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(54) **Title**: FLUID-DIRECTING MULTIPORT ROTARY APPARATUS

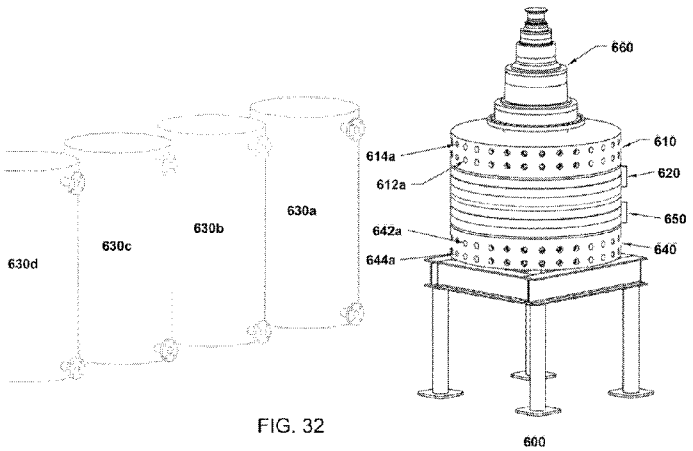


FIG. 32

(57) **Abstract**: Multiport rotary fluid-directing apparatuses are disclosed. An apparatus includes first and second stationary heads, first and second rotating heads, media vessels and a rotating system. The first stationary head has first ports configured to receive fluid from a fluid source and second ports configured to pass fluid to a media vessel. Each of the first and second rotating heads has multiple first and second ports and channels that fluidly connect corresponding first and second ports of the corresponding rotating head. The second stationary head has first ports configured to pass fluid to an output and second ports configured to receive fluid from a media vessel. The media vessels are configured to receive fluid from a second port of a first stationary head and transmit fluid to a corresponding second port of a second stationary head. The rotating system is configured to cause the first and second rotating heads to rotate.

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A. TITLE: FLUID-DIRECTING MULTIPORT ROTARY APPARATUS

B. CLAIM OF PRIORITY TO RELATED APPLICATIONS

[0001] This application claims priority to United States Provisional Application Serial No. 61/389,510 entitled "Fluid-Directing Multiport Rotary Apparatus" and filed October 4, 2010, which is incorporated herein by reference in its entirety.

C-E. Not Applicable

F. BACKGROUND

[0002] The present disclosure generally relates to a multiport rotary apparatus for directing multiple fluid streams. In particular, the present disclosure relates to an improved multiport rotary apparatus for simultaneously directing a plurality of fluid streams into and out of a fluid-solid contacting apparatus employed for treatment of a multi-component fluid mixture for purification, recovery, separation and synthesis.

[0003] Multiport rotary valves with turntables have been used for many years in continuous ion exchange and chromatographic separation applications. However, some users desired designs that imposed different space requirements and/or required fewer moving parts in order to achieve the ion exchange process.

[0004] Turntableless designs were developed to overcome the necessity of moving the fluid containers with which they were associated. In a turntableless design, the input and output streams are changed from process step to process step while the fluid containers remain stationary. Resulting turntableless designs do not require the additional mechanical moving parts associated with turntable designs and are not hampered by the stringent space requirements of turntable designs.

G. SUMMARY

[0005] This disclosure is not limited to the particular systems, devices and methods described, as these may vary. The terminology used in the description is for the purpose of describing the particular versions or embodiments only, and is not intended to limit the scope.

[0006] As used in this document, the singular forms "a," "an," and "the" include plural references unless the context clearly dictates otherwise. Unless defined otherwise, all technical and scientific terms used herein have the same meanings as commonly understood by one of ordinary skill in the art. Nothing in this disclosure is to be construed as an admission that the embodiments described in this disclosure are not entitled to antedate such disclosure by virtue of prior invention. As used in this document, the term "comprising" means "including, but not limited to."

[0007] The present invention provides a combined multi-port rotary valve for simultaneously directing a plurality of fluid streams sequentially into or out of a plurality of stationary fluid-solid contacting chambers employed for purifying and separating multi-component fluids while eliminating many of the disadvantages in the art. Less complex processes like SMB chromatography may employ one single multi port valve, but in practice, it is preferred to have two multiport rotary valves joined into one combined multiport rotary valve apparatus. While two valves can be configured physically independent of each other, they must rotate or index in synchronization with one another, which makes it preferable to integrate them together as a combined multiport rotary valve. It is also preferred to have more than two contacting chambers, for example.

[0008] It is an aspect of the present invention to provide a combined multiport rotary valve that eliminates rotating fluid-solid chambers on a turntable, which addresses the mechanical complexity, layout limitations and safety issues of a turntable in the prior art.

[0009] It is another aspect of the present invention to provide a combined multiport rotary valve that has the same configuration design in any process and many symmetrical components which allows for simplified inventory of multiport rotary valve parts and addresses the disadvantage of the process specific design of prior art.

[0010] It is still another aspect of the present invention to provide a combined multiport rotary valve with only two planar sealing surfaces, which eliminates the complex circular channel and annular sealing technology employed in prior art.

[0011] Another aspect of the present invention is to provide a simplified and accessible design that allows for visual inspection of a majority of the parts.

[0012] In an embodiment, a multiport rotary fluid-directing apparatus may include a first stationary head having a plurality of first ports and a plurality of second ports, wherein each first port of the first stationary head is configured to receive fluid from a fluid source, wherein each second port of the first stationary head is configured to pass fluid to a media vessel, a first rotating head having a plurality of first ports, a plurality of second ports and a plurality of channels, wherein each channel of the first rotating head fluidly connects a first port of the first rotating head to a corresponding second port of the first rotating head, a second rotating head having a plurality of first ports, a plurality of second ports and a plurality of channels, wherein each channel of the second rotating head fluidly connects a first port of the second rotating head to a corresponding second port of the second rotating head, a second stationary head having a plurality of first ports and a plurality of second ports, wherein each first port of the second stationary head is configured to pass fluid to an output,

wherein each second port of the second stationary head is configured to receive fluid from a media vessel, a plurality of media vessels configured to receive fluid from a second port of a first stationary head and transmit fluid to a corresponding second port of a second stationary head, and a rotating system configured to cause the first rotating head and the second rotating head to rotate, wherein the rotating system comprises a motor and a controller.

H. BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG. 1 is a schematic drawing of a combined multiport rotary valve being used as a continuous contacting apparatus for fluid purification.

[0014] FIG. 2 is an exploded perspective of a combined multiport rotary valve in accordance with invention.

[0015] FIG. 2b is a continuation of the exploded perspective of a combined multiport rotary valve in accordance with invention.

[0016] FIG. 3 is an exploded cross sectional view of the combined multiport rotary valve from FIG. 2.

[0017] FIG. 4 is a top plan view of top end cap **210** of FIG. 3.

[0018] FIG. 5 is a side view of top end cap **210** of FIG. 3.

[0019] FIG. 6 is a top plan view of the pressure plate **220** of FIG. 3.

[0020] FIG. 7 is a side view of the pressure plate **220** of FIG. 3.

[0021] FIG. 8 is a bottom plan view of the pressure plate **220** of FIG. 3.

[0022] FIG. 9 is a top plan view of the top stationary head **230** of FIG. 3.

[0023] FIG. 10 is a side view of the top stationary head **230** of FIG. 3.

[0024] FIG. 11 is a bottom plan view of the top stationary head **230** of FIG. 3.

[0025] FIG. 12 is a top plan view of the top rotating head **240** of FIG. 3.

[0026] FIG. 13 is a side view of the top rotating head **240** of FIG. 3.

[0027] FIG. 14 is a bottom plan view of the top rotating head **240** of FIG. 3.

[0028] FIG. 15 is a top plan view of the sprocket gear **250** of FIG. 3.

[0029] FIG. 16 is a side view of the sprocket gear **250** of FIG. 3.

[0030] FIG. 17 is a bottom plan view of the sprocket gear **250** of FIG. 3.

[0031] FIG. 18 is a top plan view of the bottom rotating head **260** of FIG. 3.

[0032] FIG. 19 is a side view of the bottom rotating head **260** of FIG. 3.

[0033] FIG. 20 is a bottom plan view of the bottom rotating head **260** of FIG. 3.

[0034] FIG. 21 is a top plan view of the bottom stationary head **270** of FIG. 3.

[0035] FIG. 22 is a side view of the bottom stationary head **270** of FIG. 3.

[0036] FIG. 23 is a bottom plan view of the bottom stationary head **270** of FIG. 3.

[0037] FIG. 24 is a top plan view of bottom end cap **280** of FIG. 3.

[0038] FIG. 25 is a side view of bottom end cap **280** of FIG. 3.

[0039] FIG. 26 is a side view of the multiport rotary valve stand **290** of FIG. 3.

[0040] FIG. 27 is a bottom plan view of stationary head **230** of FIG. 11 with simplified overlay of rotating head internal transverse conduits **238** from FIG. 12 before one index.

[0041] FIG. 28 is a bottom plan view of stationary head **230** of FIG. 11 with simplified overlay, of rotating head internal transverse conduits **238** from FIG. 12 after one index.

[0042] FIG. 29 is a perspective view of an alternative stand, housing and drive of multiport rotary valve **200** from FIG. 3.

[0043] FIGS. 30A-D depict a graphical representation of an exemplary 20-port valve as it is rotated through a plurality of positions according to an embodiment.

[0044] FIG. 31 depicts an exploded view of an exemplary 30-port rotating head assembly according to an embodiment.

[0045] FIG. 32 depicts an exemplary multiport apparatus for directing fluid according to an embodiment.

[0046] FIG. 33 depicts a block diagram of exemplary internal hardware that may be used to contain or implement program instructions according to an embodiment.

I. DETAILED DESCRIPTION

[0047] The following terms shall have, for the purposes of this application, the respective meanings set forth below.

[0048] Referring to FIG. 1, invention **200** is shown in a schematic with a plurality of fluid contacting chambers **1-8**. Chambers **1-8** have a first connection **1a-8a** that connects by conduits **120** to multiport valve **200** at ports labeled **21-28**. The same chambers **1-8** have a second connection **1b-8b** that connect by conduits **140** to multiport valve **200** at ports labeled **41-48**. Process streams A-H connect by conduits **110** with multiport valve **200** through ports **11-18** and are in connection with chamber connections **21-28** by internal conduits **226**, **238** and **227**. Process streams A'-H' connect by conduits **130** to the same multiport valve **200** through ports **31-38** and are in connection with chamber connections **41-48** by internal conduits **276**, **258** and **277**. For the sake of clarity, labels **226** and **227** refer to all similar internal conduits on stationary head **230** while labels **276** and **277** refer to all similar internal conduits on stationary head **270**. Labels **238** and **258** refer to all internal transverse channels in rotating heads **240** and **260** respectively and are rotatable in relation to the process

connections **11-18**, **31-38** and the chamber connections **21-28**, **41-48** thereby allowing a simulated movement of chambers **1-8** to the process streams A-H and A'-H'. Note that the number of contacting chambers is merely an example and the actual number of chambers utilized can be of any number greater than two. Correspondingly, the number of inlets, outlets, conduits, ports and so on would be adjusted accordingly.

[0049] The present embodiment of the combined multiport rotary valve **200** of the invention is shown and described in conjunction with fluid solid contacting chambers containing a treatment media wherein a contaminated feed stream is continually treated by the media while at the same time the exhausted media is continually regenerated and put back into service. Using water softening ion exchange as an example, each chamber will contain the same typical strong acid cation resin. The four required steps in a water softening application are described as "Service", "Backwash", "Chemical" and "Rinse". "Service" is the treatment of the incoming water with the cation resin until the resin capacity is exhausted, "Backwash" is the removal of particulates from the resin, "Chemical" is the process of reverse ion exchange where salt is used to put the resin back into a usable form, "Rinse" is the process of removing excess salt from and around the resin prior to placing it back into "Service". In a batch operation like a domestic water softener these four steps are preformed sequentially after the batch system is taken out of operation. In a continuous system like the one described here all four steps occur at the same time since at least one chamber is in each step at each instant, allowing for continuous operation. In the water softening example with this invention, streams A-E will be the incoming contaminated or hard water and are in "Service" and are being treated by the resin in chambers **1-5**. Water for treatment would enter stationary head **230** of multiport rotary valve **200** by conduit **111-115** at port connections **11-15**. Streams A-E proceed by internal conduits **226** to rotary head **240** and are redirected by internal transverse conduits **238** back to stationary head **230** and by internal conduits **227** to chamber connections **21-25**. Streams A-E then proceed by conduits 121-**125** to enter chambers **1-5** through connections **1a-5a**. Streams A-E contact the strong acid cation resin contained in chambers **1-5** and exchange hard ions in solution like calcium and magnesium for the soft ion sodium on the resin. The calcium and magnesium are captured by the strong acid cation resin while an equivalent number of sodium ions are exchanged into the streams. Hard water streams A-E now become soft or treated water streams A'-E' and exit chambers **1-5** through connections **1b-5b** and connect by conduits **141-145** to the stationary head **270** at ports **41-45**. Streams A'-E' proceed by internal conduits **277** to rotating head **260** and are redirected by internal transverse conduits **258** back to the stationary head **270**.

Streams A'-E' now proceed by internal conduits **276** and exit at ports **31-35** to conduits **131-135** as treated soft water. Continuing with the softening example the other streams in total are generally called "regeneration" and include streams F, G, H, F', G' and H'. The steps will be described in reverse order since the resin in the chambers will move counter-currently to the streams. Stream H' by conduit **138** directs untreated water into multiport valve **200** at port **38** in stationary head **270**. Stream H' proceeds by an internal conduit **276** to rotating head **260** and is redirected by an internal transverse conduit **258** back to stationary head **270** and proceeds by an internal conduit **277** to exit at port **48**. Stream H' proceeds by conduit **148** to chamber **8** through connection **8b**. Stream H' proceeds in an upward direction through the resin contained in chamber **8** and serves as a backwash stream to remove any entrained particulates or broken resin beads and proceeds out of chamber **8** through connection **8a** as stream H. Stream H proceeds by conduit **128** to stationary head **230** of multiport valve **200** through connection **28** and proceeds by an internal conduit **227** to rotary head **240** and is redirected by an internal transverse conduit **238** back to stationary head **230**. Stream H proceeds by an internal conduit **226** to exit multiport valve **200** through port **18** where Backwash waste stream H is directed to waste by conduit **118**. Stream G is the "Chemical" step and directs a salt (NaCl) solution by conduit **117** into multiport valve **200** through port **17** in stationary head **230**. Stream G proceeds by an internal conduit **226** to rotating head **240** and is redirected by an internal transverse conduit **238** back to stationary head **230** and proceeds by an internal conduit **227** to exit through port 27. Salt stream G then proceeds by conduit **127** to chamber **7** through connection **7a**. Stream G proceeds in a downward direction through the resin contained in chamber **7** and serves as a regeneration stream to exchange soft monovalent ions (Na+) in solution for hard divalent ions (Ca++ and Mg++) captured on the resin. The strong acid cation resin generally prefers divalent ions over monovalent ions in low concentrations as in the untreated water. However, a high concentration of monovalent sodium ions in the salt stream will overwhelm and displace the divalent ions and put the resin back in the monovalent sodium form and is called regeneration. Stream G proceeds out of chamber **7** through connection **7b** as stream G'. Stream G' proceeds by conduit **147** to stationary head **270** of multiport valve **200** through port **47** and proceeds by an internal conduit **277** to rotary head **260** and is redirected by an internal transverse conduit **258** back to stationary head **270**. Stream G' then proceeds by an internal conduit **276** to exit multiport valve at port **37** as regeneration waste stream G' which is directed to waste by conduit **137**. Stream F is water used for rinse and proceeds by conduit **116** to enter multiport valve **200** through port 16 in stationary head **230** and proceeds by an

internal conduit **226** to rotating head **240** and is redirected by an internal transverse conduit **238** back to stationary head **230**. Stream F then proceeds by an internal conduit **227** to exit through port **26** and proceed by conduit **126** to chamber 6 through connection **6a**. Stream F proceeds in a downward direction through the resin contained in chamber 6 and serves as a rinse stream to displace the excess NaCl in the chamber. Stream F proceeds out of chamber **6** through connection **6b** as stream F' and connects by conduit **146** to stationary head **270** of multiport valve **200** at port **46**. Stream F proceeds by an internal conduit **277** to rotary head **260** and is redirected by an internal transverse conduit **258** back to stationary head **270** and proceeds by an internal conduit **276** to exit the multiport valve through port **36** as rinse waste stream F', which is directed to waste by conduit **136**.

[0050] The rotating heads **240** and **260** of multiport rotary valve **200** remain in the same position and maintain the current flow path by internal transverse conduits **238** and **258** until an end point time when substantially all monovalent sodium ions on the strong acid cation resin in chamber **1** have been exchanged for divalent ions calcium and magnesium in Stream A. This end point time can be determined empirically by sensor, or estimated by time based on resin capacity, feed service flow rate and ion load in the feed. When the end point is reached and capacity for divalent ions in chamber **1** is exhausted, the rotating heads **240** and **260** are indexed clockwise, looking from top down, one position. This index essentially moves by internal transverse conduits **238** and **258**, chamber **1** from "Service" and places it into the first regeneration step called "Backwash" which chamber **8** previously held. At this same time, chambers **2-8** also move one position in the sequence so that chamber **2** is now in the lead "Service" position which chamber **1** previously held, chambers **3-5** moved one position, but remain in "Service", chamber **6** is brought into the last "Service" position which chamber **5** previously held, chamber **7** is moved into a "Rinse" position that chamber 6 previously held and chamber **8** moves to the "Chemical" position that chamber **7** previously held. In this way, the resin in each chamber is being moved counter-currently to the incoming streams. As the resin is exhausted it is moved out of the service cycle, into the regeneration cycle and back finally back into "Service" by successive indexing of the rotating heads.

[0051] After one index of the rotating heads **240** and **260** as described in the previous paragraph, the flow paths are modified as follows:

[0052] Streams A-E continue as incoming hard water for treatment and are in "Service" and enter the stationary head **230** of multiport rotary valve **200** by conduits **111-115** at port connections **11-15**. Streams A-E proceed by internal conduits **226** to rotary head

240 and are redirected by internal transverse conduits **238** back to stationary head **230** and by internal conduits **227** to chamber ports **22-26**. Streams A-E then proceed by conduit 122-126 to enter chambers **2-6** through connections **2a-6a**. Hard water streams A-E contact the strong acid cation resin contained in chambers **2-6** become soft or treated water streams A'-E' and exit chambers **2-6** through connections **2b-6b** and connect by conduits **142-146** to the stationary head **270** at ports **42-46**. Streams A'-E' proceed by internal conduits **277** to rotating head **260** and are redirected by internal transverse conduits **258** back to the stationary head **270**. Streams A'-E' now proceed by internal conduits **276** and exit at ports **32-36** to conduits **132-136** as treated soft water.

[0053] Stream H' by conduit **138** directs untreated water into multiport valve **200** at port **38** in stationary head **270**. Stream H' proceeds by an internal conduit **276** to rotating head **260** and is redirected by an internal transverse conduit **258** back to stationary head **270** and proceeds by an internal conduit **277** to exit at port **41**. Stream H' proceeds by conduit **141** to chamber **1** through connection **1b**. Stream H' proceeds in an upward direction through the resin contained in chamber **1** and proceeds out of chamber **1** through connection **1a** as stream H. Stream H proceeds by conduit **121** to stationary head **230** of multiport valve **200** through port **21** and proceeds by an internal conduit **227** to rotary head **240** and is redirected by an internal transverse conduit **238** back to stationary head **230**. Stream H proceeds by an internal conduit **226** to exit multiport valve **200** through port **18** where Backwash waste stream H is directed to waste by conduit 118.

[0054] Stream G directs a salt (NaCl) solution by conduit **117** into multiport valve **200** through port **17** in stationary head **230**. Stream G proceeds by an internal conduit **226** to rotating head **240** and is redirected by an internal transverse conduit **238** back to stationary head **230** and proceeds by an internal conduit **227** to exit through port **28**. Stream G then proceeds by conduit **128** to chamber **8** through connection **8a**. Stream G proceeds in an downward direction through the resin contained in chamber **8** and proceeds out of chamber **8** through connection **8b** as stream G'. Stream G' proceeds by conduit **148** to stationary head **270** of multiport valve **200** through port **48** and proceeds by an internal conduit **277** to rotary head **260** and is redirected by an internal transverse conduit **258** back to stationary head **270**. Stream G' then proceeds by an internal conduit **276** to exit the multiport valve at port **37** as regeneration waste stream G' which is directed to waste by conduit **137**.

[0055] Stream F is treated water used for rinse and proceeds by conduit **116** to enter multiport valve **200** through port **16** in stationary head **230** and proceeds by an internal conduit **226** to rotating head **240** and is redirected by an internal transverse conduit **238** back

to stationary head **230**. Stream F then proceeds by an internal conduit **227** to exit through port **27** and proceed by conduit **127** to chamber **7** through connection **7a**. Stream F proceeds in a downward direction through the resin contained in chamber **7** and proceeds out of chamber **7** through connection **7b** as stream F' and connects by conduit **147** to stationary head **270** of multiport valve **200** at port **47**. Stream F proceeds by an internal conduit **277** to rotary head **260** and is redirected by an internal transverse conduit **258** back to stationary head **270** and proceeds by an internal conduit **276** to exit multiport valve through port **36** as rinse waste stream F", which is directed to waste by conduit **136**.

