding backflow water conduit 350 both slough off contaminants from outer surfaces 232 and produce rotation of the discs 120 which are loosely held together. It is appreciated that the rotation of the discs 120, produced by the action of the jets may produce different extents of rotation of mutually adjacent discs 120 in the stack, thus further enhancing sloughing off of contaminants from outer surfaces 232.

It will be appreciated by persons skilled in the art that the present invention is not limited by what has been particularly shown and described hereinabove. Rather the scope of the present invention includes both combinations and subcombinations of features described hereinabove as well as modifications and variations thereof which would occur to a person of skill in the art upon reading the foregoing and which are not in the prior art.

CLAIMS

1. A disc filter comprising:

at least one stack of apertured filter discs arranged about an axis, said at least one stack having an outer surface and an inner surface and being mounted such that during backflush, individual discs are rotatable relative to adjacent discs about said axis; and

a disc cleaning assembly operative to rotate at least some of said discs in said at least one stack about said axis relative to others of said discs in said at least one stack, said disc cleaning assembly including:

at least one first fluid conduit for producing at least one outer liquid jet directed generally tangentially into engagement with said outer surface of said at least one stack for rotationally driving said at least some of said discs in said at least one stack about said axis relative to others of said discs in said at least one stack; and

at least one second fluid conduit for producing at least one inner backflushing liquid jet directed into engagement with said inner surface of said at least one stack.

2. A disc filter according to claim 1 and wherein said at least one stack of apertured filter discs is arranged in a compressed stacked disc operative orientation during filtering operation and arranged in a non-compressed disc operative orientation during backflushing operation.

3. A disc filter according to claim 1 and also comprising a core element lying interiorly of and nearly touching each of said at least one stack of apertured filter discs.

4. A disc filter according to claim 3 and wherein said core element includes a central vertical conduit.

5. A disc filter according to claim 3 and wherein said core element includes

at least one peripheral vertical conduit.

6. A disc filter according to claim 5 and wherein at least one of said at least one peripheral vertical conduit is formed with a vertical array of outwardly directed backflush water outlet apertures.

7. A disc filter according to claim 3 and also comprising:
a first piston assembly disposed within said core element; and
a second piston assembly disposed within said core element.

8. A disc filter according to claim 7 and wherein:
in a filtering operative orientation, said first piston assembly is in an open state and said second piston assembly is in a closed state; and
in a backflushing operative orientation, said first piston assembly is in a closed state and said second piston assembly is in an open state.

9. A disc filter according to claim 8 and wherein in said filtering operative orientation, said first piston assembly is operative to allow filtered water to flow therethrough from an inlet opening to an outlet opening.

10. A disc filter according to claim 9 and wherein said first piston assembly comprises a piston element including a throughgoing bore.

11. A disc filter according to claim 10 and wherein said throughgoing bore allows water flow therethrough even when said first piston assembly is in said closed state.

12. A disc filter according to claim 1 and wherein said disc cleaning assembly comprises at least one upstanding backflow water conduit including a generally vertical array of backflow water outlet apertures.

13. A disc filter according to claim 12 and wherein said at least one

upstanding backflow water conduit communicates with an inlet opening of said filter.

14. A disc filter according to claim 1 and wherein:

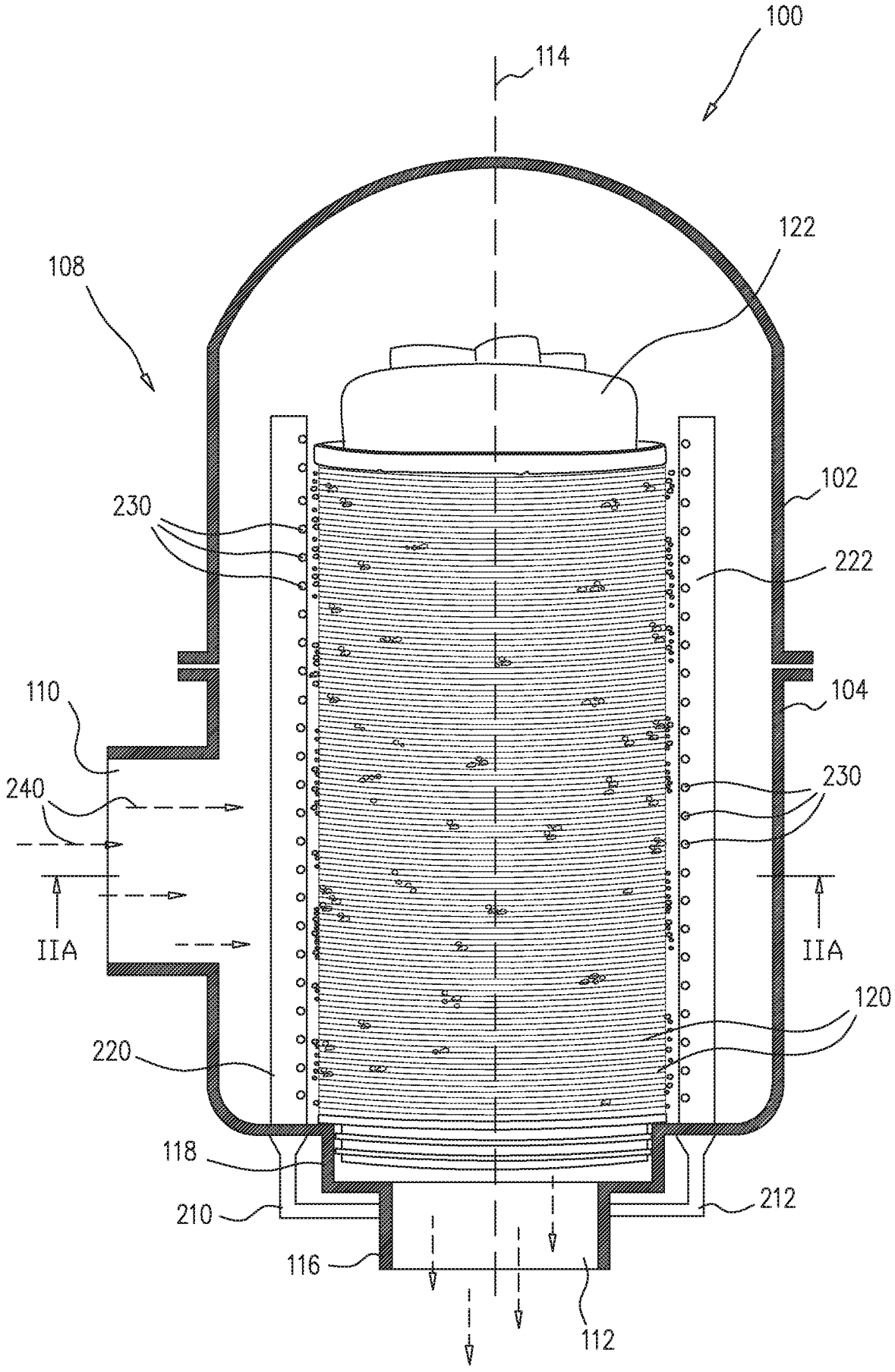
said at least one stack of apertured filter discs comprises a plurality of stacks of apertured filter discs; and

said disc cleaning assembly comprises at least one upstanding backflow water conduit including a plurality of generally vertical arrays of tangentially directed backflow water outlet apertures, said plurality of generally vertical arrays providing a plurality of outer located liquid jets directed generally tangentially into engagement with different ones of said plurality of stacks.

15. A disc filter according to claim 14 and wherein said apertured filter discs comprise generally radially grooved filter discs.

16. A disc filter according to claim 1 and wherein said apertured filter discs comprise generally radially grooved filter discs.

FIG. 1A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114
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112

FIG. 1B

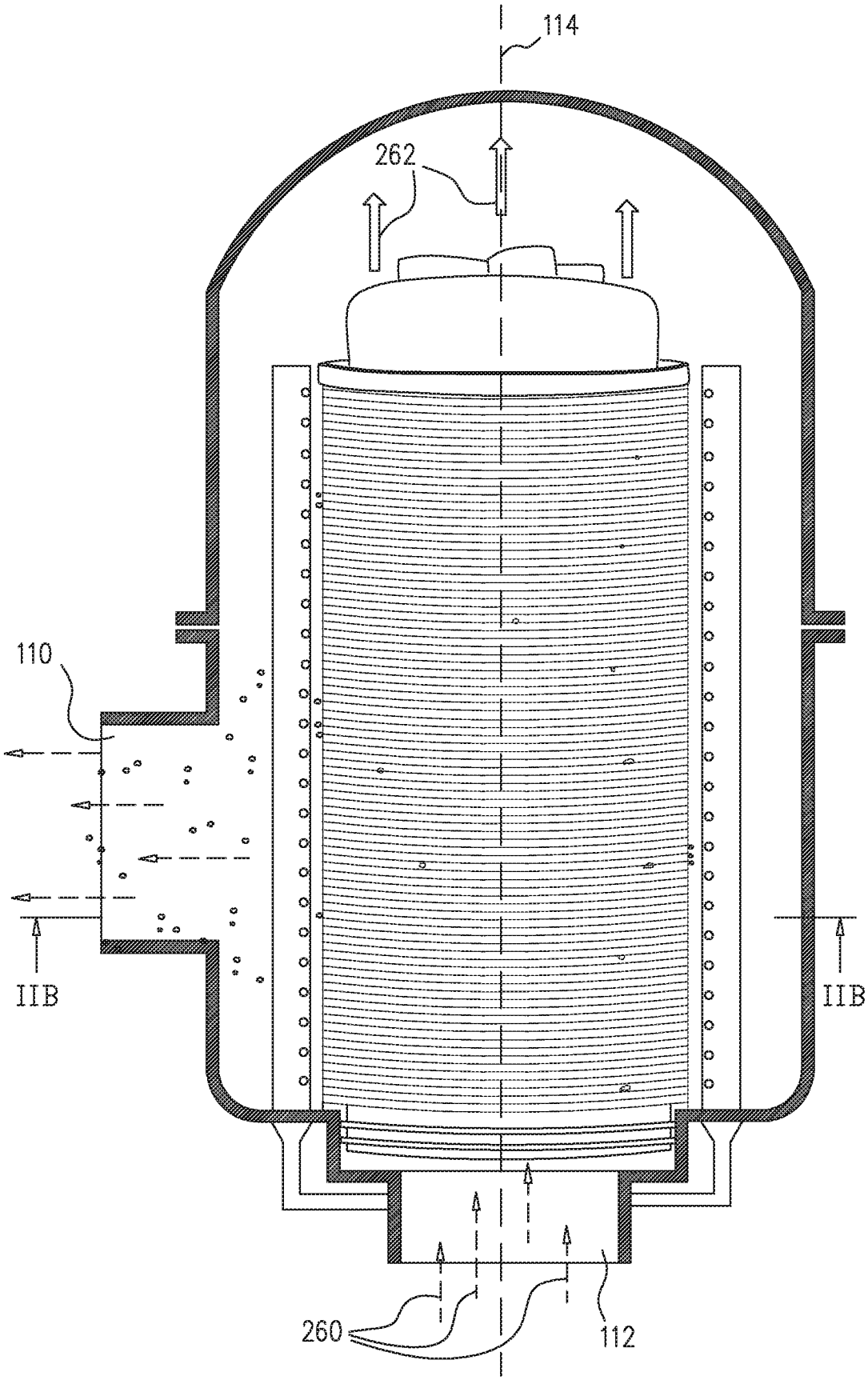

FIG. 2A

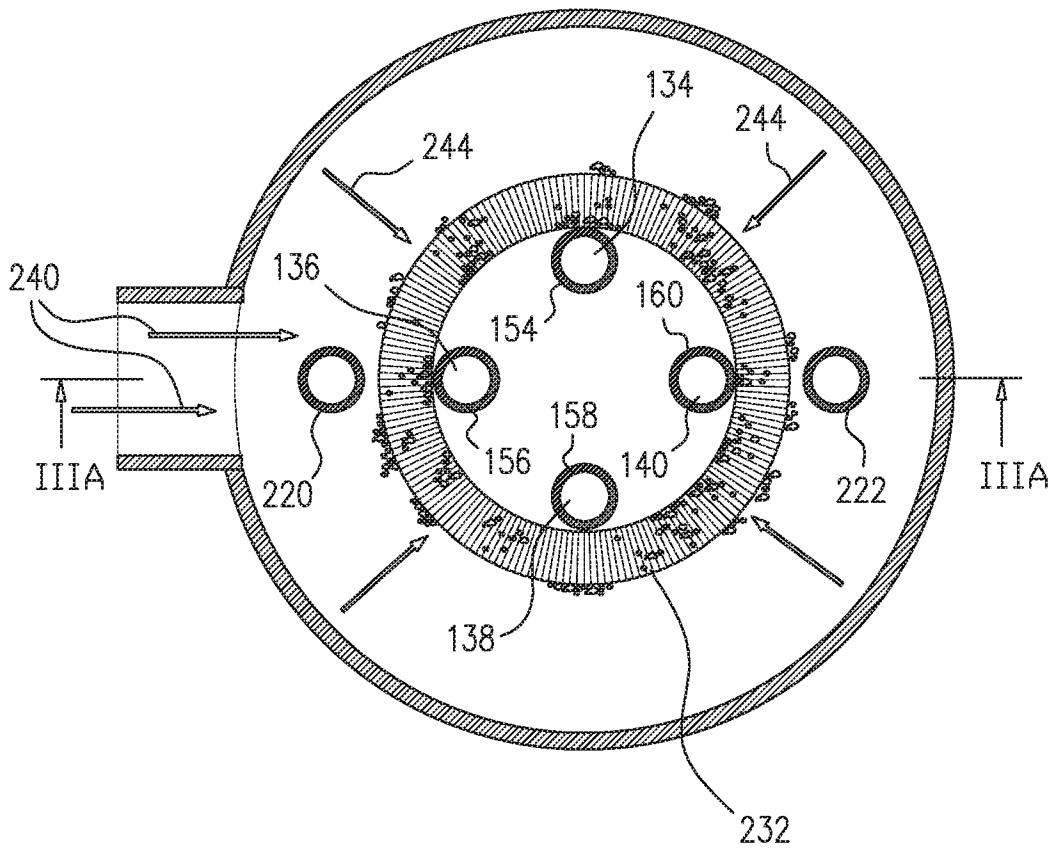
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FIG. 2B

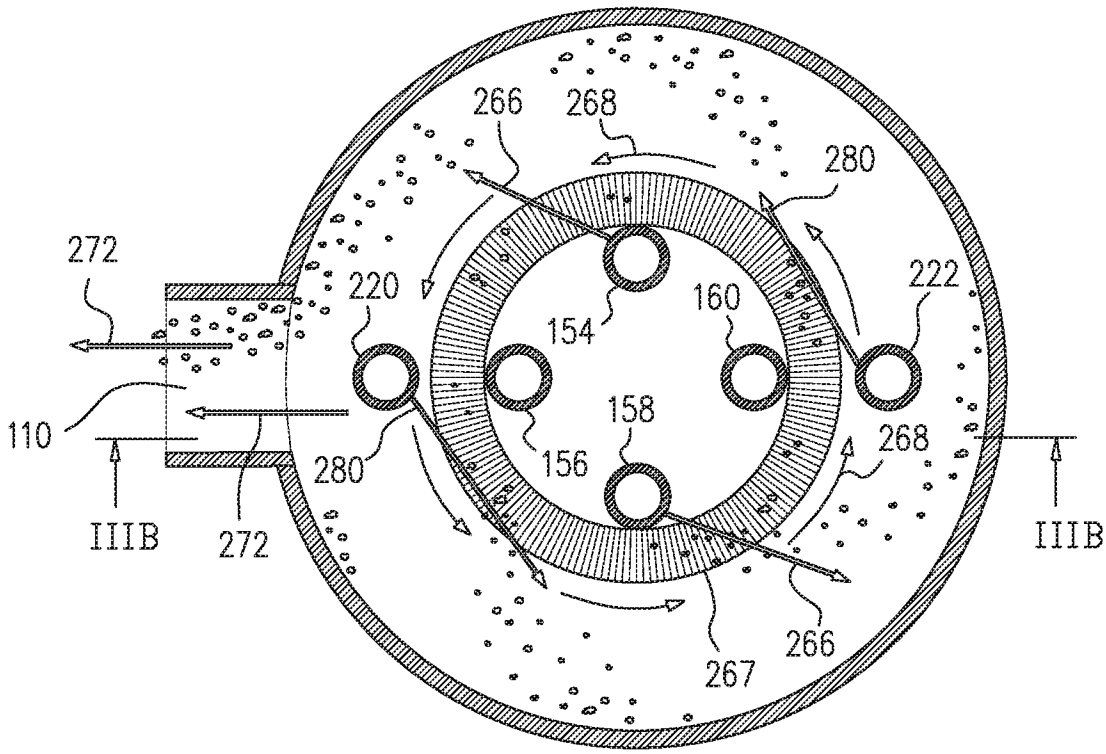
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FIG. 3A