[0056] The rotating heads **240** and **260** of multiport rotary valve **200** remain in the same position and maintain the current flow path by internal transverse conduits **238** and **258** until an end point time. When the end point is reached and capacity for divalent ions in chamber **2** is exhausted, the rotating heads **240** and **260** are again indexed clockwise one position. This index essentially moves by internal transverse conduits **238** and **258**, chamber **2** from "Service" and places it into the first regeneration step called "Backwash" which chamber **1** previously held. The remaining chambers also move one position in the sequence. At every index, the chambers essentially move one position forward in the sequence and complete a full cycle 2x in every 360-degree rotation of the rotating heads **240** and **260**. In this manner, the use of a turntable in the prior art has been eliminated.

[0057] According to the present embodiment, the invention **200** retains complete flexibility in assigning the inlet and outlet ports **11-18** and **31-38** to any desired fluid stream and direction and combination therefore eliminating the fixed configuration issues with prior art valves. Treatment of fluid streams, gas or liquid, in the fluid solid contacting apparatus chambers could, for example, be accomplished by any such media, chemical reactant or physical process like ion exchange, chromatography, adsorption, reaction, catalysis, filtration or heat exchange and is solely determined by the media choice and by fixed conduits exterior to the multiport rotary valve and not by the valve itself, such that multiport rotary valve **200** provides an efficient and continuous means of contacting the media or reactant in the chamber with the various fluid streams.

[0058] FIG. 2 shows an exploded perspective of the combined multiport rotary valve of the present invention. Rotary valve **200** comprises two major assemblies, upper multiport rotary valve **215** and lower multiport rotary valve **285**; all are of circular shape having substantially equal diameter and each having opposed planar sealing surfaces. The present embodiment of this invention utilizes a keyed and threaded central shaft **205** for assembling the entire rotary valve apparatus and for providing a mechanical means to force a

seal of the stationary head **230** to the rotating head **240** and rotating head **260** to stationary head **270**. Other means to force the seal of the stationary and rotating heads by means like pneumatic bladder or hydraulic cylinder in combination with internal seals would also be suitable.

[0059] The stationary head assemblies **230**, **270** are held fixed from rotating by pressure plate **220** and end cap **280** and are forced against the rotating head assemblies **240**, **260** by mechanical means from pressure plate **220** while constrained by central shaft **205**, nut **202** and end cap **210** and stand **290** from FIG. 2b.

[0060] Top stationary head **230** has ports **11-18** for the connection of process inlets and outlets and ports **21-28** for one connection to each fluid solid contacting chamber and has internal conduits in the head for the communication of these ports to a planar face in sealing contact with the top rotating head **240**.

[0061] Top rotating head **240** is in sealing contact with top stationary head **230** and accepts all fluid flows from top stationary head **230** through holes **241a-248a** and **241b-248b** and redirects the flows by internal transverse conduits connecting these holes back to the same top stationary head **230**.

[0062] Sprocket gear **250** is provided for the purpose of moving the two rotating heads **240**, **260** by means of external drive motor **292** and drive chain **291**.

[0063] Bottom rotating head **260** is in sealing contact with bottom stationary head **270** and accepts all fluid flows from the bottom stationary head **270** and redirects the flows by internal transverse conduits back to the same bottom stationary head **270**. Rotating head **260** has proximity targets **293** for position indication by proximity sensor **294** to properly align the rotating heads **240**, **260** with their respective stationary heads **230**, **270**.

[0064] Bottom stationary head **270** has ports 31-**38** for the connection of process inlets and outlets and ports **41-48** for one connection to each fluid solid contacting chambers **1-8** and internal conduits in the head for the communication of these ports to recessed arcuate obround windows **272** and **273** on a planar face in sealing contact with the bottom rotating head **270**.

[0065] Bottom end cap **280** provides an opposing surface for the assembly and urging of the heads **230**, **240**, **250**, **260** and **270** together.

[0066] A drive chain **291** and drive motor **292** indexes the rotating heads upon a signal from a control device (not shown, well known in the art) like a total flow indicator, timer, PLC, DCS or PC system programmed to initiate an index at a selected end point. The drive motor **292** and chain **291** drive the sprocket gear **250** which moves the rotating heads

240, **260** clockwise from a top vantage point until the next target **293** activates the proximity sensor which in turn stops rotation. The drive motor, chain and sprocket gear could be replaced with any such suitable method for moving or indexing the rotating heads like drive shaft, direct gear contact, drive belt or ratchet arrangement.

[0067] Stationary heads **230**, **270** are preferably made of a polymeric material or composite material that is strongly resistant to abrasion and chemically compatible with the components of the fluid mixture. Rotating heads **240**, **260** are preferably made of a machinable metal or of a machinable metal face in conjunction with composite polymeric disks that are all compatible with the components of the fluid mixture to be separated. Alternatively, stationary heads **230**, **270** may be made of a machinable metal while the rotating heads may be made of a machinable polymeric or composite all of which are compatible with the components of the fluid mixture to be separated. To simplify construction, the stationary or rotating heads can be made from multiple plates or disks so that the internal conduits are easily routed into the plates and attached or fastened together into a composite head assembly. The rotating and stationary heads are made from materials that are compatible with the components of the fluid mixture to be separated and may be ceramics, composites, polymeric materials, metals, metal alloys and high-performance alloys.

[0068] Valve **200** provides for two rotating heads **240**, **260** and two stationary heads **230**, **270** with only one planar sealing surface between each valve assembly **215**, **285** which greatly simplifies the sealing complexities of prior art turntable-less valve designs.

[0069] FIG. 2b shows the multiport rotary valve stand **290** supports the bottom end cap **280** and valve apparatus **200** and fixes the central shaft **205** at the vertical axis **204**. Bottom end cap **280** can be fixed by any suitable method to the stand **290**.

[0070] FIG. 3 shows an exploded cross sectional view of multiport rotary valve **200** from FIG. 2 and clearly shows a flow path by one internal conduit **226** from the top stationary head **230** through the internal transverse conduit **238**a of the top rotating head **240** redirected back to one internal conduit **227** of the top stationary head **230**. Similarly, one internal conduit flow path **276** in the bottom stationary head **270** enters internal transverse conduit **258**a in the bottom rotating head **260** and is redirected back to one internal conduit **277** of the bottom stationary head **270**. The cross sectional view shows the internal conduits of the stationary heads and rotating heads connect at their respective planar sealing faces. It further shows as an example, the shortest internal transverse conduit length in the rotating heads **240** and **260**. For clarity, only one set of internal conduits in is shown in this drawing.

[0071] FIG. 4 and FIG. 5 show top planar and side views of the top end cap **210** preferably made of metal. Gussets **209** substantially strengthen the end plate **211** and locate the shaft tube **206** central to the end plate. The end cap **210** is held fixed from turning by key **208** which mates with the slotted central shaft **205**, FIG. 2. The end plate has holes **207** for threaded rods **219** and nuts **216** which constrain the springs **218**. While valve **200** uses a mechanically simple method of sealing force by a plurality of springs **218**, alternate means of providing a sealing force like hydraulic piston, pneumatic piston or Belleville washers are possible. The internal diameter of **206** is slightly larger than the threaded shaft **205** and essentially limits sideways movement of shaft **205** while surface **203** provides a flat for nut **202** to limit vertical movement of end cap **210**.

[0072] FIGS. 6, 7 and 8 show side and planar views of pressure plate **220** preferably made of metal and centrally located around shaft **205**. FIGS. 6 and 7 show, for example, four threaded rods **219**, each with an associated spring **218** and end stop 2**17**. The number and force of the springs are designed to provide adequate sealing pressure for the planar sealing faces of the stationary heads **230**, **270** and rotating heads **240**, **260** as shown in FIG. 3. FIG. 8 shows four, for example, keys **222** for the horizontal aligning and keeping of the top stationary head **230** of FIG. 3. These keys will prevent rotation of stationary head **230**, but allow for some vertical movement necessary for planar sealing with rotating head **240** of FIG. 3.

[0073] FIGS. 9, 10 and 11 show side and planar views of top stationary head **230**, which includes a planar disk **225**, made preferably from a polymeric material. The top face **229** of the top stationary head **230** has a sufficient number of machined in keyways **228** for centrally locating and fixing the head by keys **222** to pressure plate **220** shown in FIG. 8 around axis **204**. Internal conduits **226** and **227** are machined in the disk **225** and extend from a radially outward surface **221** of the disk to the planar disk valve face **231**. On the radially outer surface **221** the internal conduits **226** end in ports **11** through **18** and the internal conduits **227** end in ports **21** through **28**. The top ports **11** through **18** are for process fluid external conduits **111-118** and the bottom ports **21-28** are for fluid solid chamber external conduits **121-128** from FIG. 1. On the planar disk valve face **231**, internal conduits **226** end in recessed arcuate obround windows **222** and internal conduits **227** end in recessed arcuate obround windows **223**. The recessed arcuate obround windows **222** are spaced equidistant around the face and form an inner concentric circle **222i** aligned around central axis **204**. The recessed arcuate obround windows **223** are spaced equidistant around the face and form an outer concentric circle **223o** aligned around central axis **204**. The angular

lengths of the recessed arcuate obround windows **222** are equal and at least 2x the angular measurement of any of the equal matching holes **241a-248a** on the rotating head **240** of FIG. 12. The angular lengths of the recessed arcuate obround windows **223** are equal and at least 2x the angular measurement of any of the equal matching holes **241b-248b** on the rotating head **240** of FIG. 12. The angular length of the recessed arcuate obround windows **222** or **223**, allows for flow communication of each window with a matching hole **241a-248a** or **241b-248b** through 2 indexes of the rotating head **240** from FIG. 12. The depth of the recessed arcuate obround windows **222** and **223** is sufficient to allow proper full flow communication with the rotating head **240** of FIG. 3. Between the recessed arcuate obround windows **222** on the inner concentric circle **222i** are equal lands **232** that are equal to or preferably slightly less than equal to the angular measurement of holes **241a-248a** on the rotating head **240** of FIG. 12. Between the recessed arcuate obround windows **223** on the outer concentric circle **223o** are equal lands **232** that are equal to or preferably slightly less than equal to the angular measurement of holes **241b-248b** on the rotating head **240** of FIG. 12. The lands **232** formed on the inner concentric circle **222i** are equally offset in angular measurement either way from the lands **232** on the outer concentric circle **223o** so as to provide a staggered progression of flow communication between the stationary head **230** and the rotating head holes **241a-248a** and **241b-248b** upon each index of the rotating head **240** of FIG. 12.

[0074] Upon a complete reading of the detailed descriptions for the various figures, it will be appreciated that the recessed arcuate obround windows **222** and **223** and corresponding offset of the land **232** between the windows or holes on the inner and outer concentric circles **222i** and **223o** allows sequential and proper flow between the multiport valves and chambers without any cross contamination of the various fluid streams. A multiport valve formed solely with holes on both the stationary and rotating head sealing faces, without the recessed arcuate obround windows and offsets will function, but with a different sequence and a resultant cross contamination. It will also be appreciated that the recessed arcuate obround windows **222** and **223** and corresponding offset of the land **232** between the windows or holes on the inner and outer concentric circles can be moved from the stationary head **230** to the rotating head **240** in any combination. The recessed arcuate obround windows can be placed on one head, either the stationary **230** or the rotating **240**, while the land offset between windows or holes will also be placed on one head, either the stationary **230** or the rotating head **240**. Therefore, there are at least 4 combinations of recessed arcuate obround windows and land offset that allows for proper flow communication

between the stationary head **230** and rotating head **240**. It is critical to note that the top and bottom rotating heads **240** and **260** must move in concert so as to maintain the proper and complimentary flow paths.

[0075] FIGS. 12, 13 and 14 show side and planar views of top rotating head **240** which includes a planar disk **235** of the afore mentioned material, preferably with a metal planar face **239**. The bottom face **237** of the top rotating head **240** has a sufficient number of machined in keyways **236** for centrally locating and fixing the head by keys **254** to the sprocket plate **250** of FIG. 3 and FIG. 15 around axis **204**. The top planar disk face **239** has holes 241a-248a that are spaced equidistant and form an inner concentric circle **235i** and are in communication with recessed arcuate obround windows **222** in FIG. 11. The top planar disk face **239** has holes **241b-248b** that are spaced equidistant and form an outer concentric circle **235o** and are in communication with recessed arcuate obround windows **223** in FIG. 11. In this embodiment, the holes in the inner and outer concentric circles are sufficient for proper flow and are equal in diameter and are angularly equidistant apart and aligned radially in angular measurement. For this example, eight fluid solid chambers were used and therefore there are eight inner and eight outer holes, but any number of chambers and pairs of holes can be used equal to or greater than two. It is critical that numbering of the holes **241a-248a** on the inner concentric circle **235i** and **241b-248b** on the outer concentric circle **235o**, start at a nearest neighbor and proceed in opposite directions resulting in a very specific pattern of internal transverse conduits that redirect the flow between holes on the inner and outer concentric circles. In this embodiment, 241a on the inner concentric circle starts the pattern and connects to the nearest neighbor on the outer concentric circle, which is labeled **241b**. Proceeding from that point, the inner concentric circle holes are labeled consecutively proceeding counterclockwise, looking from the top. Similarly, the outer concentric circle holes are labeled consecutively proceeding in an opposite or clockwise direction, looking from the top. Internal transverse conduits **238** are machined internally into the disk **235** in a pattern so as to connect each inner hole to an outer hole in the pattern of **241a** to **241b**, **242a** to **242b**, through to **248a** to **248b**. It is critical in a combined multiport rotary valve that the top multiport rotary valve **215** is aligned with the bottom multiport rotary valve **285** so as the flows between the valves are complimentary. For ease of manufacturing, it is envisioned that the top planar face **239** may be made of one of the previously referenced metals, while the internal conduits are machined into a number of easily machinable disk materials and combined to form a composite disk **235**.

[0076] FIGS. 15, 16 and 17 show the central sprocket gear assembly **250** preferably made of metal that provides for rotational movement of the rotating heads **240** and **260**. The sprocket is axially aligned around the central shaft **205** and axis **204** by bearings **252**. The bearings allow for smooth and precise rotation of the sprocket without impeding slight vertical movement of the various heads **230**, **240**, **260** and **270**. FIGS. 15 and 17 show keys **254** and **253** for centrally locating and fixing the rotating heads **240** and **260** of FIG. 3. The keys provide for rotational force to the rotating heads when the sprocket is moved. The sprocket has teeth **255** for engagement with the chain **291** and drive motor **292** of FIG. 2.

[0077] FIGS. 18, 19 and 20 show side and planar views of bottom rotating head **260** which includes a planar disk **255** of the afore referenced material, preferably with a metal planar face. The top face **261** of the bottom rotating head **260** has a sufficient number of machined in keyways **257** for centrally locating and fixing the head by keys **253** to the sprocket plate **250** of FIG. 17 around axis **204**. The bottom planar disk face **259** has holes **261a-268a** that are spaced equidistant and form an inner concentric circle **255i** and are in communication with recessed arcuate obround windows **272** in FIG. 21. The bottom planar disk face **259** has holes **261b-268b** that are spaced equidistant and form an outer concentric circle **255o** and are in communication with recessed arcuate obround windows **273** in FIG. 21. In this embodiment, the holes in the inner and outer concentric circles are sufficient for proper flow and are equal in diameter and are angularly equidistant apart and aligned radially in angular measurement. For this example, eight fluid solid chambers were used and therefore there are eight inner and eight outer holes, but any number of chambers and pairs of holes can be used equal to or greater than two. It is critical that numbering of the holes **261a-268a** on the inner concentric circle **255i** and **261b-268b** on the outer concentric circle **255o**, start at a nearest neighbor and proceed in opposite directions resulting in a very specific pattern of conduits that redirect the flow between inner and outer holes. In this embodiment, **261a** on the inner concentric circle starts the pattern and connects to the nearest neighbor on the outer concentric circle, which is labeled **261b**. Proceeding from that point, the inner concentric circle holes are labeled consecutively proceeding clockwise looking from the bottom. Similarly, the outer concentric circle holes are labeled consecutively proceeding in an opposite or counter clockwise direction looking from the bottom. It will be noted that the second multiport valve **285** of FIG. 3 is numbered in mirror image to the top multiport valve **215** and vertically aligned at the same starting point numbers so as to maintain complimentary flow paths between the valves. Internal transverse conduits **258** are machined internally into the disk **255** in a pattern so as to connect each inner hole to an outer hole in the

pattern of **261a** to **261b**, **262a** to **262b**, through to **268a** to **268b**. For ease of manufacturing, it is envisioned that the top planar face **259** may be made one of the previously referenced metals, while the internal conduits are machined into a number of easily machinable disk materials and combined to form a composite disk **255**.

[0078] Rotating head **260** has 2x the number of targets **293** as number of chambers described in FIG. 1 and are made of any such material that can be registered by proximity sensor **294**. The targets **293** are precisely located around the rotating head **260** to indicate when the rotary and stationary head holes and recessed arcuate obround windows are aligned. In the example discussed in FIG. 1, there are eight chambers and 16 targets aligned with the 16 possible flow paths.

[0079] FIGS. 21, 22 and 23 show side and planar views of bottom stationary head **270**, which includes a planar disk **275**, made preferably from a polymeric material. The bottom face **269** of the bottom stationary head **270** has a sufficient number of machined in keyways **274** for centrally locating and fixing the head by the keys **281** to end plate **280** of FIG. 2b and FIG. 24 around axis **204**. Internal conduits **276** and **277** are machined in the disk **275** and extend from a radially outward surface **278** of the disk to the planar disk valve face **271**. On the radially outer surface **278** the internal conduits **276** end in ports **31** through **38** and the internal conduits **277** end in ports **41** through **48**. The bottom ports **31** through **38** are for process fluid conduits **131-138** and the top ports **41-48** are for fluid solid chamber conduits **141-148** from FIG. 1. On the planar disk valve face **271**, internal conduits **276** end in recessed arcuate obround windows **272** and internal conduits **277** end in recessed arcuate obround windows **273**. The recessed arcuate obround windows **272** are spaced equidistant around the face and form an inner concentric circle **272i** aligned around central axis **204**. The recessed arcuate obround windows **273** are spaced equidistant around the face and form an outer concentric circle **273o** aligned around central axis **204**. The angular lengths of the recessed arcuate obround windows **272** are equal and at least 2x the angular measurement of any of the equal matching holes **261a-268a** on the rotating head **260** of FIG. 20. The angular lengths of the recessed arcuate obround windows **273** are equal and at least 2x the angular measurement of any of the equal matching holes **261b-268b** on the rotating head **260** of FIG. 20. The angular length of the recessed arcuate obround windows, **272** or **273** allows for flow communication of each window with a matching hole **261a-268a** or **261b-268b** through 2 indexes of the rotating head **260** of FIG. 20. The depth of the recessed arcuate obround windows **272** and **273** is sufficient to allow proper full flow communication with the rotating head **260** of FIG. 3. Between the recessed arcuate obround windows **272** on the inner

concentric circle **272i** are equal lands **279** that are equal to or preferably slightly less than equal to the angular measurement of holes **261a-268a** on the rotating head **260** of FIG. 20. Between the recessed arcuate obround windows **273** on the outer concentric circle **273o** are equal lands **279** that are equal to or preferably slightly less than equal to the angular measurement of holes **261b-268b** on the rotating head **260** of FIG. 20. The lands **279** formed on the inner concentric circle **272i** are equally offset in angular measurement either way from the lands **279** on the outer concentric circle **273o** so as to provide a staggered progression of flow communication between the stationary head **270** and the rotating head holes **261a-268a** and **261b-268b** upon each index of the rotating head **260** of FIG. 20.

[0080] Again, upon a complete reading of the detailed descriptions for the various figures, it will be appreciated that the recessed arcuate obround windows **272** and **273** and corresponding offset of the land **279** between the windows or holes on the inner and outer concentric circles allows sequential and proper flow between the multiport valves and chambers without any cross contamination of the various fluid streams. A multiport valve formed solely with holes on both the stationary and rotating head sealing faces, without the recessed arcuate obround windows and offsets will function, but with a different sequence and a resultant cross contamination. It will also be appreciated that the recessed arcuate obround windows **272** and **273** and corresponding offset of the land **279** between the windows and holes on the inner and outer concentric circles can be moved from the stationary head **270** to the rotating head **260** in any combination. The recessed arcuate obround windows can be placed on one head, either the stationary **270** or the rotating **260**, while the land offset will also be placed on one head, either the stationary **270** or the rotating head **260**. Therefore, there are at least 4 combinations of recessed arcuate obround windows and land offset that allow for proper flow communication between the stationary head **270** and rotating head **260**. It is critical to note that the top and bottom rotating heads **240** and **260** must move in concert so as to maintain the proper and complimentary flow paths.

[0081] FIGS. 24 and 25 show the bottom end plate **280**, preferably made of metal, axially aligned around the central axis **204**. FIG. 24 shows keys **281** for fixing and centrally locating the bottom stationary head **270** of FIG. 23 around the central axis **204**. Key **282** fixes the bottom end plate **280** with the keyed central shaft **205** of FIG. 2b and FIG. 26. The end plate **280** provides a face for opposing the force from the pressure plate **220** of FIG. 7.