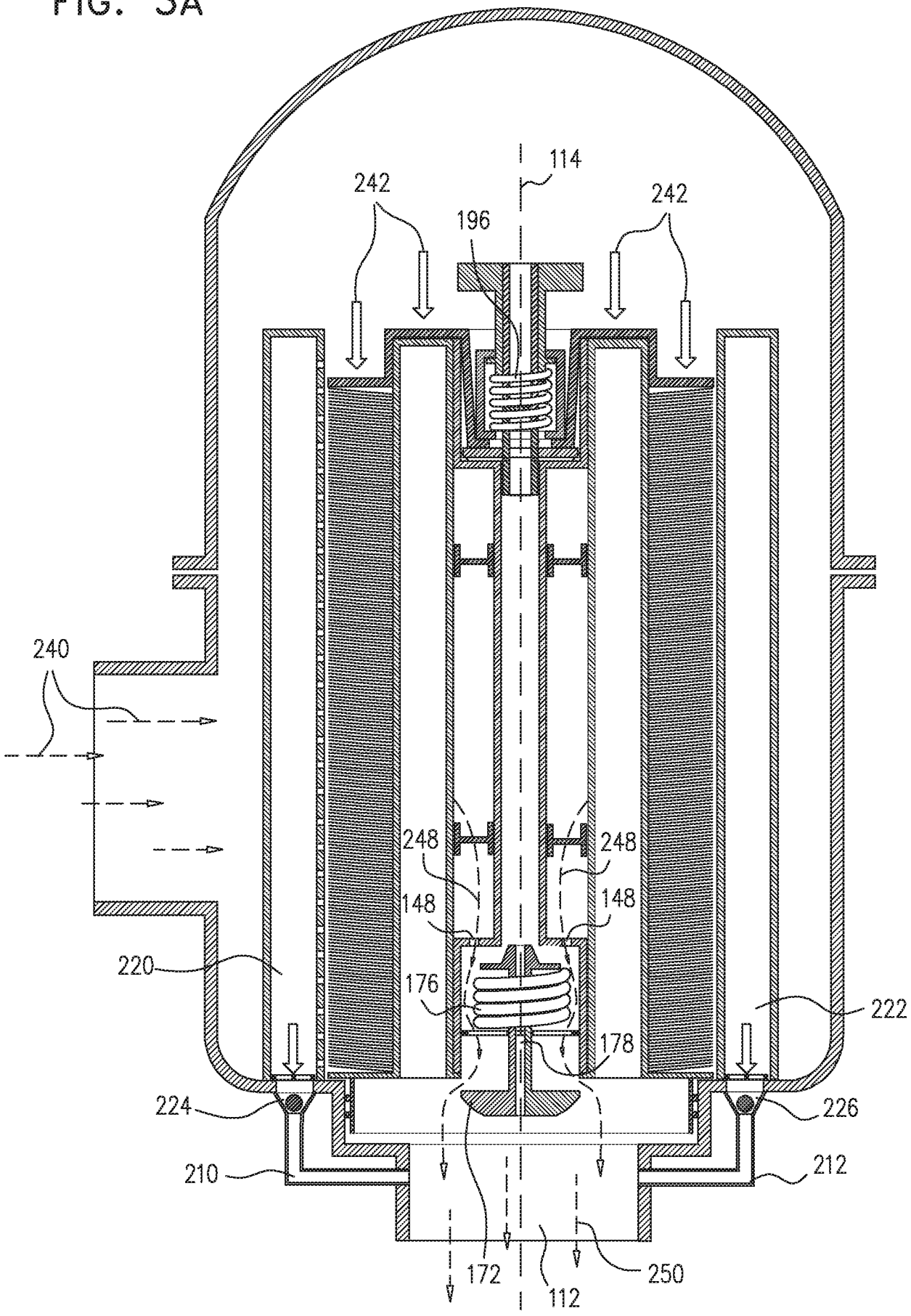
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FIG. 3B