[0082] FIG. 26 shows a side view of multiport rotary valve stand **290** and shaft **205** with threaded ends **213** and keyways **214** to mate with key **208** from FIG. 4 and keyway **215** for mating with key **282** from FIG. 24. The stand is preferably made of metal and designed

so as to adequately support the end plate **280** of FIG. 25 yet not unreasonably obstruct the valve heads. End plate **280** can be affixed to stand **290** in any suitable way so as to avoid rotation of the end plate **280**. Stand **290** is also designed to adequately fix central shaft tube **295** which limits horizontal movement of shaft **205** while surface **296** provides a flat for constraining the vertical movement of shaft by nuts **202**.

[0083] FIG. 27 is an example of how the internal transverse conduits **38** of rotating head **240** from FIG. 12 redirect the flow back into stationary head **230** of FIGS. 10 and 11 before an index of the rotating head **240**. The stationary head **230** is shown in plan view, looking up, with bottom face **231** exposed. The recessed arcuate obround windows **222** on the inner concentric circle connect to ports **11-18** by internal conduits **226** and recessed arcuate obround windows **223** on the outer concentric circle connect to ports **21-28** by internal conduits **227** as per FIG. 10. The internal transverse conduits **238** which connect to holes **241a-248a** and **241b-248b** in rotating head **240** from FIG. 12 are in communication with stationary head **230** and are shown in dark overlay on the face **231** of the stationary head **230**. It can be seen that port **11** will connect to port **21** through internal transverse conduit **238**a. Port **12** will connect to port **22** through internal transverse conduit **238b** and so on, until port **18** will connect with port **28** through internal transverse conduit **238h**.

[0084] FIG. 28 is an example of how the internal transverse conduits **38** of rotating head **240** from FIG. 12 redirect the flow back into stationary head **230** of FIGS. 10 and 11 after one index of the rotating head **240**. Internal transverse conduits **238** have been indexed one position from that in FIG. 27 counterclockwise looking from a bottom perspective. Port **11** will now connect to port **22** though internal transverse conduit **238b**. Port **12** will connect to port **23** through internal transverse conduit **238c** and so on until port **18** will connect to port **21** by internal transverse conduit **238a**. In this manner, the internal transverse conduits sequentially move the flows from one chamber to the next upon each index. Combining the top multiport valve **215** with the bottom multiport valve **285** and indexing both valves in concert, allows proper and sequential flow through the various chambers. In the 8 chamber example two complete cycles are accomplished in each revolution of the rotating heads. Combining this concept with the water softener example described in FIG. 1, it can be seen how the chambers move sequentially through the entire process.

[0085] Therefore, the combined multiport rotary valve **200** with recessed arcuate obround windows and offsets operates as follows: By means of the drive motor **292** the rotating heads **240**, **260** are moved together to a position where a target **293** aligns with the proximity sensor **294**. For this example, the rotating heads are aligned so stream A will

connect with fluid solid chamber **1** as will the other streams B through H align with fluid solid chambers **2** through **8**. Referring back to FIGS. 1, 10-12, 20-22 and 27 for the above-mentioned water softening application and using only feed water stream A as an example, stream A will enter by conduit **111** the invention **200** at port **11** of the top stationary head **230** and proceeds through an internal conduit **226** to a recessed arcuate obround window **222** on the inner concentric circle **222i** at the planar face **231** disposed in sealing contact with the top rotating head planar face **239**, the flow enters the rotating head hole **241a** on the inner concentric circle **235i** and proceeds through internal transverse conduit **238**a to hole **241b** on the outer concentric circle **235o** on the top rotating head planar face **239** and reenters the top stationary head **230** at a recessed arcuate obround window **223** at the outer concentric circle **223o** and proceeds by an internal conduit **227** to the stationary head port **21**. Stream A then proceeds by conduit **121** to enter the first fluid solid contacting chamber **1** by **1a** and makes contact with the treatment resin contained therein, it then exits chamber **1** at **1b** as treated stream A' and enters by conduit **141** the bottom stationary head **270** at port **41**. Treated stream A' then proceeds by an internal conduit **277** to a recessed arcuate obround window **273** on the outer concentric circle **273o** on the top planar face **271** of the bottom stationary head **270** disposed in sealing contact with the bottom rotating head planar face **259** and proceeds into the bottom rotating head at hole **261b** on the outer concentric circle **255o**. Stream A' proceeds by internal transverse conduit **258a** through the bottom rotating head **260** and is redirected to the rotating head planar surface **259** and hole **261a** on the inner concentric circle **255i**. Stream A' crosses back through the planar surface to bottom stationary head **270** and enters by a recessed arcuate obround window **272** on the inner concentric circle **272i** and proceeds by conduit **276** to exit the invention at port **31** and external conduit **131**. In this 8-chamber example, the other 7 streams will proceed to their respective 7 chambers through their respective paths. The 8 fluid streams will continue with the same paths until such a time when a control device initiates an index of the rotary heads **240** and **260** one position clockwise when viewed from the top, to the next target position **293**.

[0086] After the first clockwise index, stream A enters the invention **200** by conduit **111** at port **11** of the top stationary head **230** and proceeds through an internal conduit **226** to a recessed arcuate obround window **222** on the inner concentric circle **222i** at the planar face **231** disposed in sealing contact with the top rotating head planar face **239**. Due to the rotation of head **240**, stream A enters a new rotating head hole **242a** on the inner concentric circle **235i** and proceeds through the internal transverse conduit **238b** to hole **242b** on the outer concentric circle **235o** on the top rotating head planar face **239** and reenters the top

stationary head **230** at a recessed arcuate obround window **223** on the outer concentric circle **223o**, passes through an internal conduit **227** and exits at port **22**. Stream A then proceeds by conduit **122** to enter by **2a** the second fluid solid contacting chamber **2** and makes contact with the treatment resin contained therein, it then exits the chamber at **2b** as treated stream A' and proceeds by conduit **142** to enter the bottom stationary head **270** at port **42**. Treated stream A' then proceeds by an internal conduit **277** to a recessed arcuate obround window **273** on the outer concentric circle **273o** on the top planar face **271** of the bottom stationary head **270** disposed in sealing contact with the bottom rotating head planar face **259**. Due to the recessed arcuate obround window **273** in the bottom stationary head **270**, treated stream A' proceeds back into the bottom rotating head **260** at the previous hole **261b** on the outer concentric circle **255o**. Stream A' proceeds by the internal transverse conduit **258a** in the bottom rotating head **260** and is redirected to hole **261a** on the inner concentric circle **255i** on the rotating head planar surface **259**. Stream A' crosses back through the planar surface to bottom stationary head **270** and enters by a recessed arcuate obround window **272** on the inner concentric circle **272i** associated with port **31** and proceeds to exit the invention by conduit **131**.

[0087] After the second clockwise index, stream A enters the invention by conduit **111** at port **11** of the top stationary head **230** and proceeds through an internal conduit **226** to a recessed arcuate obround window **222** on the inner concentric circle **222i** at the planar face **231** disposed in sealing contact with the top rotating head planar face **239**. Due to the recessed arcuate obround window **222**, stream A continues to enter the previous rotating head hole **242a** on the inner concentric circle **235i** and proceeds through the internal transverse conduit **238b** to hole **242b** on the outer concentric circle **235o** on the top rotating head planar face **239**. The stream now reenters the top stationary head **230** at a recessed arcuate obround window **223** on the outer concentric circle **223o**, passes through an internal conduit **227** and exits at port **23**. Stream A then proceeds by conduit **123** to enter by **3a** the third fluid solid contacting chamber and makes contact with the treatment resin contained therein, it then exits the chamber at **3b** as Treated stream A' and proceeds by conduit **143** to enter the bottom stationary head **270** at port **43**. Treated stream A' then proceeds by an internal conduit **277** to a recessed arcuate obround window **273** on outer concentric circle **273o** on the top planar face **271** of the bottom stationary head **270** disposed in sealing contact with the bottom rotating head planar face **259** and because of the recessed arcuate obround window proceeds back into the bottom rotating head at the same hole **262b** on the outer concentric circle **255o**. Stream A' proceeds by internal transverse conduit **258b** through the bottom rotating head **260**

and is redirected to hole **262a** on the inner concentric circle **255i** on the rotating head planar surface **259**. Stream A' crosses back through the planar surface to bottom stationary head **270** and enters by a recessed arcuate obround window **272** on the inner concentric circle **272i** and proceeds by internal conduit **276** to exit the invention **200** at port **31** and conduit **131**. The third index will move stream A through chamber **4** and so on until stream A comes back to chamber **1** upon the 8th index which is one half of a complete cycle or 180 angular degrees. This pattern will proceed upon each index until it has completed the sequence 2x in one 360-degree revolution of the rotating heads. All of the other chambers will follow the same pattern so as to move each chamber counter currently and sequentially through the various feed streams A through H.

[0088] FIG. 29 shows an alternative stand and housing for the combined multiport rotary valve **200** using an outer clamshell housing **301** and **302** combined with a motor and gearbox **292** driving the central drive shaft **205** on valve stand **290**. The outer clamshell housing will prevent rotation of the stationary heads, while allowing the rotating heads to move. The central drive shaft will be connected to the rotating heads and drive them at the proper time. The outer housing will encase and urge the rotating and stationary heads together around a central shaft by mechanical, hydraulic or pneumatic means.

[0089] FIG. 30A depicts a graphical representation of an exemplary 20-port valve in a first position according to an embodiment. As shown in FIG. 30A, each valve includes a stationary head **405** and a rotating head **410**. The stationary head **405** remains stationary and the rotating head **410** rotates during operation.

[0090] The stationary head **405** includes a plurality of first ports, such as **P1-20**, and a plurality of second ports, such as ports **C1-20**. Each first port **P1-20** is connected to a pipe, tube or other channel (not shown) that provides a fluid stream for performing a particular step of, for example, an ion exchange process. Each second port **C1-20** is connected to a media vessel (not shown) containing, for example, a fluid-solid mixture on which the process operates. The media vessels remain stationary during the process because the attachment to the stationary head does not move as a result of the process. More or fewer first ports and second ports may be incorporated into a stationary head **405** within the scope of this disclosure.

[0091] The rotating head **410** includes a plurality of first ports, such as **415(A)**, a plurality of second ports, such as **420(A)**, and a plurality of channels, such as **425(A)**, connecting each first port to a corresponding second port. Each of the first ports **415** and the

second ports **420** labeled in FIG. 30A with a common letter (A-T) correspond to each other and are connected by a corresponding channel **425**.

[0092] In operation, fluid directed to a first port, such as **P1**$_5$ of the stationary head **405** is passed to a first port, such as **415(A)**, of the rotating head **410** with which it is aligned at that time. The fluid flows through the corresponding channel **425(A)** of the rotating head **410** to the corresponding second port **420(A)** of the rotating head. The fluid is then directed to the second port **C1** of the stationary head **405** with which the second port **420(A)** of the rotating head **410** is aligned at that time.

[0093] As shown in FIG. 30A, the first ports **P1-20** and second ports **C1-20** of the stationary head **405** are substantially wider than the first ports **415** and the second ports **420** of the rotating head **410**. In an embodiment, the first ports **P1-20** and second ports **C1-20** of the stationary head **405** are approximately 3 times wider than the first ports **415** and the second ports **420** of the rotating head **410**. In other words, the angular lengths of the first ports **P1-20** and second ports **C1-20** of the stationary head **405** may be longer than (e.g., approximately 3 times longer than) the angular lengths of the first ports **415** and the second ports **420** of the rotating head **410**. Accordingly, in FIG. 30A, fluid flowing from first port **P1** of the stationary head **405** to first port **415(A)** of the rotating head **410** flows from the left-hand side of first port **P1**. Similarly, fluid flowing from the second port **420(A)** of the rotating head **410** flows through the right-hand side of second port **C1** of the stationary head **405**. As such, fluids flowing from first ports **P1-20** of the stationary head **405** are directed to second ports **C1-20** of the stationary head in the first valve position depicted in FIG. 30A.

[0094] FIG. 30B depicts a graphical representation of the exemplary 20-port valve in a second position according to an embodiment. FIG. 30B depicts the valve in the second position in which the rotating head **410** has rotated 9° (1/40 of a complete revolution) from its position in FIG. 30A. In general, the rotation between each position equals 1 divided by 2 times the number of first ports.

[0095] As shown in FIG. 30B, fluid flowing from first port **P1** of the stationary head **405** to first port **415(A)** of the rotating head **410** flows from the right-hand side of first port **P1**. Similarly, fluid flowing from the second port **420(A)** of the rotating head **410** flows through the left-hand side of second port **C2** of the stationary head **405**. As such, fluids flowing from first ports **P1-20** of the stationary head **405** are directed to second ports **C2-20** and **C1**, respectively, of the stationary head in the second valve position depicted in FIG. 30B.

[0096] FIG. 30C depicts a graphical representation of the exemplary 20-port valve in a third position according to an embodiment. FIG. 30C depicts the valve in the third position in which the rotating head **410** has rotated 9° (1/40 of a complete revolution) from its position in FIG. 30B.

[0097] As shown in FIG. 30C, fluid flowing from first port **P1** of the stationary head **405** to first port **415(B)** of the rotating head **410** flows from the left-hand side of first port **P1**. Similarly, fluid flowing from the second port **420(B)** of the rotating head **410** flows through the right-hand side of second port **C3** of the stationary head **405**. As such, fluids flowing from first ports **P1-20** of the stationary head **405** are directed to second ports **C3-20** and **C1-C2**, respectively, of the stationary head in the third position depicted in FIG. 30C.

[0098] FIG. 30D depicts a graphical representation of the exemplary 20-port valve in a fourth position according to an embodiment. FIG. 30D depicts the valve in the fourth position in which the rotating head **410** has rotated 9° (1/40 of a complete revolution) from its position in FIG. 30C.

[0099] As shown in FIG. 30D, fluid flowing from first port **P1** of the stationary head **405** to first port **415(B)** of the rotating head **410** flows from the right-hand side of first port **P1**. Similarly, fluid flowing from the second port **420(B)** of the rotating head **410** flows through the left-hand side of second port **C4** of the stationary head **405**. As such, fluids flowing from first ports **P1-20** of the stationary head **405** are directed to second ports **C4-20** and **C1-C3**, respectively, of the stationary head in the fourth position depicted in FIG. 30D.

[0100] As the rotating head **410** continues to rotate, each media vessel consecutively receives fluid from the first ports of the stationary head **405**. As a result of providing fluid to ports in such a manner, any fluid retained by the passage between the input port and the output port of the stationary head may be passed to an appropriate media vessel.

[0101] In an embodiment, a second stationary head (not shown) and a second rotating head (not shown) are aligned with stationary head **405** and rotating head **410** to receive any output from a media vessel. For example, the ports of the second stationary head and stationary head **405** are aligned in a fixed orientation. The ports of the second rotating head and rotating head **410** are aligned and rotate in a fixed orientation with respect to each other.

[0102] FIG. 31 depicts an exploded view of an exemplary 30-port rotating head assembly according to an embodiment. As shown in FIG. 31, the 30 port rotating head assembly **500** includes a top plate **505** and one or more layered disks, such as **510-520**. The top plate **505** includes a plurality of first ports, such as **506a**, and a plurality of second ports,

such as **507a**. Each first port, such as **506a**, is aligned with a first port, such as P1, of the stationary head **105**, during each step of an ion exchange process. Each second port, such as **507a**, is aligned with a second port, such as C1, of the stationary head **105**, during each step of an ion exchange process. As the rotating head assembly **500** rotates, the first port **506a** and the second port **507a** connect to different first and second ports of the stationary head **105**.

[0103] As fluid enters first port **506a**, the fluid enters the assembly and is directed to a channel **508a** connecting first port **506a** and second port **507a**. The channel may be present on and/or may pass through one or more of the layered disks **510-520**. In an embodiment, a channel, such as **508a**, is appropriately designed for the flow. In this manner, each channel contains the fluid passing from the corresponding output port to the corresponding input port without leaking. Other channel depths and layered disk thicknesses may be used within the scope of this disclosure. In addition, differing numbers of layered disks may be used depending upon the width of the channels, the width of the disks, and the number of channels to be implemented. Such modifications to the depicted embodiment are further incorporated within the scope of this disclosure.

[0104] FIG. 32 depicts an exemplary multiport apparatus for directing fluid according to an embodiment. As shown in FIG. 32, the apparatus **600** includes a first stationary head **610**, a first rotating head **620**, a plurality of media vessels, such as **630a-d**, a second stationary head **640**, a second rotating head **650** and a rotating system **660**.

[0105] The first stationary head **610** includes a plurality of first ports, such as **612a**, and a corresponding plurality of second ports, such as **614a**. The number of first ports **612a** equals the number of second ports **614a**. Each first port **612a** is configured to receive fluid from a fluid source (not shown). Each second port **614a** directs fluid to a corresponding media vessel, such as **630a**.

[0106] The first rotating head **620** includes a plurality of first ports, such as **506a** in FIG. 31, a corresponding plurality of second ports, such as **507a** in FIG. 31, and a plurality of channels, such as **508a** in FIG. 31, connecting each first port to the corresponding second port. The number of first ports **506a** equals the number of second ports **507a**. Each first port **506a** is configured to receive fluid from a first port, such as **612a**, of the first stationary head **610** with which it is aligned at a given time. The received fluid passes through the first port **506a**, the corresponding channel **508a** and the corresponding second port **507a**. The fluid then passes to a second port, such as **614a**, on the first stationary head **610** with which the second port **507a** is aligned.

[0107] The fluid is directed from the second port **614a** of the first stationary head **610** to a corresponding media vessel, such as **630a**. Each media vessel **630a** is used to perform, for example, an ion exchange process. The fluid directed from the second port **614a** of the first stationary head **610** is used to perform a step of such a process. Other processes may also be performed within the scope of this disclosure. Each media vessel, such as **630a**, remains stationary during performance of the process and remains attached to a corresponding second port **614a** of the first stationary head **610** and a corresponding second port, such as **644a**, of the second stationary head **640**.

[0108] The second stationary head **640** includes a plurality of first ports, such as **642a** and a plurality of second ports, such as **644a**. The number of first ports **642a** is equal to the number of second ports **644a**. Each second port **644a** receives fluid output from a corresponding media vessel, such as **630a**. The output from the media vessel **630a** is provided to a second port, such as **644a** of a second stationary head **640**. Each first port **642a** directs fluid to an output.

[0109] The second rotating head **650** includes a plurality of first ports, such as **506a** in FIG. 31, a corresponding plurality of second ports, such as **507a** in FIG. 31, and a plurality of channels, such as **508a** in FIG. 31, connecting each first port to the corresponding second port. The number of first ports **506a** equals the number of second ports **507a**. Each second port, such as **507a**, is configured to receive fluid from a second port, such as **644a**, of the second stationary head **640** with which it is aligned at a given time. The received fluid passes through the second port **507a**, the corresponding channel **508a** and the corresponding first port **506a**. The fluid then passes to a first port, such as **644a**, on the second stationary head **640** with which the first port **506a** is aligned.

[0110] The rotating system **660** includes a motor, such as a step motor. In an embodiment, the rotating system includes a controller, such as a computer system used to operate the mechanical components of the rotating system, such as the motor. An exemplary computer system is described in more detail in FIG. 33.

[0111] The rotating system **660** is used to rotate the first rotating head **620** and the second rotating head **650**. In an embodiment, the first rotating head **620** and the second rotating head **650** are aligned such that each first port **622a-N** of the first rotating head is aligned with a corresponding first port **652a-N** of the second rotating head, and each second port **624a-N** of the first rotating head is aligned with a corresponding second port **654a-N** of the second rotating head. Other alignments are possible within the scope of this disclosure.

[0112] The rotating system **660** causes the first rotating head **620** and the second rotating head **650** to rotate a fixed number of degrees in each cycle. In an embodiment, the rotating system **660** causes the first rotating head **620** and the second rotating head **650** to rotate approximately $\frac{180}{num_of_ports}$ degrees per cycle as discussed above in reference to FIGS. 30A-D.

[0113] FIG. 33 depicts a block diagram of exemplary internal computer hardware that may be used to contain or implement program instructions used to perform a process, such as the process steps discussed above, according to an embodiment. A bus **700** serves as the main information highway interconnecting the other illustrated components of the hardware. CPU **705** is the central processing unit of the system, performing calculations and logic operations required to execute a program. CPU **705**, alone or in conjunction with one or more of the other elements disclosed in FIG. 33, is an exemplary processing device, computing device or processor as such terms are used within this disclosure. Read only memory (ROM) **710** and random access memory (RAM) **715** constitute exemplary memory devices.

[0114] A controller **720** interfaces with one or more optional memory devices **725** to the system bus **700**. These memory devices **725** may include, for example, an external or internal DVD drive, a CD ROM drive, a hard drive, flash memory, a USB drive or the like. As indicated previously, these various drives and controllers are optional devices. Additionally, the memory devices **725** may be configured to include individual files for storing any feedback information, common files for storing groups of feedback information, or one or more databases for storing the feedback information.

[0115] Program instructions, software or interactive modules for providing the interface and performing any querying or analysis associated with one or more data sets may be stored in the ROM **710** and/or the RAM **715**. Optionally, the program instructions may be stored on a tangible computer readable medium such as a compact disk, a digital disk, flash memory, a memory card, a USB drive, an optical disc storage medium, such as a Blu-ray™ disc, and/or other recording medium.

[0116] An optional display interface **730** may permit information from the bus **700** to be displayed on the display **735** in audio, visual, graphic or alphanumeric format. Communication with external devices, such as an optional printing device, may occur using various communication ports **740**. An exemplary communication port **740** may be attached to a communications network, such as the Internet or an intranet.

[0117] The hardware may also include an interface **745** which allows for receipt of data from input devices such as a keyboard **750** or other input device **755** such as a mouse, a joystick, a touch screen, a remote control, a pointing device, a video input device and/or an audio input device.

[0118] Various of the above-disclosed and other features and functions, or alternatives thereof, may be combined into many other different systems or applications. Various presently unforeseen or unanticipated alternatives, modifications, variations or improvements therein may be subsequently made by those skilled in the art, each of which is also intended to be encompassed by the disclosed embodiments.

J. CLAIMS

What Is Claimed Is:

1. A multiport rotary fluid-directing apparatus, comprising:

a first stationary head having a plurality of first ports and a plurality of second ports, wherein each first port of the first stationary head is configured to receive fluid from a fluid source, wherein each second port of the first stationary head is configured to pass fluid to a media vessel;

a first rotating head having a plurality of first ports, a plurality of second ports and a plurality of channels, wherein each channel of the first rotating head fluidly connects a first port of the first rotating head to a corresponding second port of the first rotating head;

a second rotating head having a plurality of first ports, a plurality of second ports and a plurality of channels, wherein each channel of the second rotating head fluidly connects a first port of the second rotating head to a corresponding second port of the second rotating head;

a second stationary head having a plurality of first ports and a plurality of second ports, wherein each first port of the second stationary head is configured to pass fluid to an output, wherein each second port of the second stationary head is configured to receive fluid from a media vessel;

a plurality of media vessels configured to receive fluid from a second port of a first stationary head and transmit fluid to a corresponding second port of a second stationary head; and

a rotating system configured to cause the first rotating head and the second rotating head to rotate, wherein the rotating system comprises a motor and a controller.

2. The apparatus of claim 1 wherein the angular lengths of the first ports and the second ports of the first stationary head are longer than the angular lengths of the first ports and the second ports of the first rotating head.

3. The apparatus of claim 1 wherein the angular lengths of the first ports and the second ports of the first stationary head are approximately three times longer than the angular lengths of the first ports and the second ports of the first rotating head.

4. The apparatus of claim 1 wherein the angular lengths of the first ports and the second ports of the second stationary head are longer than the angular lengths of the first ports and the second ports of the second rotating head.

5. The apparatus of claim 1 wherein the angular lengths of the first ports and the second ports of the first stationary head are approximately three times longer than the angular lengths of the first ports and the second ports of the first rotating head.

6. The apparatus of claim 1 wherein the rotating system is configured to cause the first rotating head and the second rotating head to rotate approximately $\frac{180}{num_of_ports}$ degrees at a time, wherein num_of_ports is a number of the plurality of first ports of the first rotating head.

7. The apparatus of claim 1, wherein a number of first ports of the first rotating head, a number of second ports of the first rotating head, a number of first ports of the first stationary head, a number of second ports of the first stationary head, a number of first ports of the second rotating head, a number of second ports of the second rotating head, a number of first ports of the second stationary head and a number of second ports of the second stationary head are the same.

8. A multiport valve apparatus for purifying, treating and separating fluids by directing multiple fluid streams into and out of a fluid-solid contacting apparatus having a plurality of fluid-solid contacting chambers, said multiport valve comprising:

a rotating cylindrical-shaped head having a circular-shaped sealing base, a circular-shaped fastening base with an axis of rotation therethrough the center of said bases and a cylinder side surface connecting said bases, with said bases having a radius, said sealing base having an inner concentric circle with a radius that is substantially less than said sealing base radius and said sealing base having an outer concentric circle with a radius that is greater than said inner circle radius but less than said sealing base radius,

said sealing base further comprising a plurality of first rotating ports centered on the outer concentric circle, spaced radially equidistant from one another and further comprising a plurality of second rotating ports centered on said inner concentric circle also spaced radially

equidistant from one another, wherein the plurality of first rotating ports and the plurality of second rotating ports are equal to one another in number and wherein

each first rotating port is connected to its corresponding second rotating port via a transverse channel to provide a rotating flow pair and wherein

each flow pair are connected in the following manner:

starting with any first rotating port and then connecting that first rotating port to the nearest radially adjacent second rotating port via a transverse channel to form the first rotating flow pair, then connecting the next immediately radially adjacent clockwise first rotating port from said starting first rotating port to the nearest immediately radially adjacent counterclockwise second rotating port from said starting second rotating port via a transverse channel to form the second rotating flow pair, and so on until each first rotating port is connected to a second rotating port and wherein the number of rotating flow pairs corresponds to the number of chambers and wherein

upon rotation of said valve, each of said rotating flow pairs can be sequenced to connect to said plurality of fluid-solid contacting chambers to direct fluid streams into and out of said fluid-contacting chambers.

9. The multiport valve of claim 8 wherein each of said rotating ports has a diameter wherein each of said rotating ports further comprises an arcuate obround-shaped recess aligned along the respective inner and outer concentric circles with each recess having a width corresponding to the diameter of each port and having a length such that the space between each equidistant recess from an adjacent recess is approximately less than or equal to the cross-sectional area of each port.

10. The multiport valve of claim 9 wherein each outer rotating port and its corresponding recess are located at a same outer point along the length of its corresponding recess and wherein each inner rotating port and its corresponding recess are located at a same inner point along the length of its corresponding recess.

11. The multiport valve of claim 8 wherein each outer rotating port and a corresponding recess are located at a same outer point along the length of the corresponding recess of the outer rotating port and wherein each inner rotating port and a corresponding recess are located at a same inner point along the length of the corresponding recess of the inner rotating port.

12. A multiport valve apparatus for purifying, treating and separating fluids by directing multiple fluid streams into and out of a fluid-solid contacting apparatus having a plurality of fluid-solid contacting chambers, said multiport valve comprising:

a fixed cylindrical-shaped head having a circular-shaped sealing base, a circular-shaped fastening base with a central axis therethrough the center of said bases and a side surface connecting said bases, with said bases having a radius, said sealing base having an inner concentric circle with a radius that is substantially less than said sealing base radius and said sealing base having an outer concentric circle with a radius that is greater than said inner circle radius but less than said sealing base radius,

said sealing base further comprising a plurality of first fixed ports centered on said outer concentric circle, spaced radially equidistant from one another and a plurality of second fixed ports centered on said inner concentric circle also spaced radially equidistant from one another, wherein the plurality of first fixed ports and second fixed ports are equal to one another in number and wherein

said side surface having a plurality of upper circumferential contact ports, spaced radially equidistant from one another and radially aligned in accordance with the radial alignment of said second fixed ports such that each upper contact port is connected via an internal channel to the radially adjacent second fixed port and wherein

said side surface having a plurality of lower circumferential contact ports, also spaced radially equidistant from one another and also radially aligned in accordance with the radial alignment of said first fixed ports on said sealing base such that each lower contact port on said side surface is connected via an internal channel to the radially adjacent first fixed port on said sealing base and wherein

each connected upper contact port and it corresponding second fixed port provides a first process flow pair, and wherein each connected lower contact port and its corresponding first port provides a second process flow pair, such that the number of first process flow pairs is equal to the number of second process flow pairs and is also equal to number of chambers such that each process flow pair is connected to either a preselected chamber or has a preselected fluid stream in accordance with a predetermined process such that multiple fluid streams are directed into and out of the fluid-solid contacting chambers.

13. The multiport valve of claim 12 wherein each of said fixed ports has a diameter wherein each of said fixed ports further comprises an arcuate obround-shaped recess aligned

along the respective inner and outer concentric circles with each recess having a width corresponding to the diameter of each fixed port and having a length such that the space between each equidistant recess from an adjacent recess is approximately less than or equal to the cross-sectional area of each fixed port.

14. The multiport valve of claim 13 wherein each outer fixed port and its corresponding recess are located at a same outer point along the length of its corresponding recess and wherein each inner fixed port and its corresponding recess are located at a same inner point along the length of its corresponding recess.

15. The multiport valve of claim 12 wherein each outer fixed port and a corresponding recess are located at a same outer point along the length of the corresponding recess of the outer fixed port and wherein each inner fixed port and a corresponding recess are located at a same inner point along the length of the corresponding recess of the inner fixed port.

16. A multiport valve apparatus for purifying, treating and separating fluids by directing multiple fluid streams into and out of a fluid-solid contacting apparatus having a plurality of fluid-solid contacting chambers, said multiport valve comprising:

a rotating cylindrical-shaped head having a circular-shaped sealing base, a circular-shaped fastening base with an axis of rotation therethrough the center of said bases and a cylinder side surface connecting said bases, with said bases having a radius, said sealing base having an inner concentric circle with a radius that is substantially less than said sealing base radius and said sealing base having an outer concentric circle with a radius that is greater than said inner circle radius but less than said sealing base radius,

said sealing base further comprising a plurality of first rotating ports centered on the outer concentric circle, spaced radially equidistant from one another and further comprising a plurality of second rotating ports centered on said inner concentric circle also spaced radially equidistant from one another, wherein the plurality of first rotating ports and the plurality of second rotating ports are equal to one another in number and wherein

each first rotating port is connected to its corresponding second rotating port via a transverse channel to provide a rotating flow pair and wherein

each flow pair are connected in the following manner:

starting with any first rotating port and then connecting that first rotating port to the nearest radially adjacent second rotating port via a transverse channel to form the first rotating flow pair, then connecting the next immediately radially adjacent clockwise first rotating port from said starting first rotating port to the nearest immediately radially adjacent counterclockwise second rotating port from said starting second rotating port via a transverse channel to form the second rotating flow pair, and so on until each first rotating port is connected to a second rotating port and wherein the number of rotating flow pairs corresponds to the number of chambers and wherein

upon rotation of said valve, each of said rotating flow pairs can be sequenced to connect to said plurality of fluid-solid contacting chambers to direct fluid streams into and out of said fluid-contacting chambers;

a fixed cylindrical-shaped head having a circular-shaped sealing base, a circular-shaped fastening base with a central axis therethrough the center of said bases and a side surface connecting said bases, with said bases having a radius, said sealing base having an inner concentric circle with a radius that is substantially less than said sealing base radius and said sealing base having an outer concentric circle with a radius that is greater than said inner circle radius but less than said sealing base radius,

said sealing base further comprising a plurality of first fixed ports centered on said outer concentric circle, spaced radially equidistant from one another and a plurality of second fixed ports centered on said inner concentric circle also spaced radially equidistant from one another, wherein the plurality of first fixed ports and second fixed ports are equal to one another in number and wherein

said side surface having a plurality of upper circumferential contact ports, spaced radially equidistant from one another and radially aligned in accordance with the radial alignment of said second fixed ports such that each upper contact port is connected via an internal channel to the radially adjacent second fixed port and wherein

said side surface having a plurality of lower circumferential contact ports, also spaced radially equidistant from one another and also radially aligned in accordance with the radial alignment of said first fixed ports on said sealing base such that each lower contact port on said side surface is connected via an internal channel to the radially adjacent first fixed port on said sealing base and wherein

each connected upper contact port and it corresponding second fixed port provides a first process flow pair, and wherein each connected lower contact port and its corresponding first port provides a second process flow pair, such that the number of first process flow pairs is equal to the number of second process flow pairs and is also equal to number of chambers such that each process flow pair is connected to a either a preselected chamber or has a preselected fluid stream in accordance with a predetermined process such that multiple fluid streams are directed into and out of the fluid-solid contacting chambers;

sealing means attached to said fastening base of said fixed head and the fastening base of said rotating head such that the respective sealing bases are urged against one another and aligning said bases such that the central axis of said fixed base is coincident with the rotation axis of said rotational base and such that the plurality of first fixed ports lines up with plurality of first rotating ports and such that the plurality of second fixed ports lines up with the plurality of second rotating ports; and

drive means for rotating and indexing said rotating head on its axis of rotation so that fluid streams flowing through said multiport valve to the chambers can be directed into and out of the fluid-solid contacting chambers.

17. The multiport valve of claim 16 further comprising a second fixed head and a second rotational head such that each rotational head is adjacent to one another and aligned such that their respective axis of rotation are coincident with one another and such that each rotating head is indexed in concert with one another so that proper fluid flows are maintained.

18. The multiport valve of claim 16 wherein each of said rotating ports has a diameter wherein each of said rotating ports further comprises an arcuate obround-shaped recess aligned along the respective inner and outer concentric circles with each recess having a width corresponding to the diameter of each rotating port and having a length such that the space between each equidistant recess from an adjacent recess is approximately less than or equal to the cross-sectional area of each rotating port.

19. The multiport valve of claim 18 wherein each outer rotating port and its corresponding recess are located at a same outer point along the length of its corresponding recess and wherein each inner rotating port and its corresponding recess are located at a same inner point along the length of its corresponding recess.

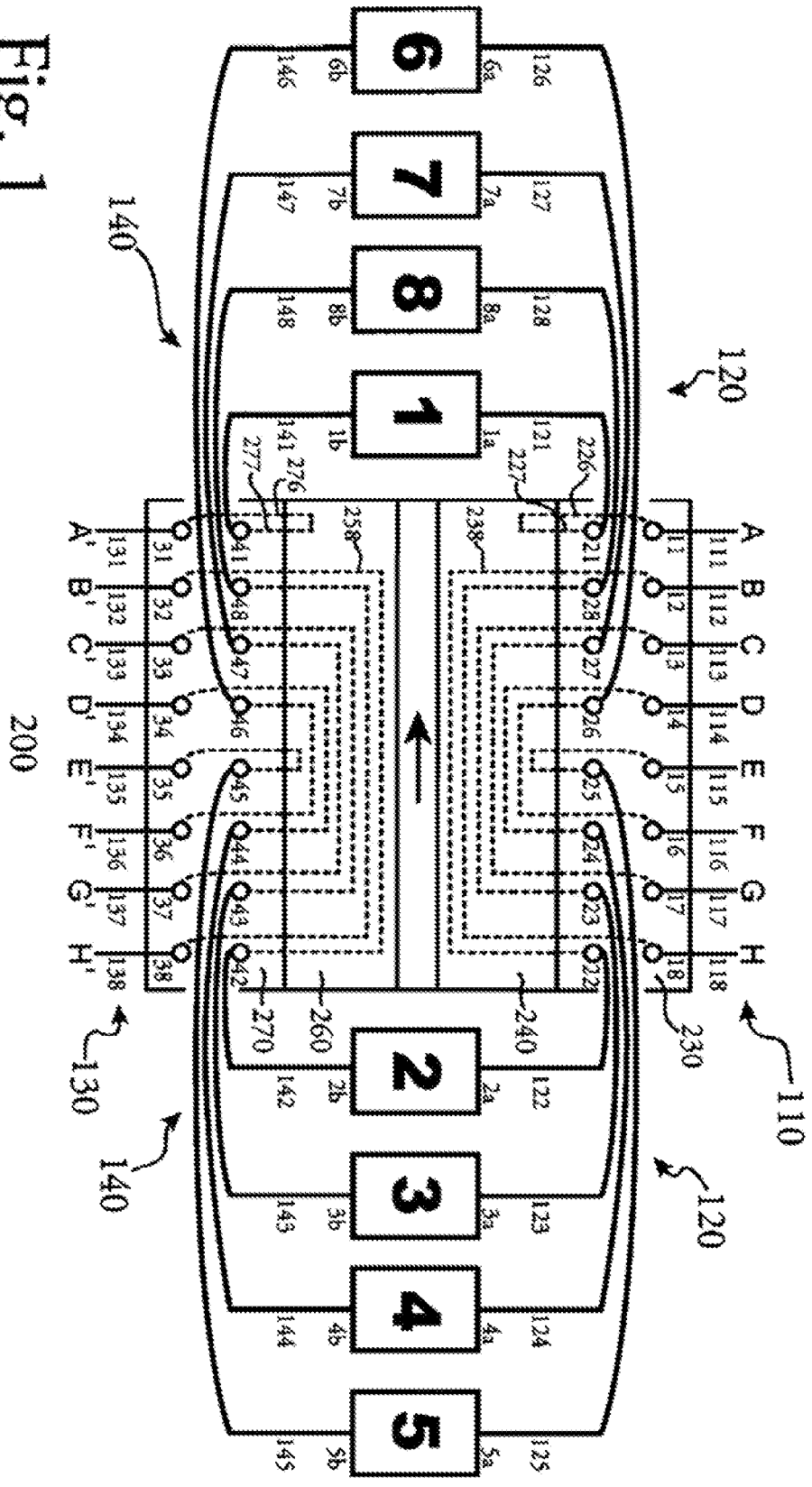
20. The multiport valve of claim 16 wherein each outer rotating port and a corresponding recess are located at a same outer point along the length of the corresponding recess of the outer rotating port and wherein each inner rotating port and a corresponding recess are located at a same inner point along the length of the corresponding recess of the inner rotating port.

21. The multiport valve of claim 16 wherein each of said fixed ports has a diameter wherein each of said fixed ports further comprises an arcuate obround-shaped recess aligned along the respective inner and outer concentric circles with each recess having a width corresponding to the diameter of each fixed port and having a length such that the space between each equidistant recess from an adjacent recess is approximately less than or equal to the cross-sectional area of each fixed port.

22. The multiport valve of claim 21 wherein each outer fixed port and its corresponding recess are located at a same outer point along the length of its corresponding recess and wherein each inner fixed port and its corresponding recess are located at a same inner point along the length of its corresponding recess.

23. The multiport valve of claim 16 wherein each outer fixed port and a corresponding recess are located at a same outer point along the length of the corresponding recess of the outer fixed port and wherein each inner fixed port and a corresponding recess are located at a same inner point along the length of the corresponding recess of the inner fixed port.

Fig. 1



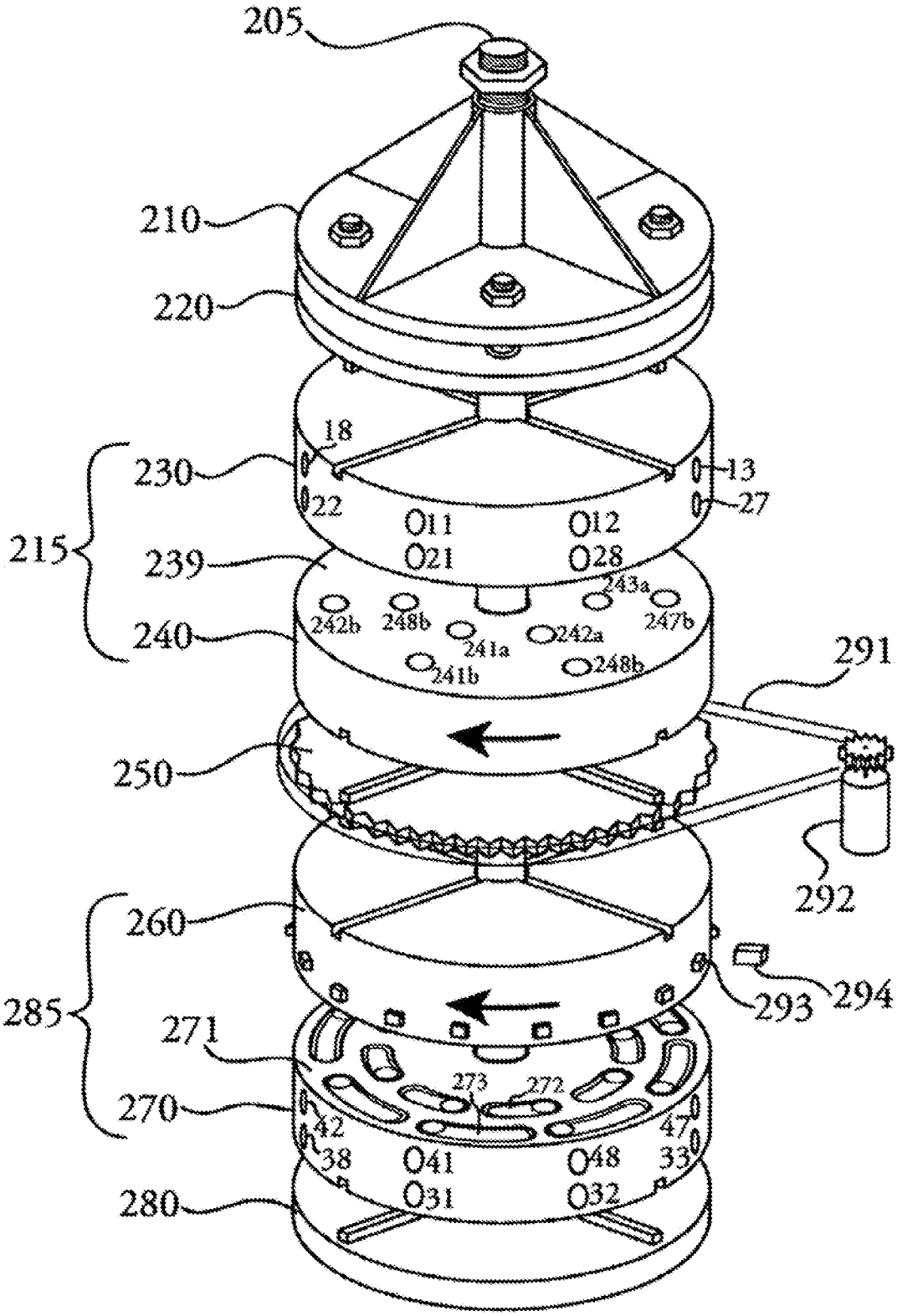

205
210
220
18
230
13
22
27
215
O11
O12
239
O21
O28
243a
240
242b
248b
241a
242a
247b
241b
248b
291
250
292
260
285
293
294
271
273
272
270
42
47
38
O41
O48
33
280
O31
O32