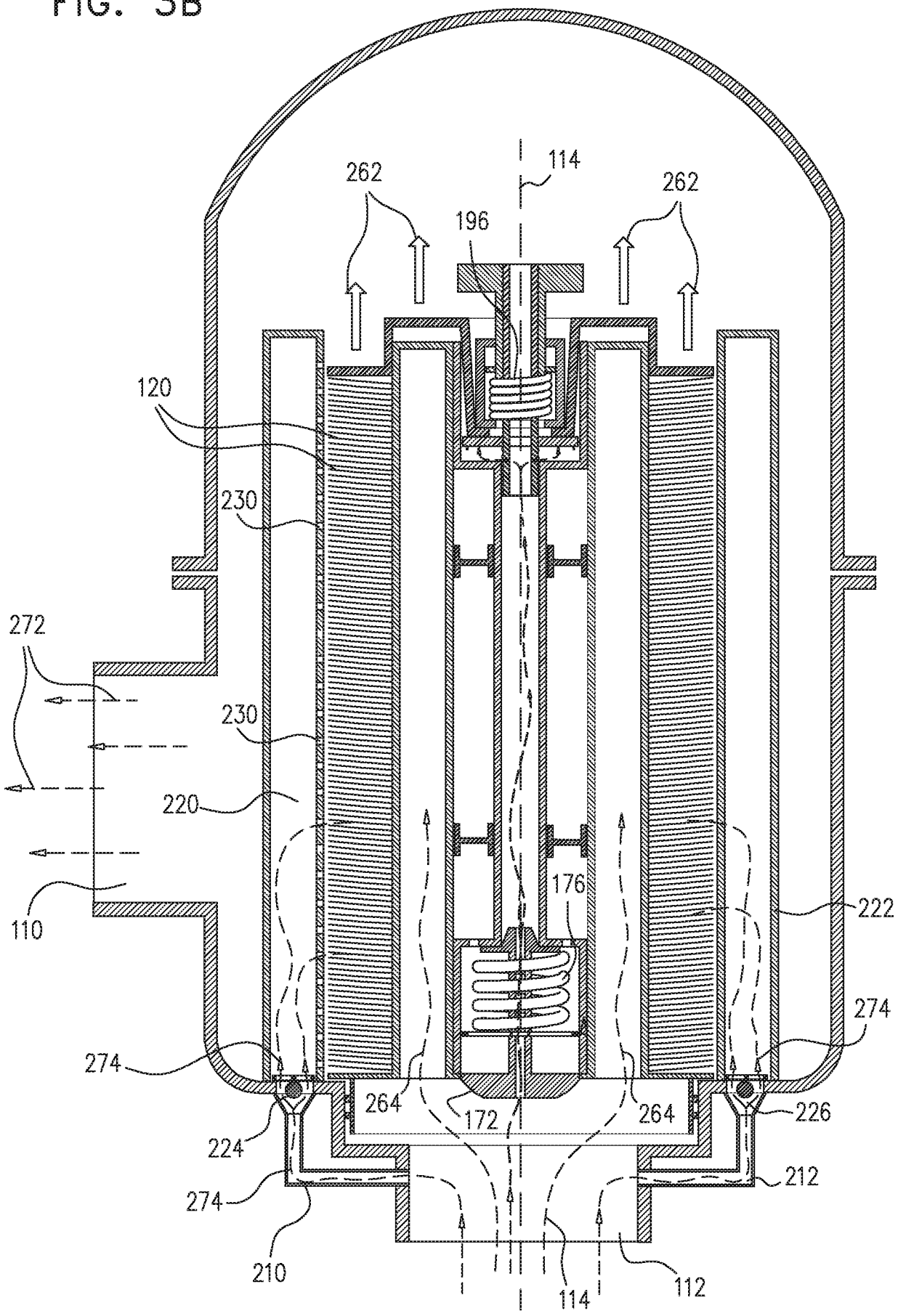
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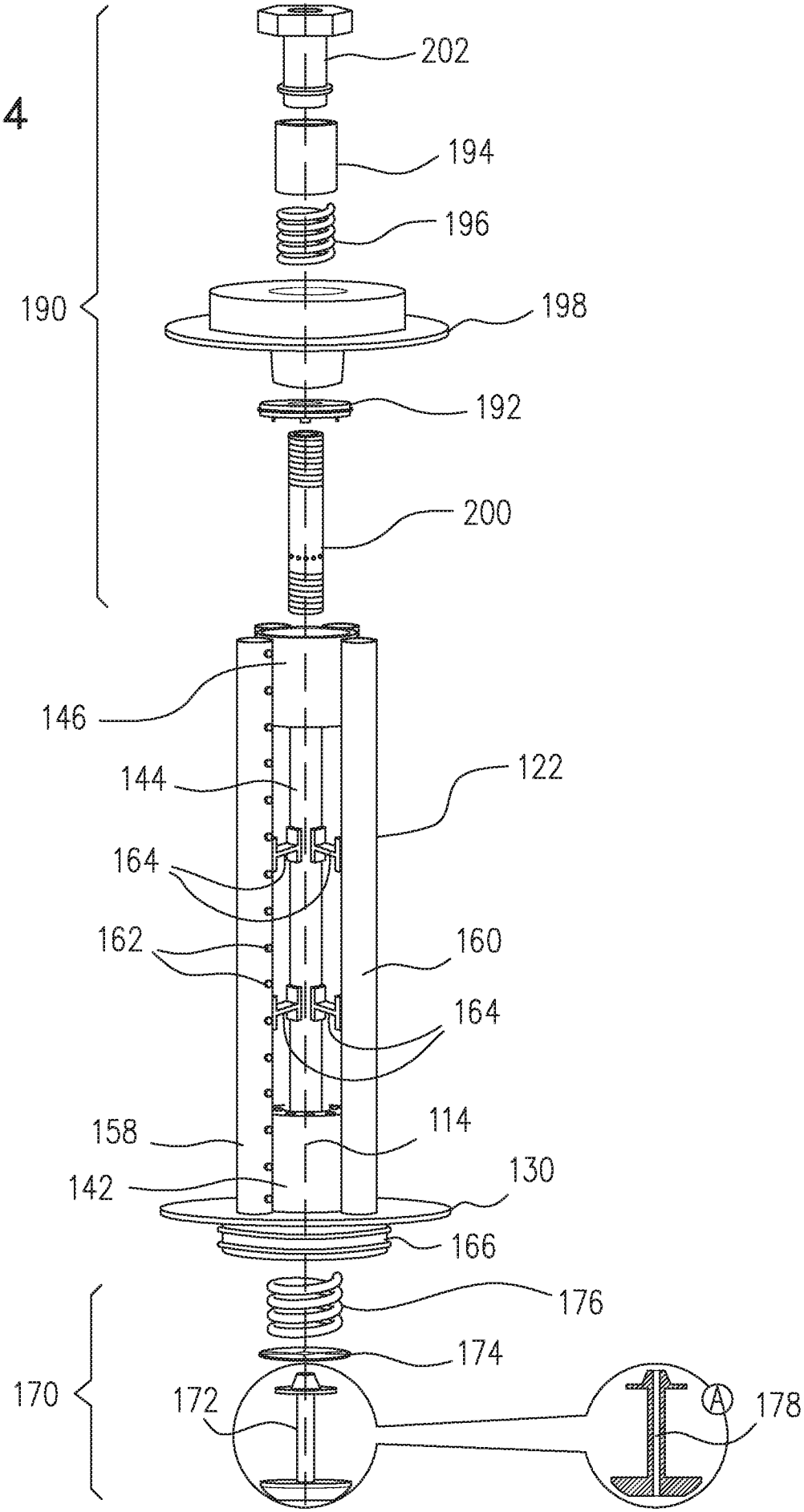