Fig. 2

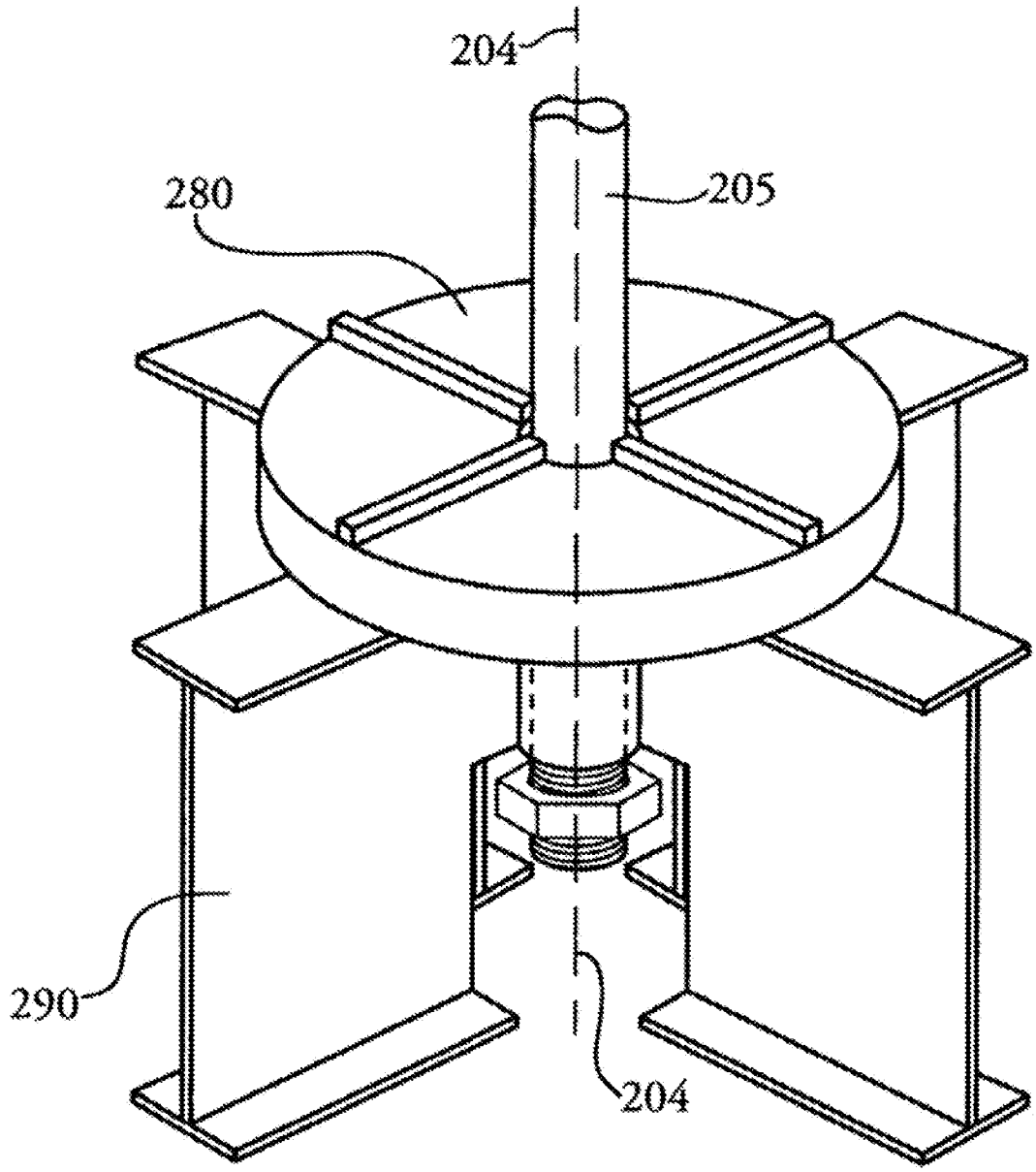


Fig. 2b

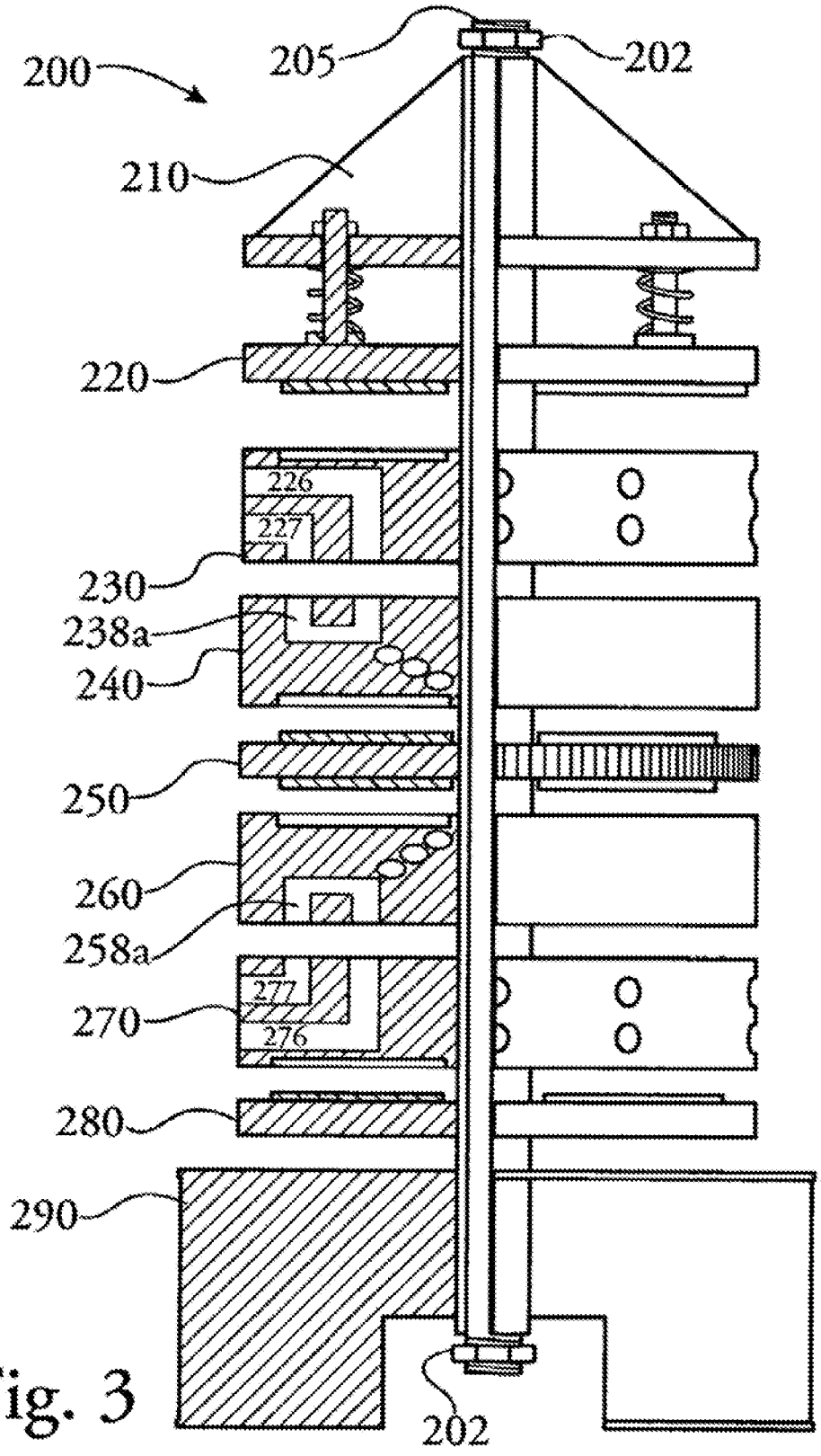

200
205
202
210
220
226
227
230
238a
240
250
260
258a
277
270
276
280
290
202

Fig. 3

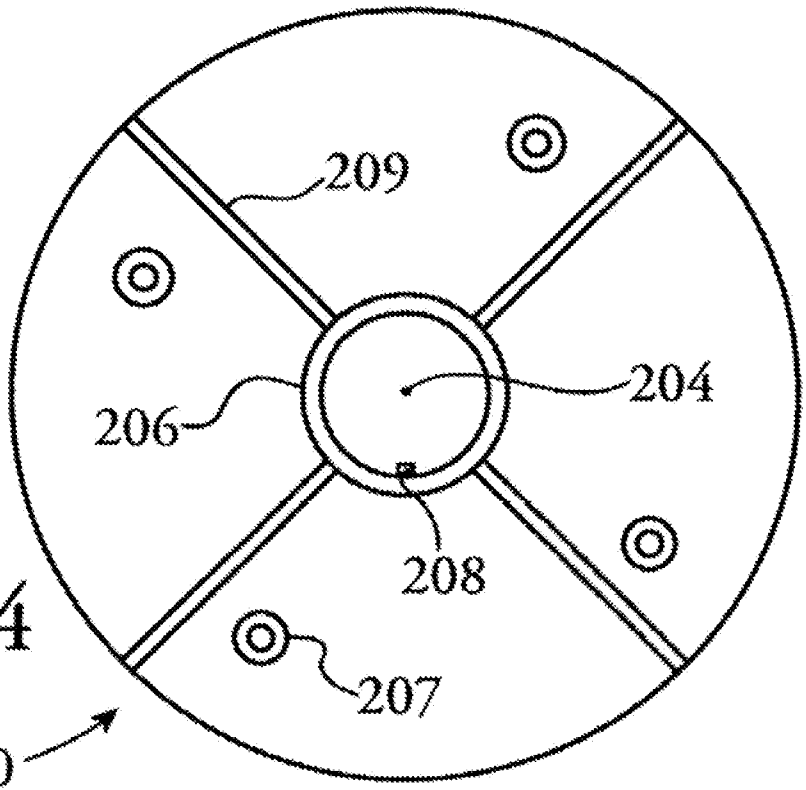


Fig. 4

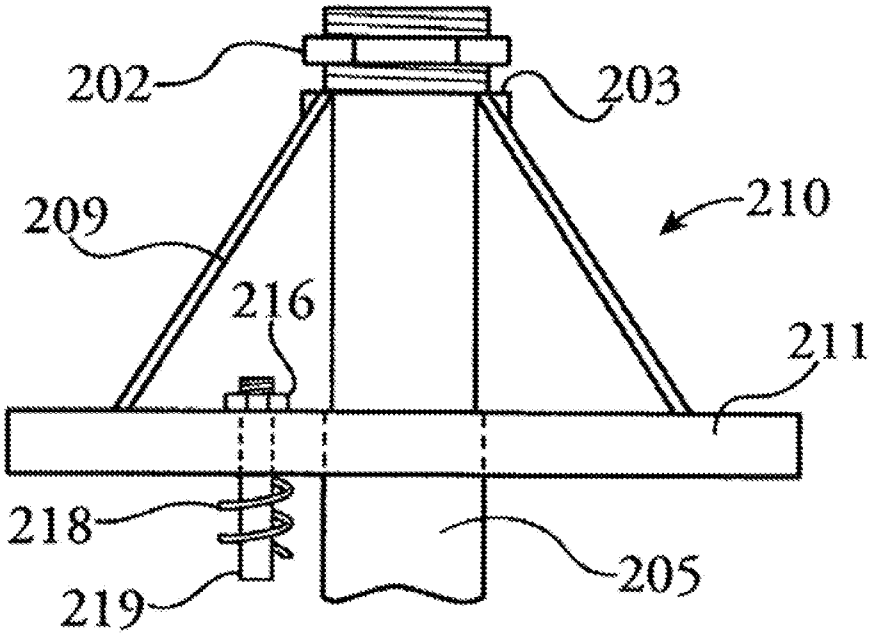


Fig. 5

Fig. 6

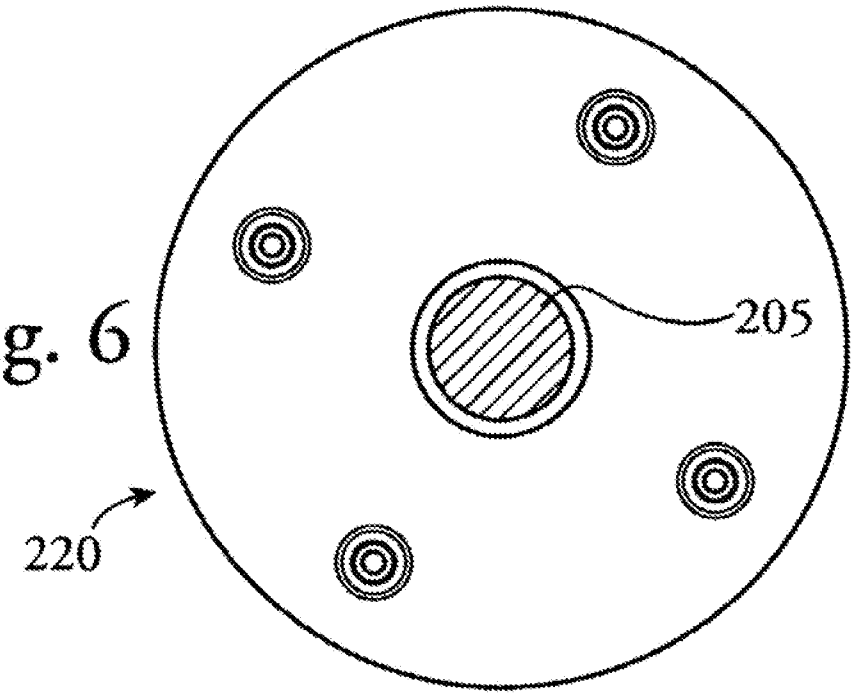


Fig. 7

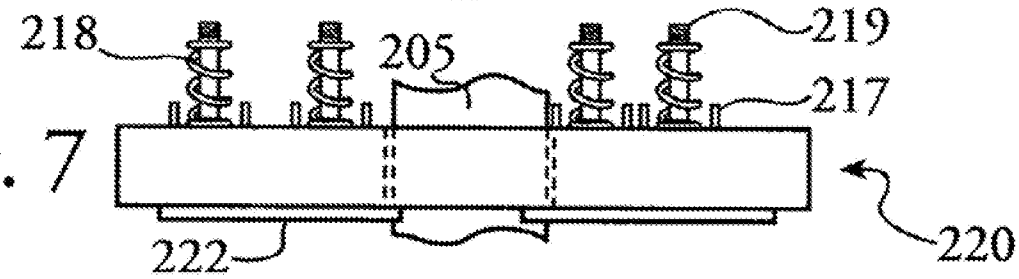
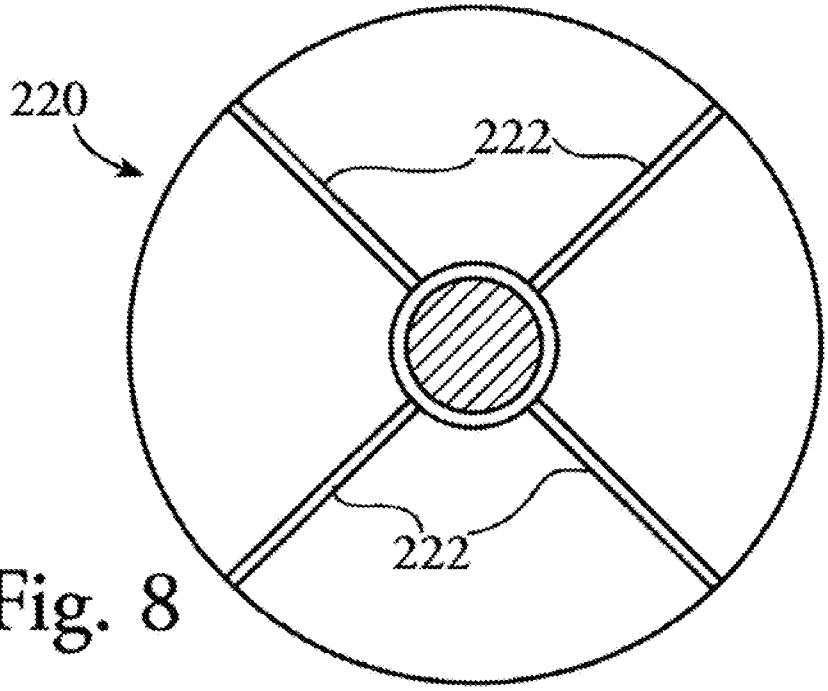