FIG. 4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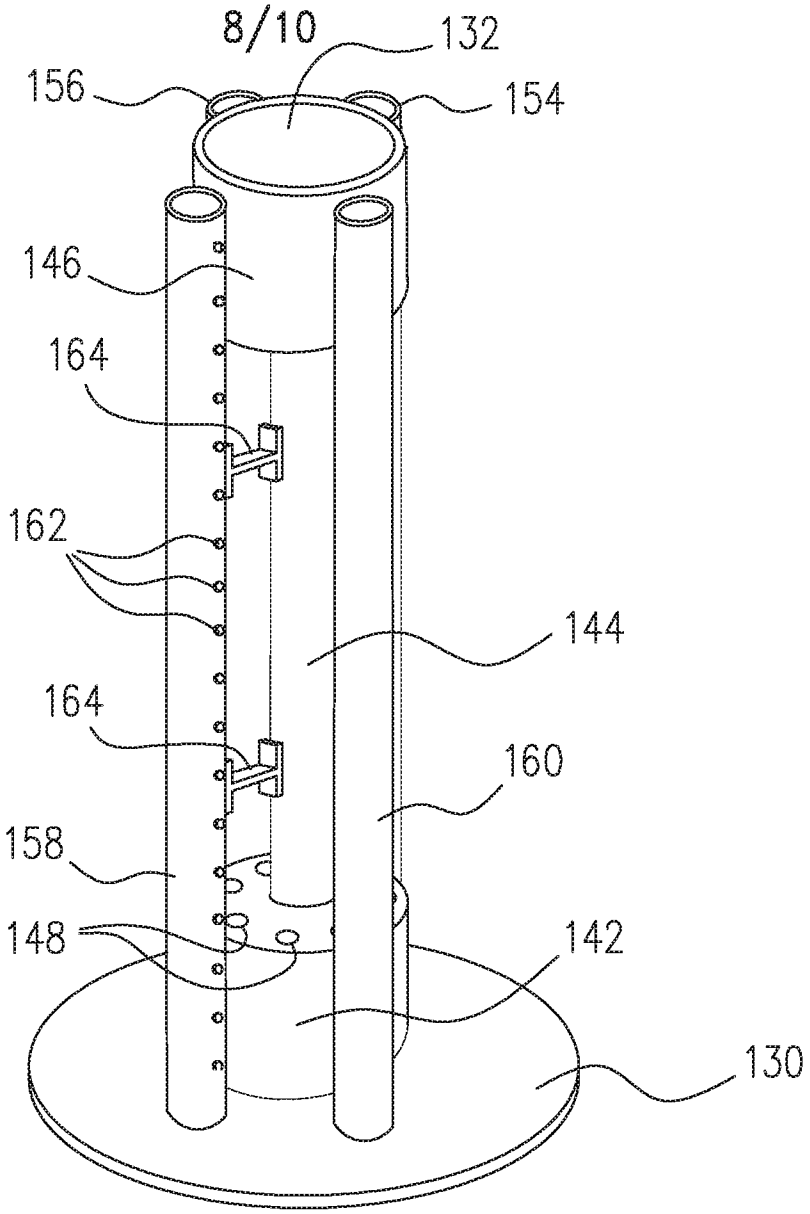
130
166
176
174
170
172
A
178

FIG. 5A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156
154
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164
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144
164
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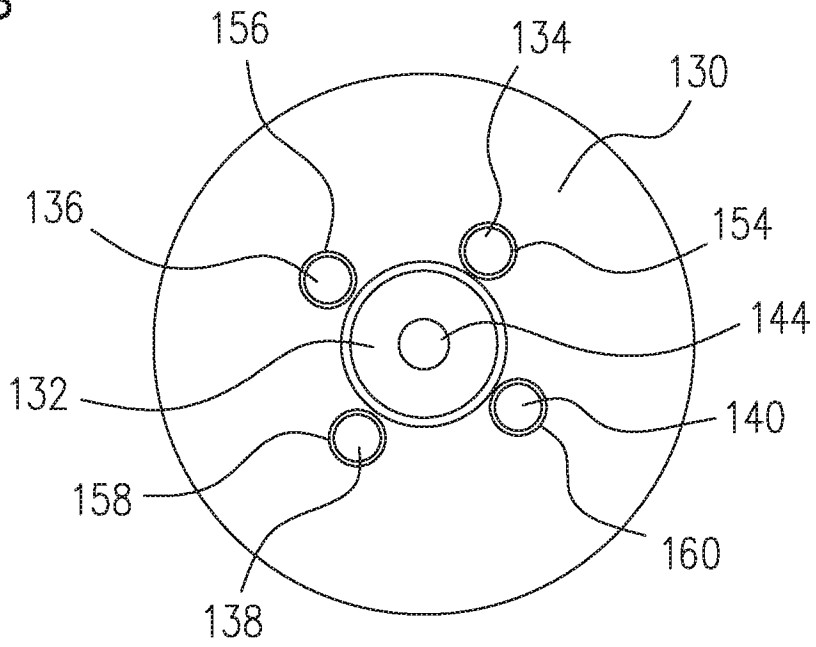
148
142
130