Fig. 8



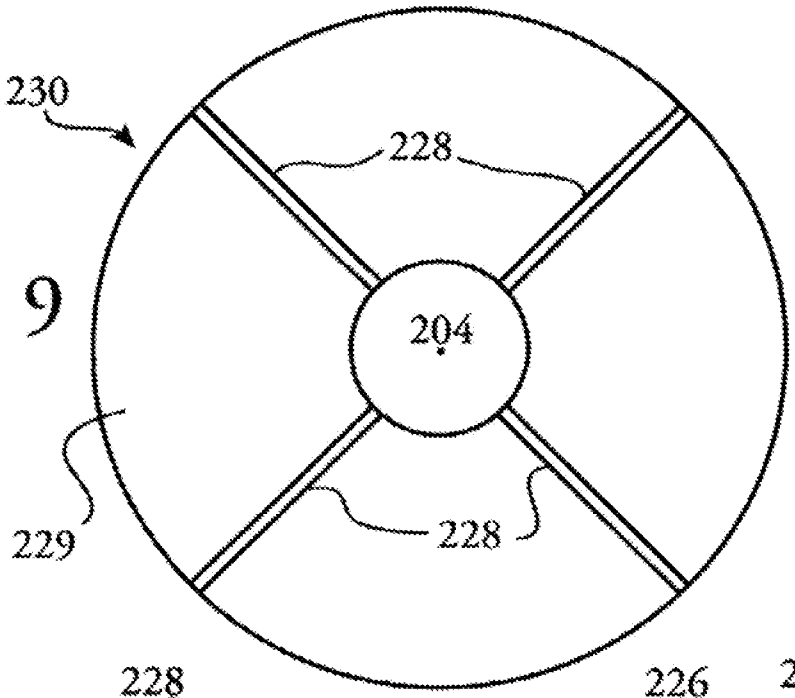


Fig. 9

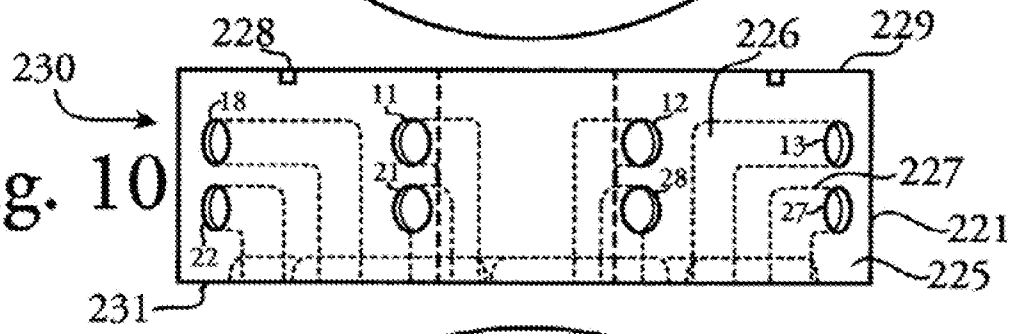


Fig. 10

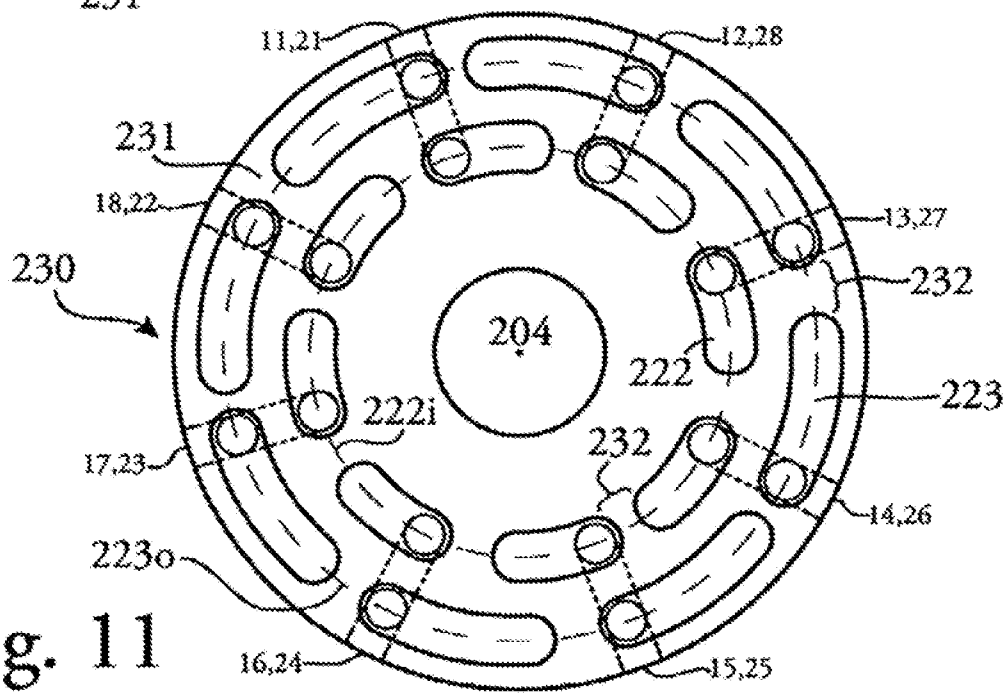


Fig. 11

Fig. 12

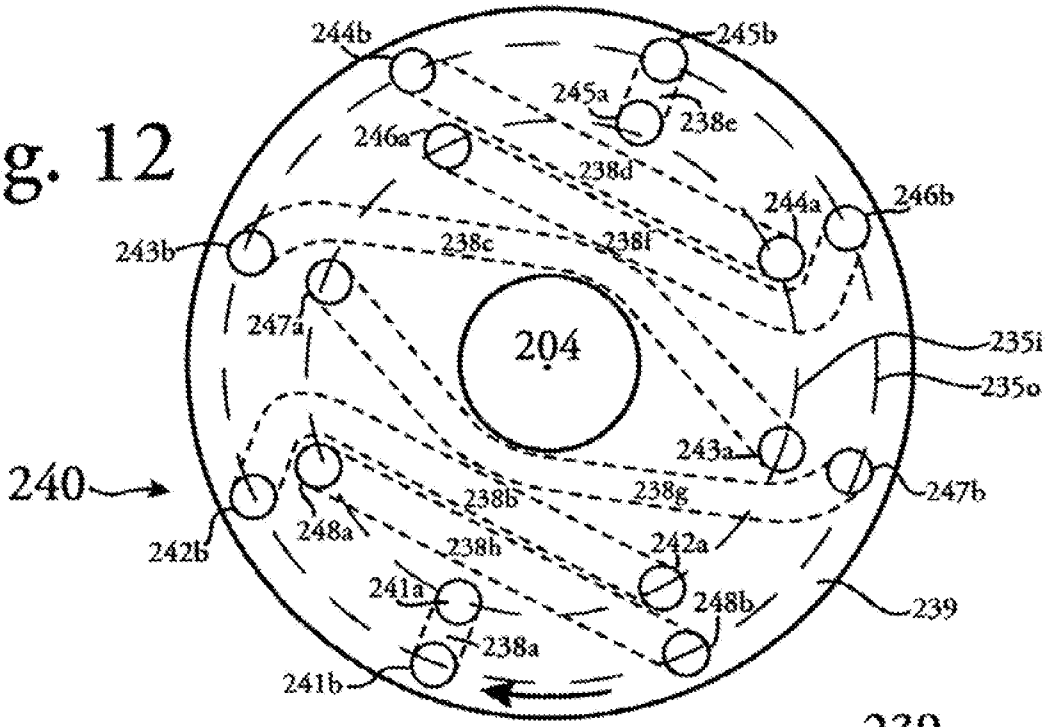


Fig. 13

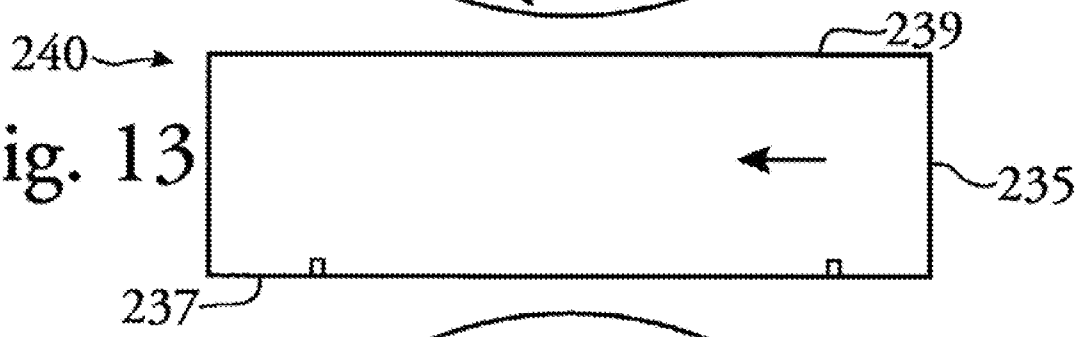


Fig. 14

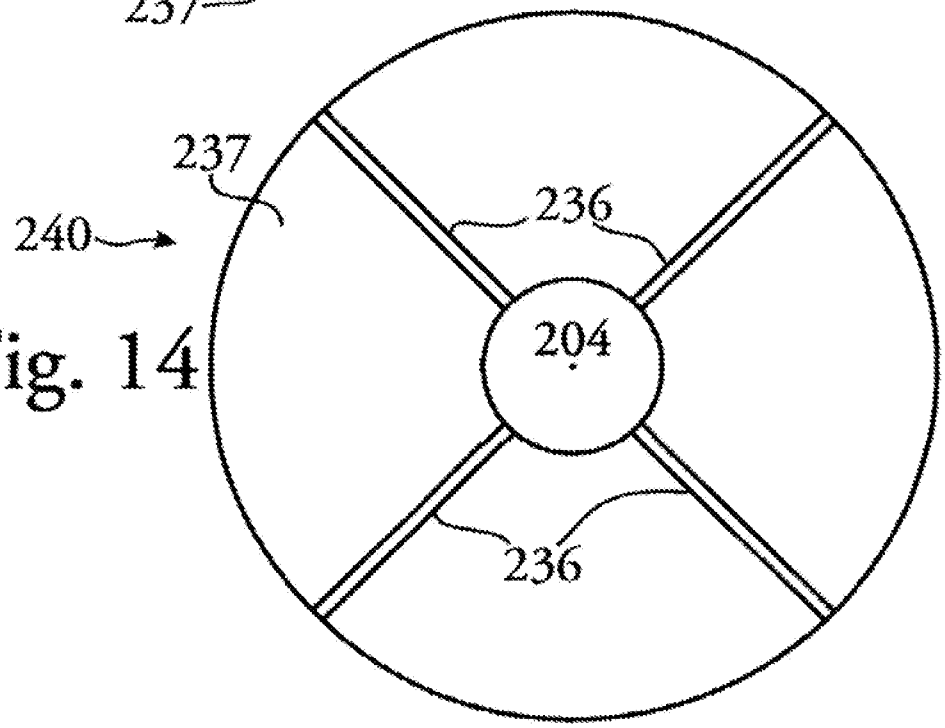


Fig. 15

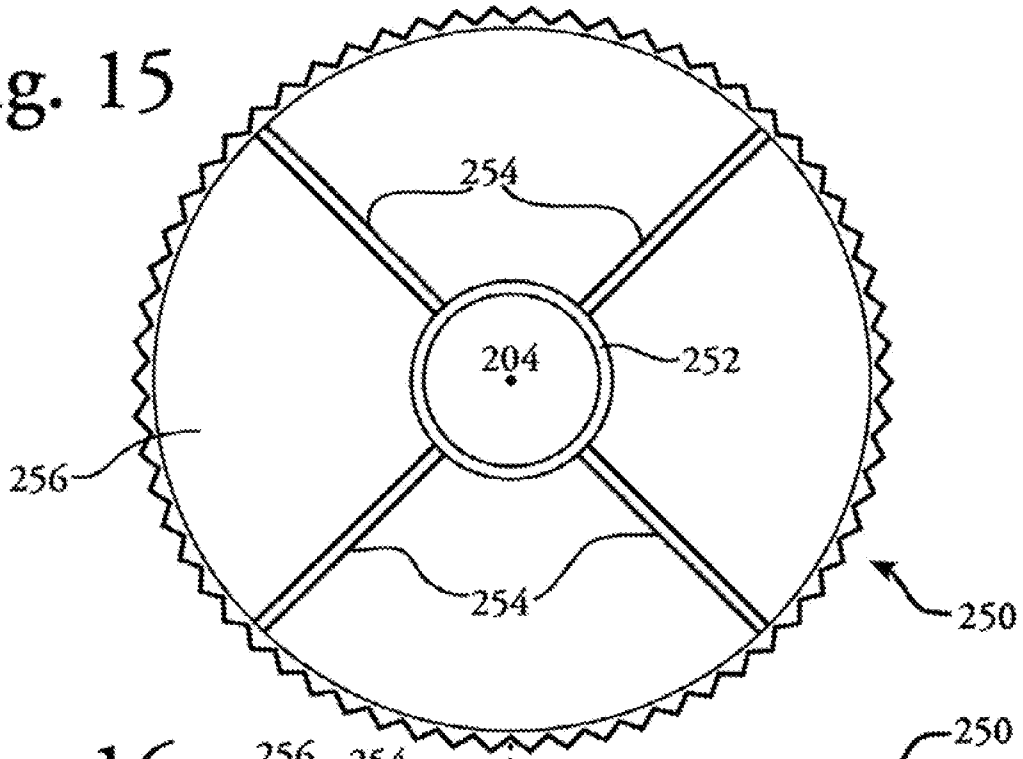


Fig. 16

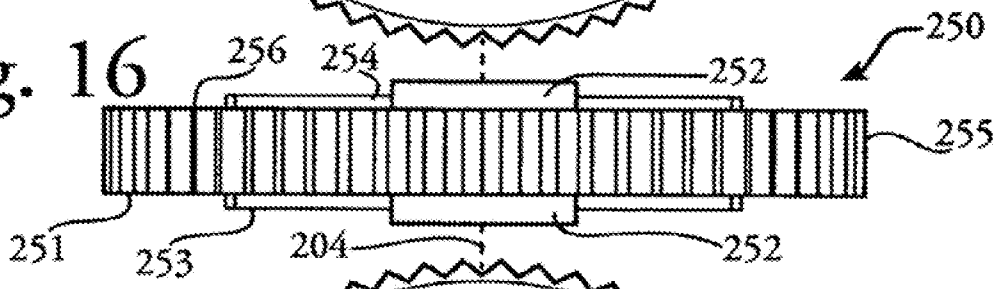


Fig. 17

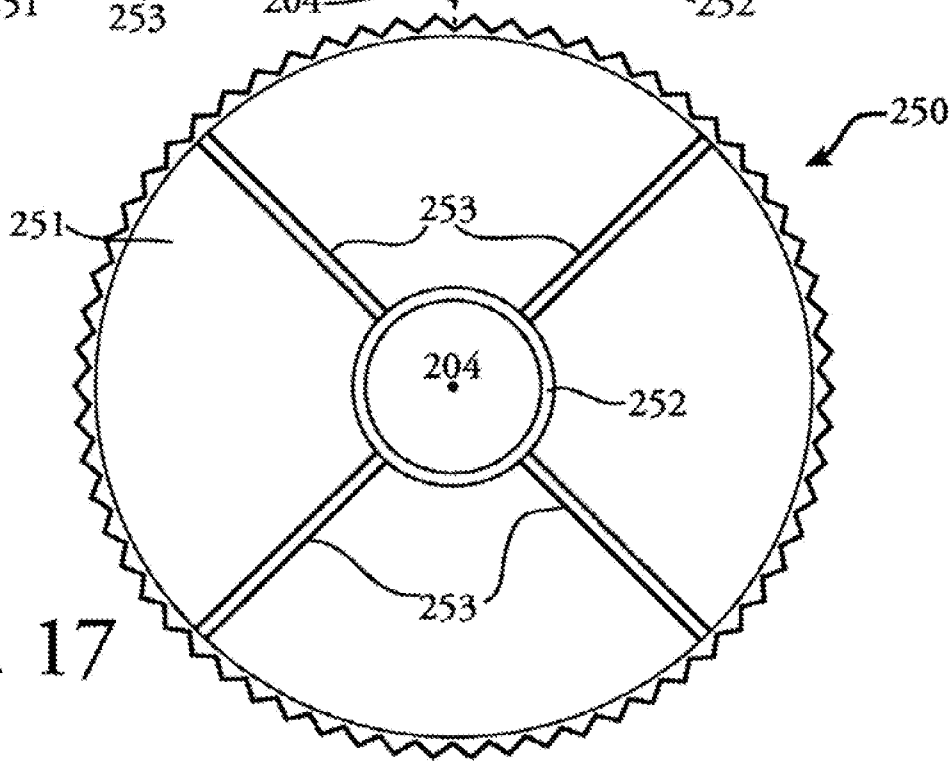


Fig. 18

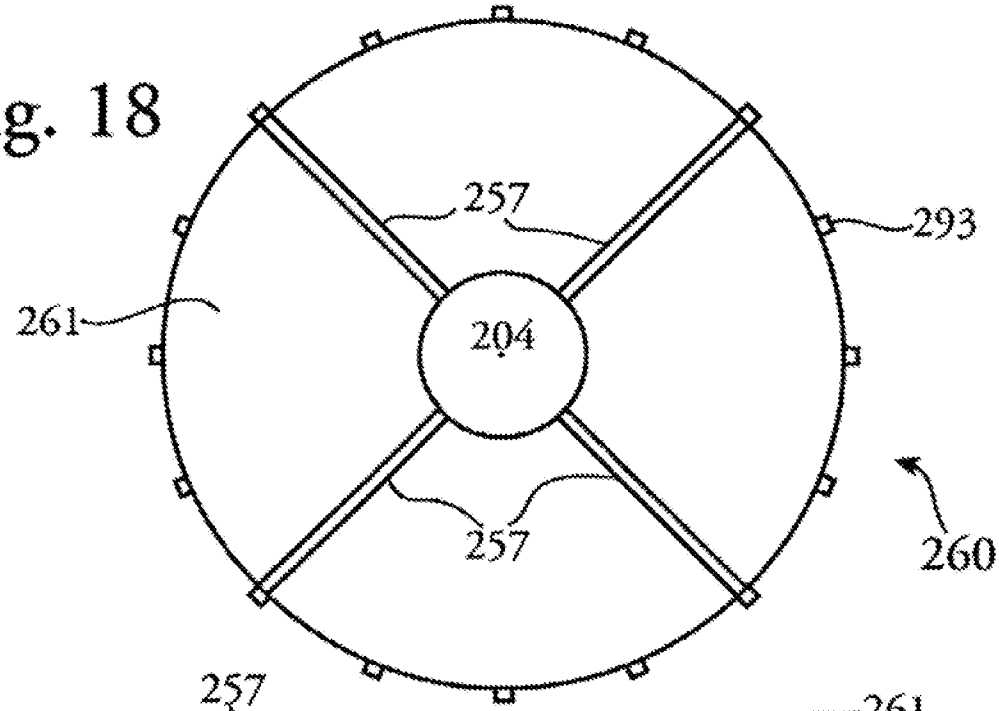


Fig. 19

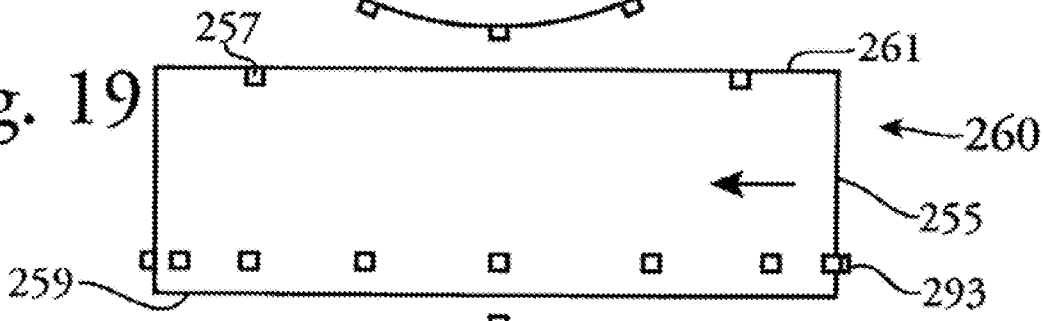


Fig. 20

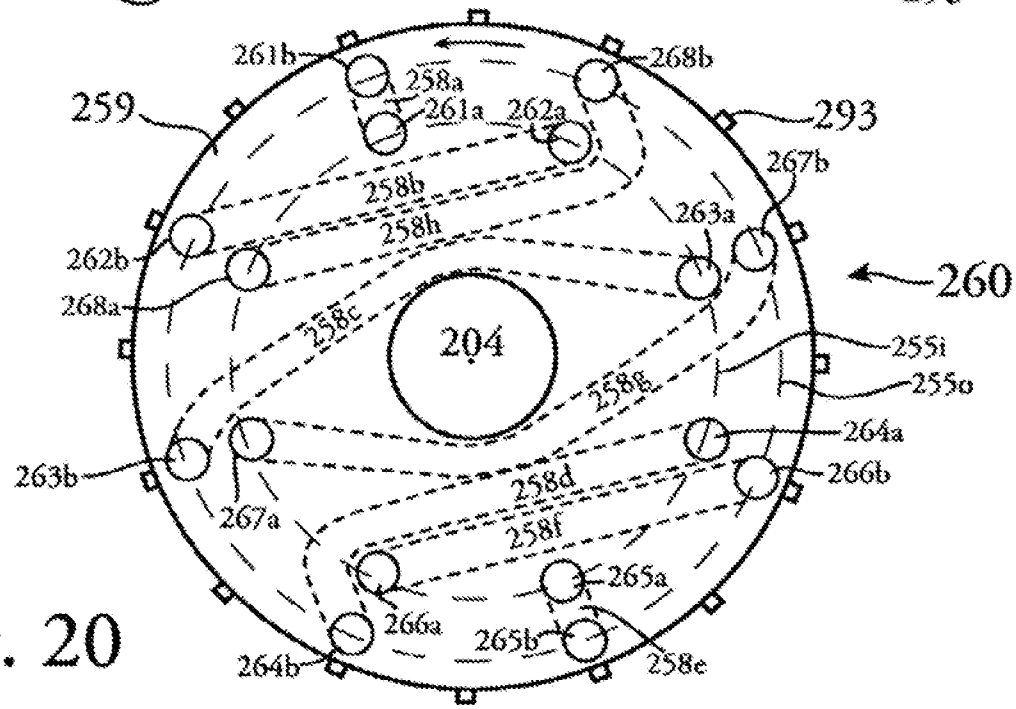