FIG. 5B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134
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140
158
160
138

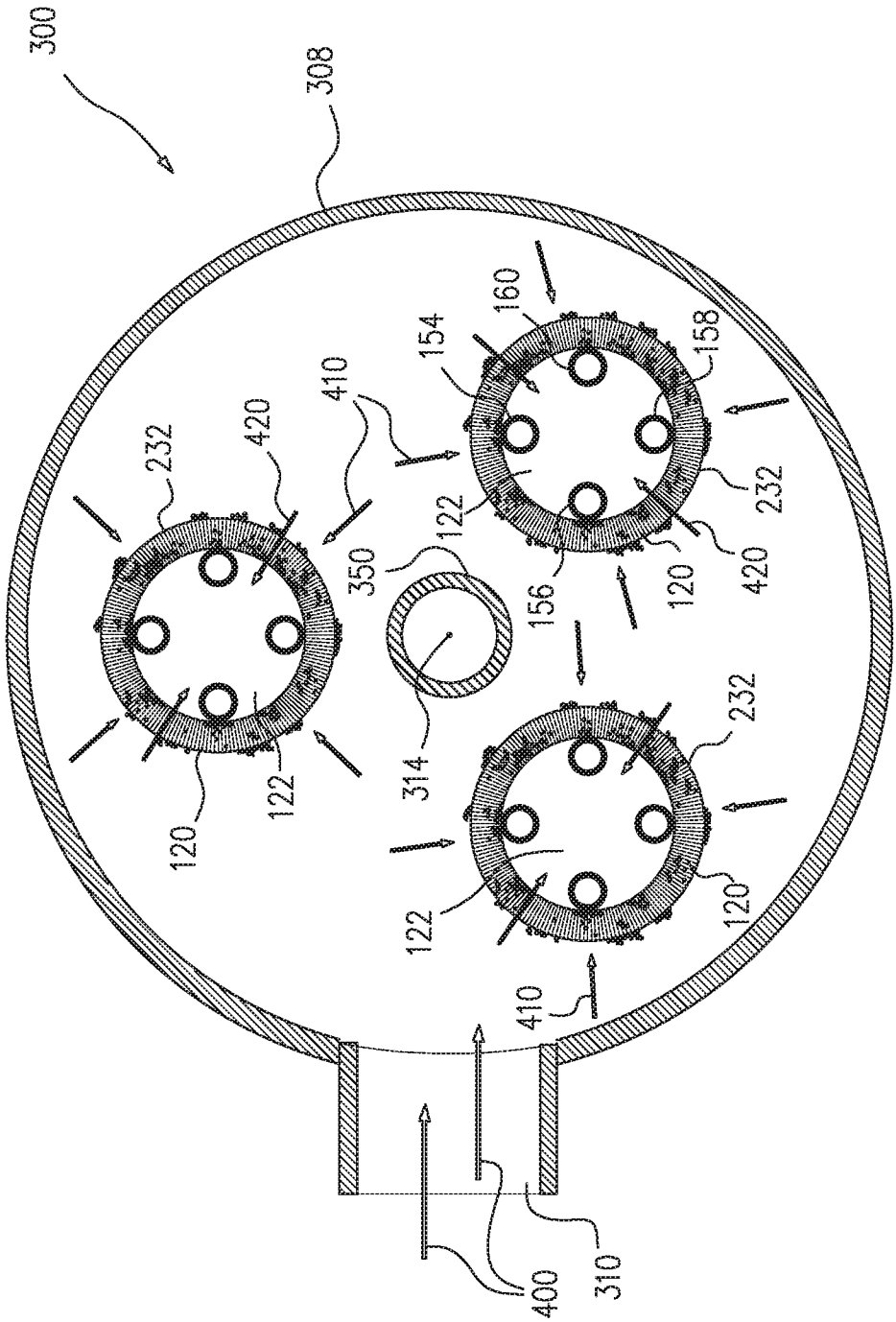
300
308
160
154
158
410
420
232
122
350
156
120
314
232
122
120
410
400
310

FIG.6A

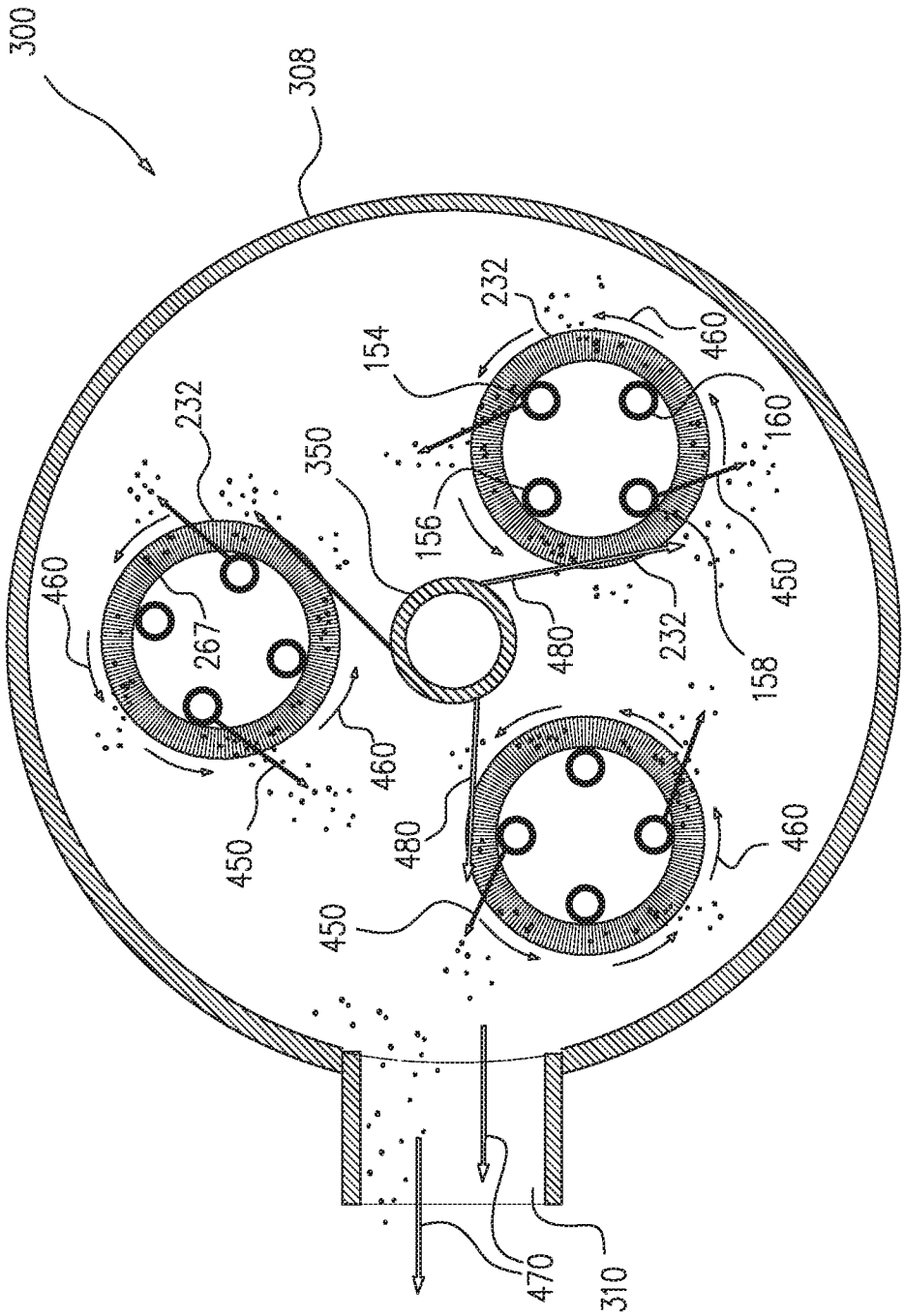
300
308
232
154
460
160
232
350
156
460
267
450
480
232
158
460
450
480
460
450
470
310

FIG.6B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL14/50954

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - B01D 29/39, 29/41, 29/68 (2015.01)
CPC - B01D 29/46, 2201/08, 2201/084
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): B01D29/01, 29/15, 29/39, 29/41, 29/46, 29/66, 29/68 (2015.01); CPC: B01D29/0011; B01D29/41; B01D29/46; B01D2201/08, 2201/081, 2201/084; B01D35/16; USPC: 210/329, 330, 332, 333.01, 352, 357, 411, 498

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)
PatSeer (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, INPADOC Data); Google; Google Scholar; ProQuest; IP.com; aperture, backflush, backwash, circumference, clean, conduit, disc, disk, edge, filter, header, hole, inject, inner, jet, leaves, manifold, nozzle, orifice, outer, pipe, radial, reverse, riser, slit, slot, spray, tangential, wash

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4,762,615 A (DRORI, M) 09 August 1988; figures 1, 1a-c, 2a; column 1, lines 26-34; column 2, lines 35-40; column 2, lines 47-50; column 3, lines 1-13; column 3, lines 30-35; column 3, lines 45-65; column 4, lines 9-20; column 4, lines 30-35; column 4, lines 45-50	1-6, 12-16
A	US 2010/0213109 A1 (BEN-HORIN, R) 26 August 2010; figures 9, 10; paragraphs [0029], [0054]-[0057]	7-11
A	US 2005/0178704 A1 (PROCHASKA, JF et al.) 18 August 2005; entire document	1-16
A	US 4,299,245 A (CLAPPER, MF) 10 November 1981; entire document	1-16
A	US 3,203,549 A (SCHAEDLER, J) 31 August 1965; entire document	1-16

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

* Special categories of cited documents:
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"E" earlier application or patent but published on or after the international filing date
"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
22 February 2015 (22.02.2015)	20 MAR 2015
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

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