Fig. 21

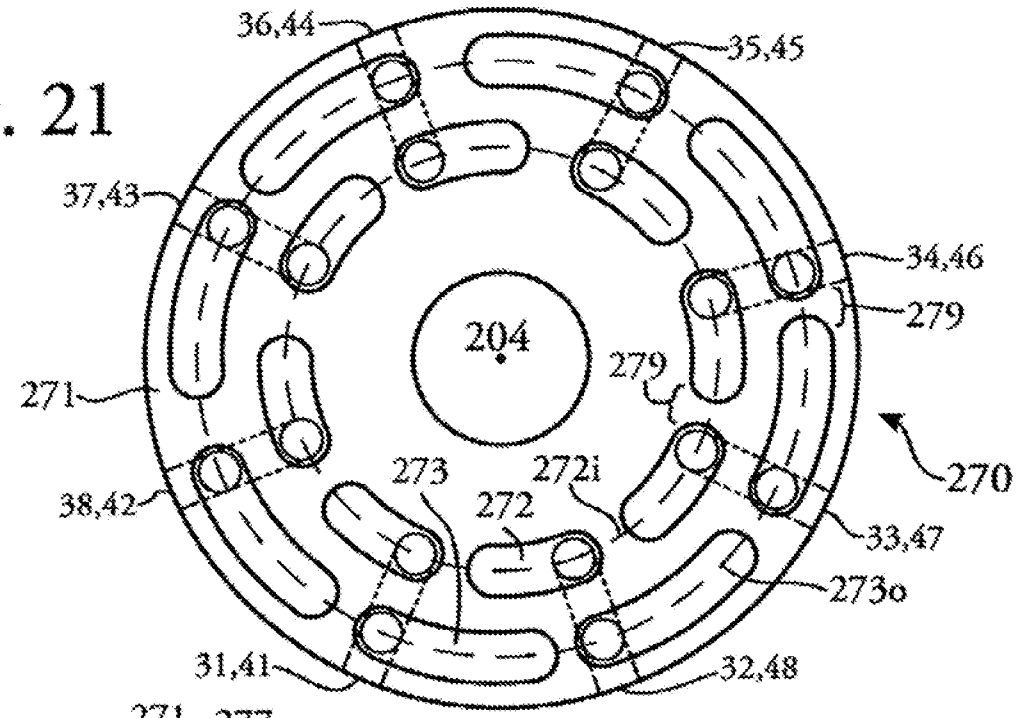


Fig. 22

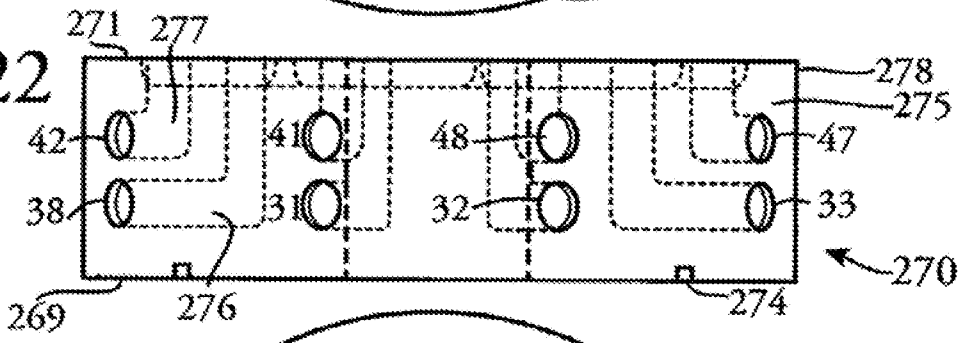


Fig. 23

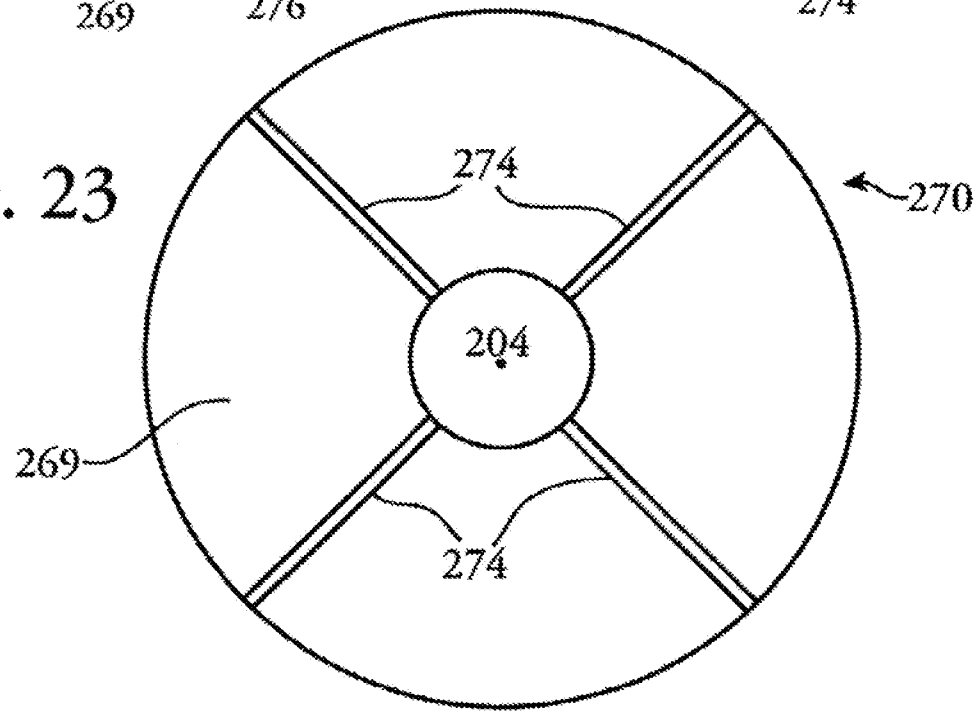


Fig. 24

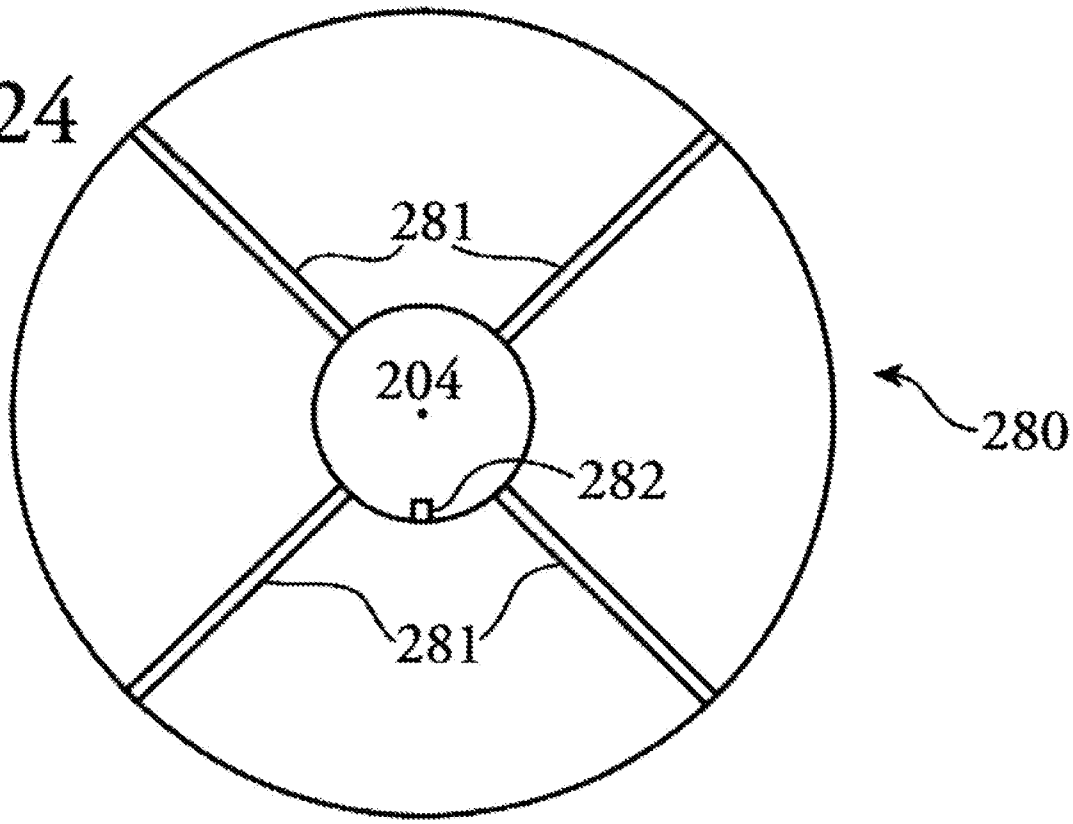
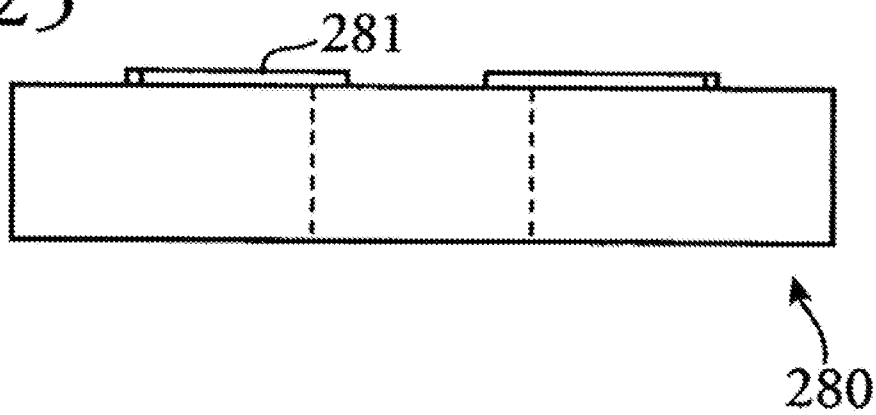


Fig. 25



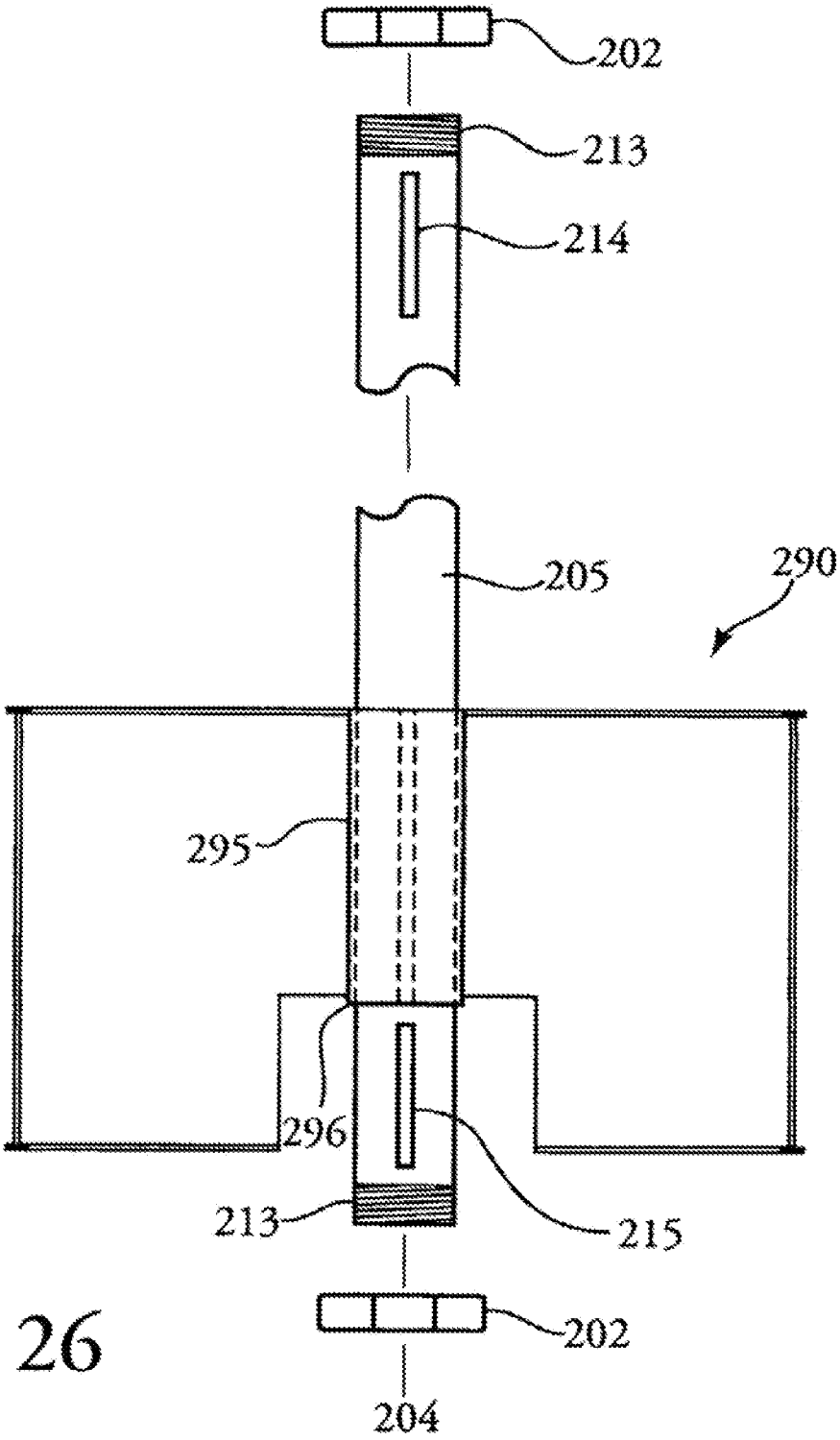


Fig. 26

Fig. 27

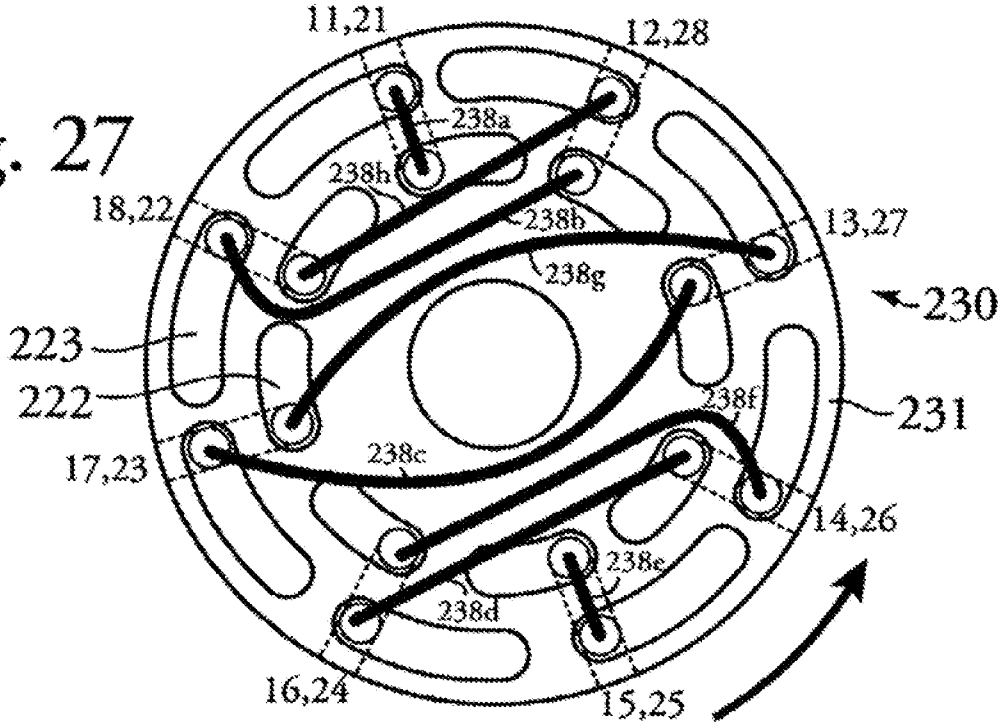
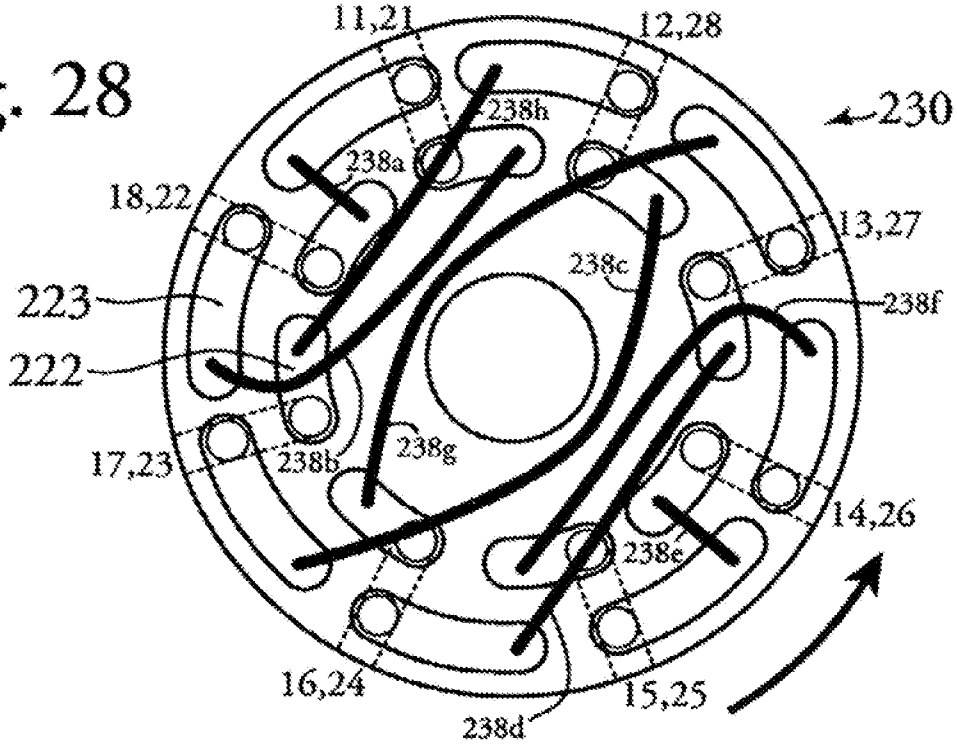

11,21
12,28
238a
238h
18,22
238b
13,27
238g
230
223
222
238f
231
17,23
238c
14,26
238e
238d
16,24
15,25

Fig. 28


11,21
12,28
238h
230
238a
18,22
13,27
238c
223
238f
222
17,23
238b
238g
14,26
238e
16,24
15,25
238d

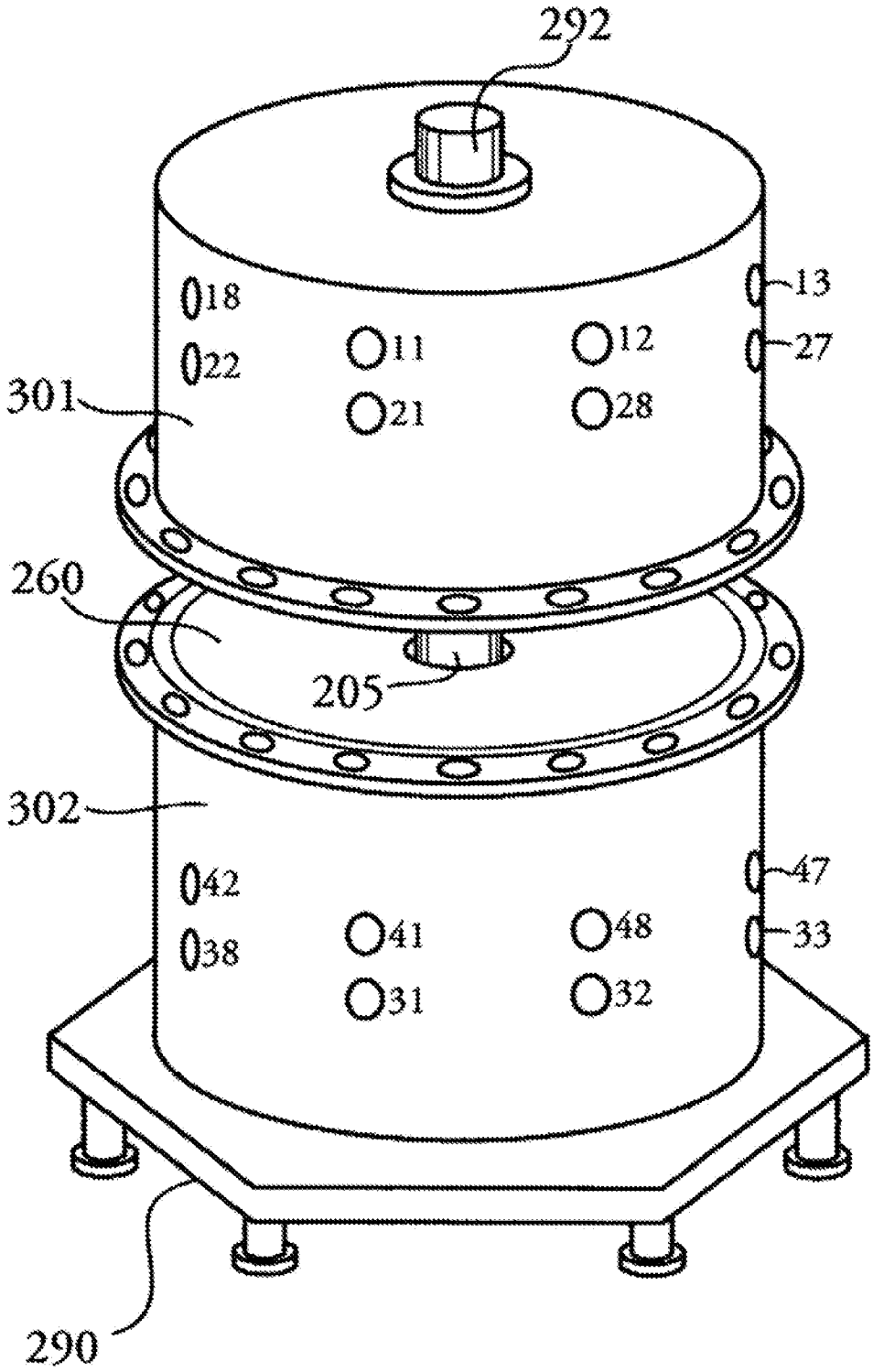

292
18
22
11
12
21
28
13
27
301
260
205
302
42
38
41
48
31
32
47
33
290

Fig. 29

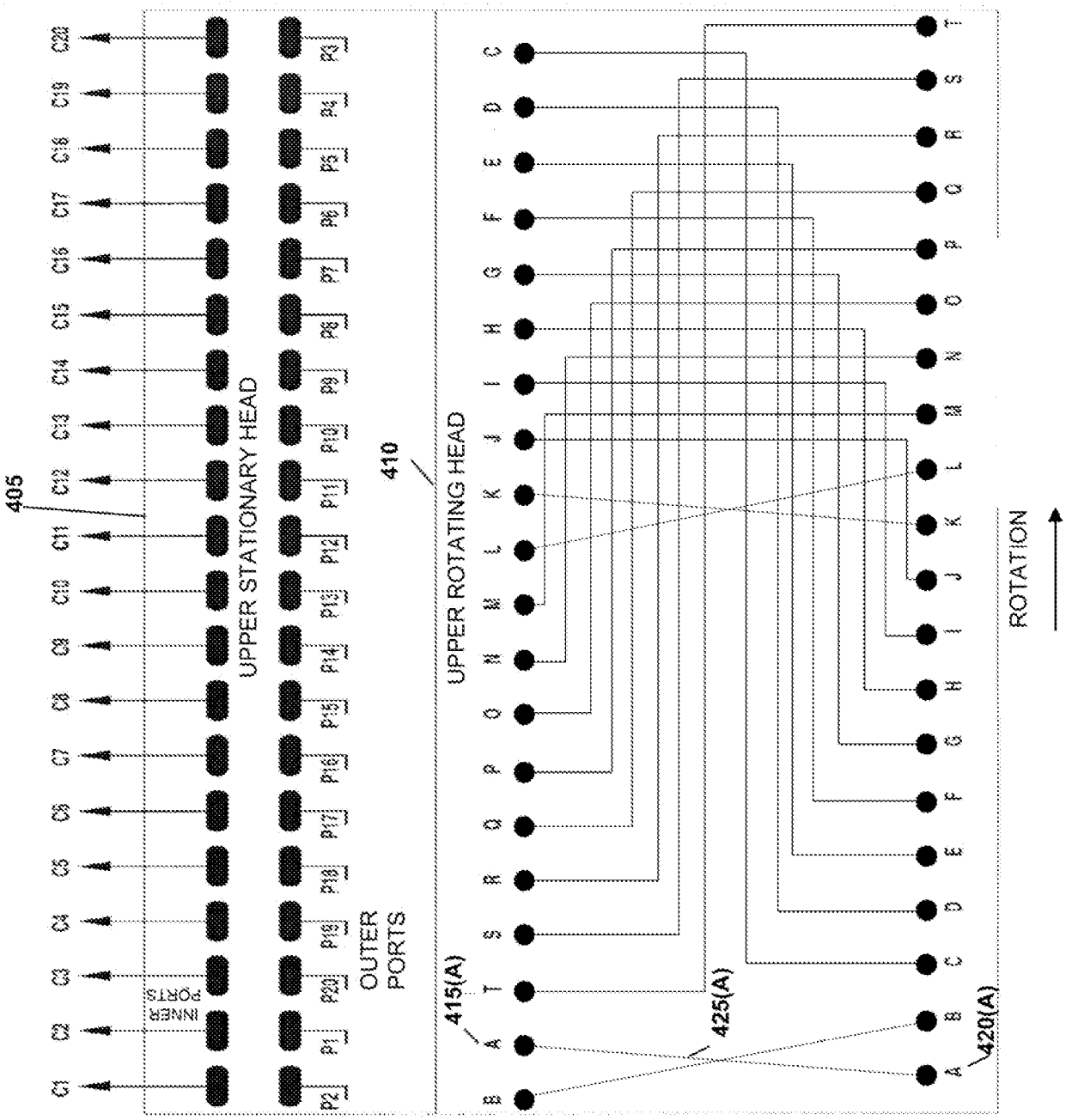

405
UPPER STATIONARY HEAD
INNER PORTS
OUTER PORTS
410
UPPER ROTATING HEAD
415(A)
425(A)
420(A)
ROTATION

FIG. 30A

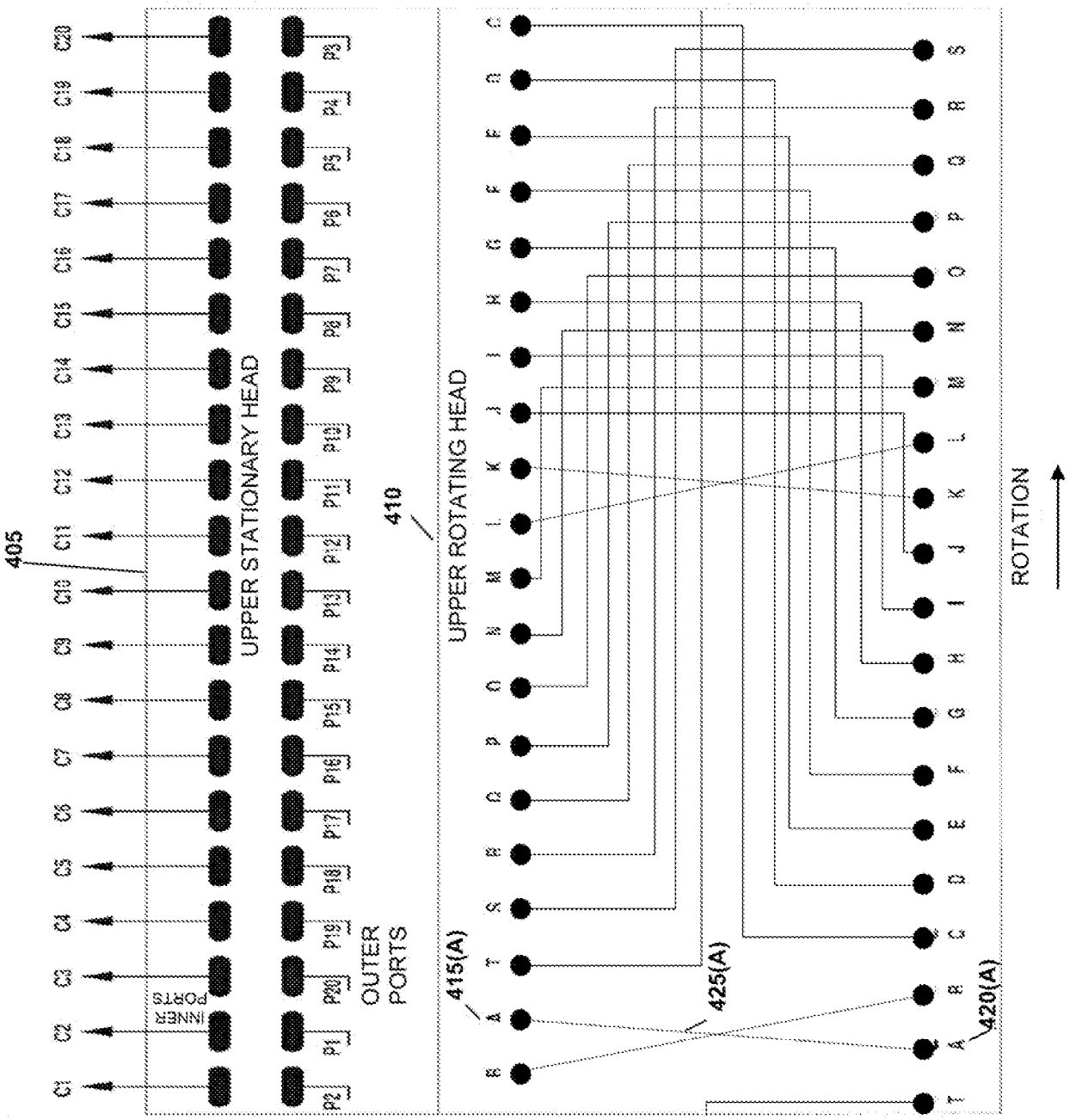

405
410
UPPER STATIONARY HEAD
UPPER ROTATING HEAD
INNER PORTS
OUTER PORTS
415(A)
425(A)
420(A)
ROTATION

FIG. 30B

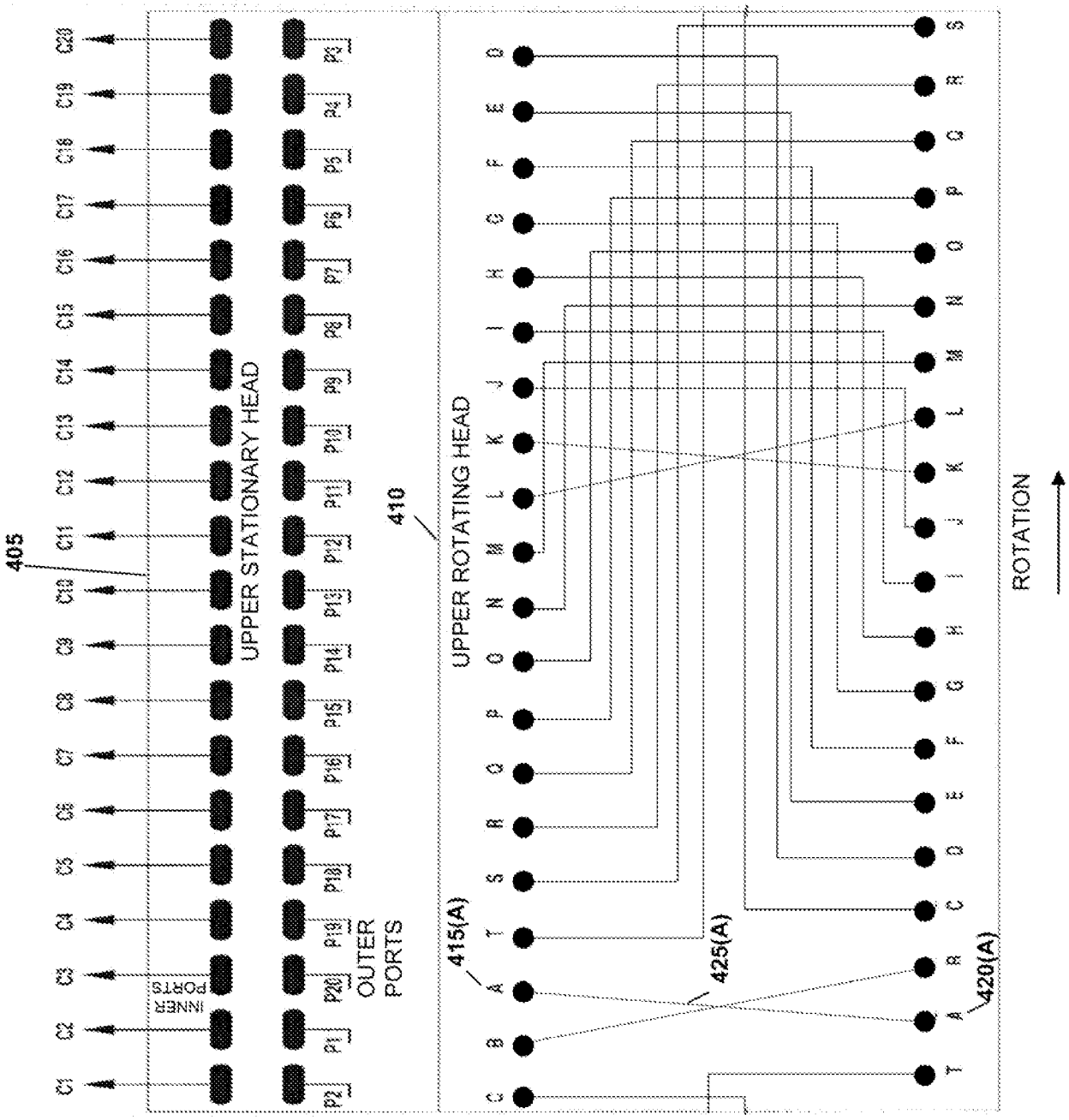

405
410
UPPER STATIONARY HEAD
UPPER ROTATING HEAD
INNER PORTS
OUTER PORTS
415(A)
425(A)
420(A)
ROTATION

FIG. 30C

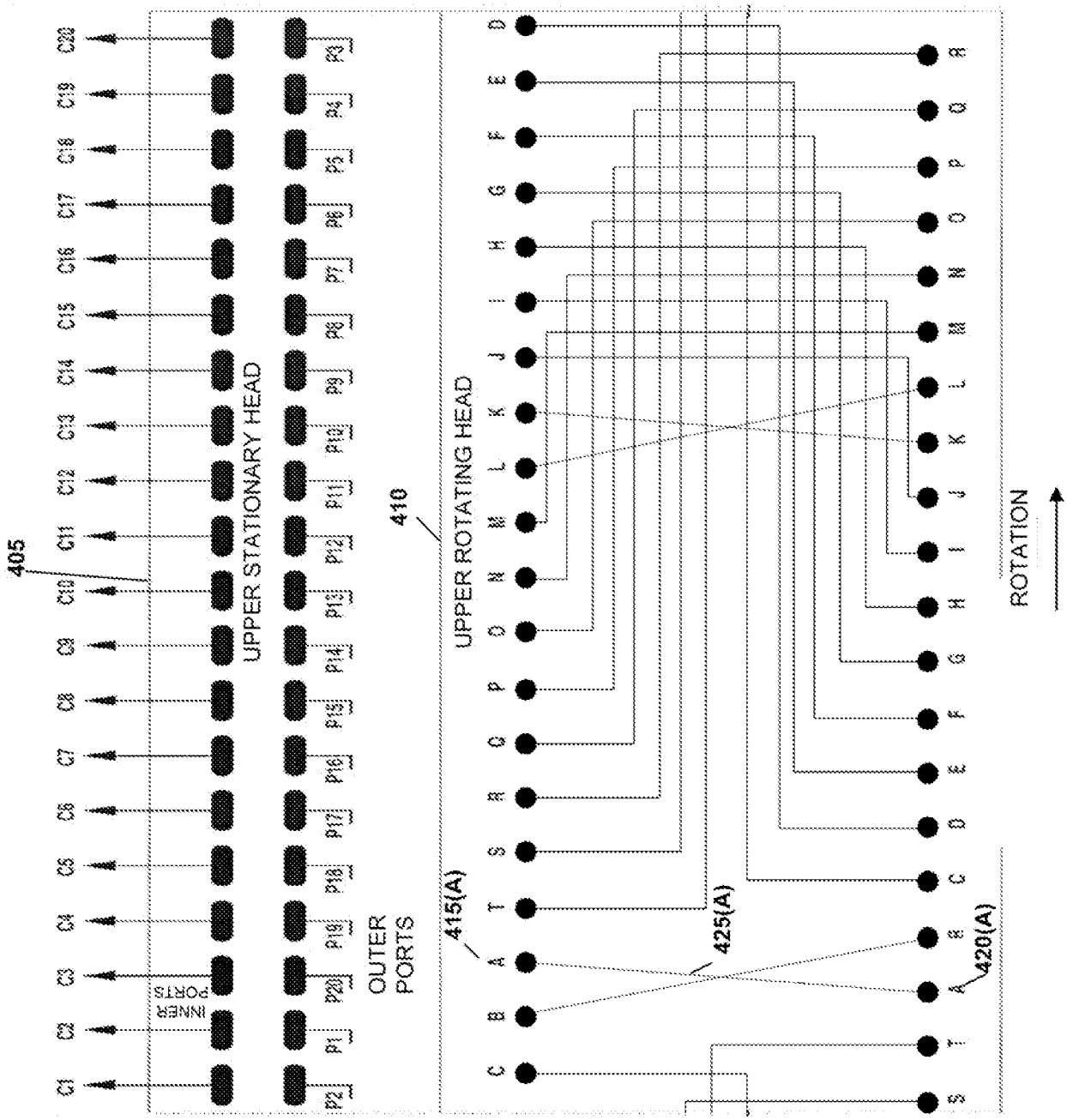

405
410
UPPER STATIONARY HEAD
UPPER ROTATING HEAD
INNER PORTS
OUTER PORTS
415(A)
425(A)
420(A)
ROTATION

FIG. 30D

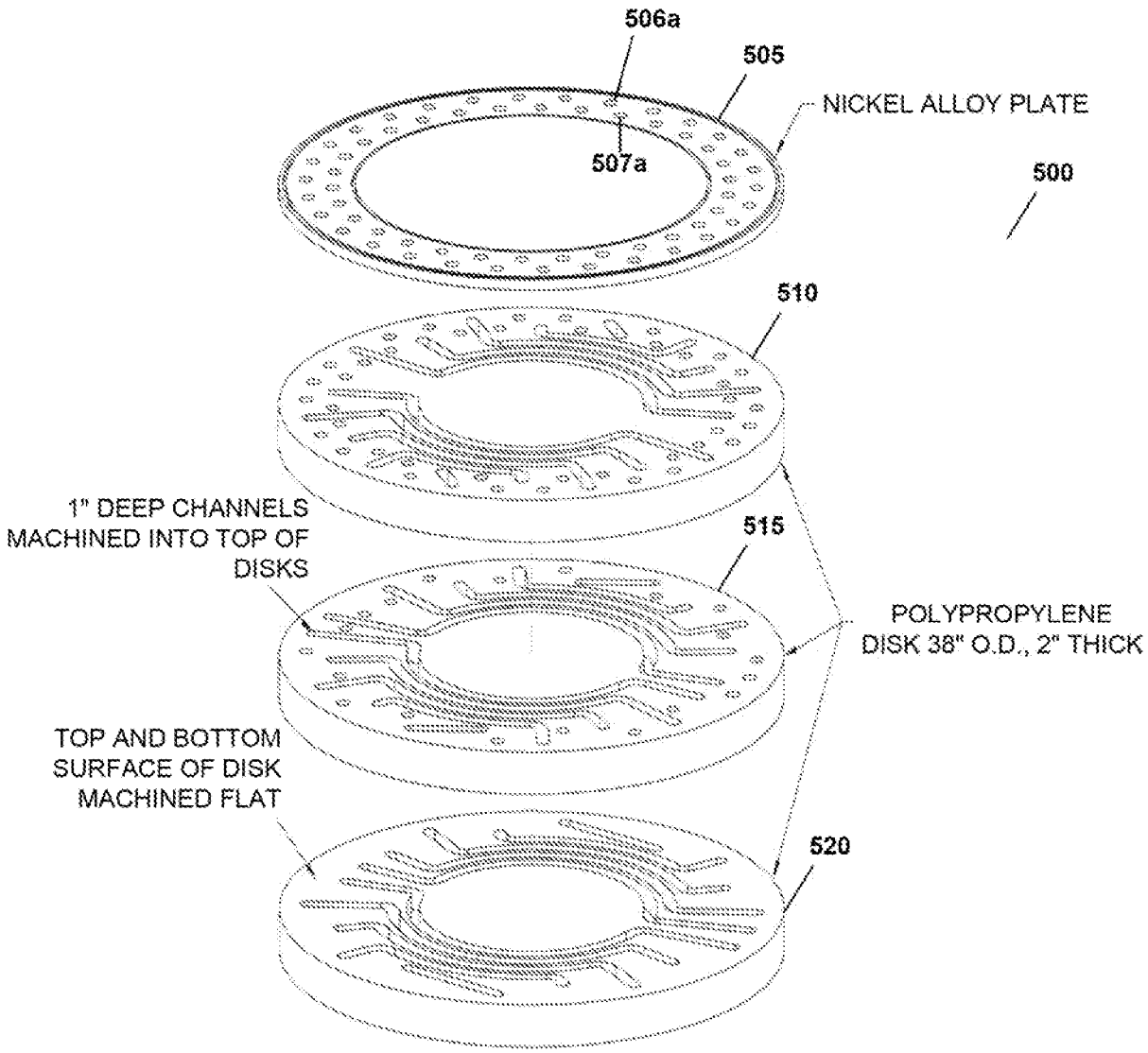

506a
505
NICKEL ALLOY PLATE
507a
500
510
1" DEEP CHANNELS MACHINED INTO TOP OF DISKS
515
POLYPROPYLENE DISK 38" O.D., 2" THICK
TOP AND BOTTOM SURFACE OF DISK MACHINED FLAT
520

FIG. 31

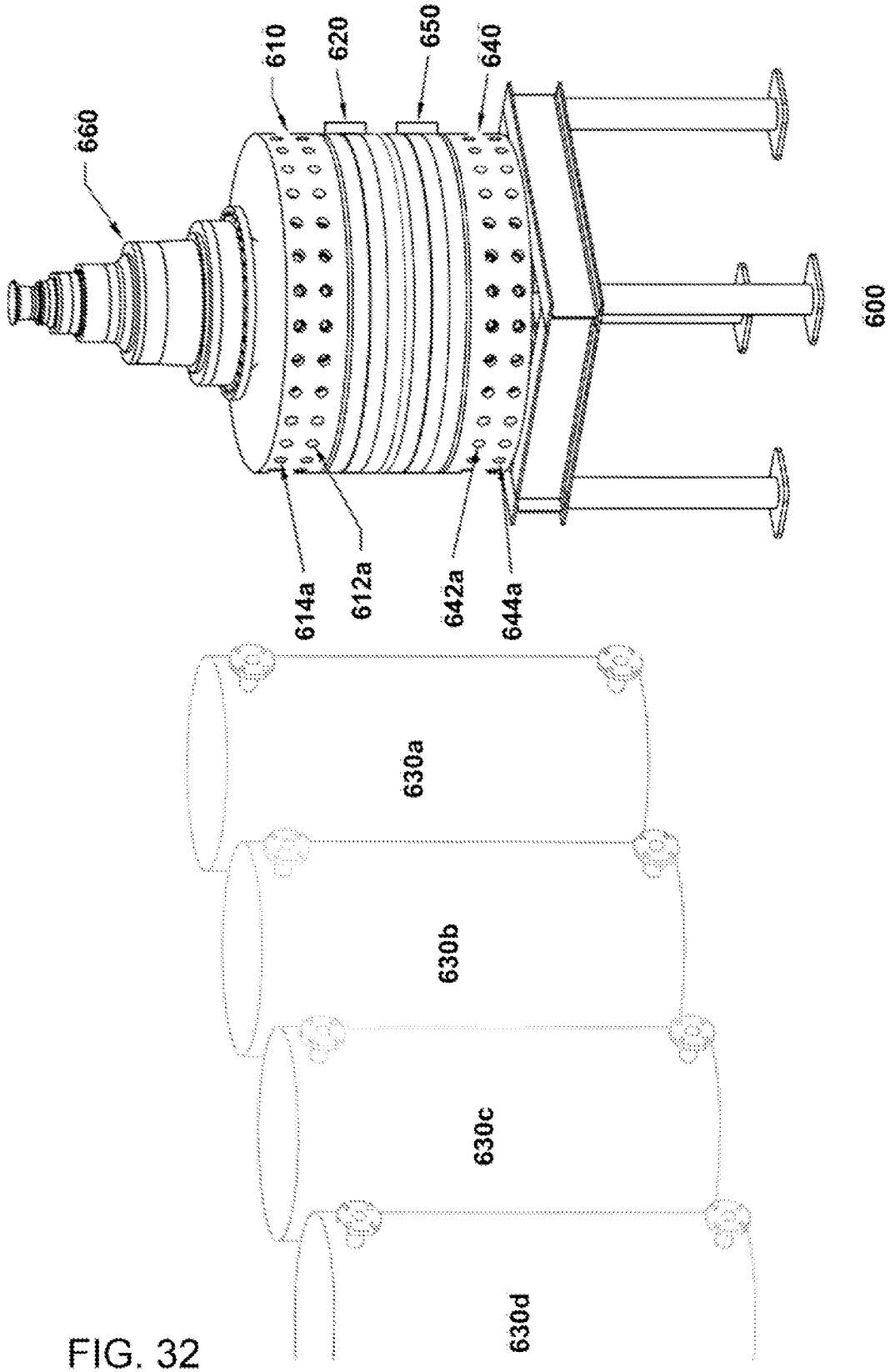

660
610
620
650
640
600
614a
612a
642a
644a
630a
630b
630c
630d

FIG. 32

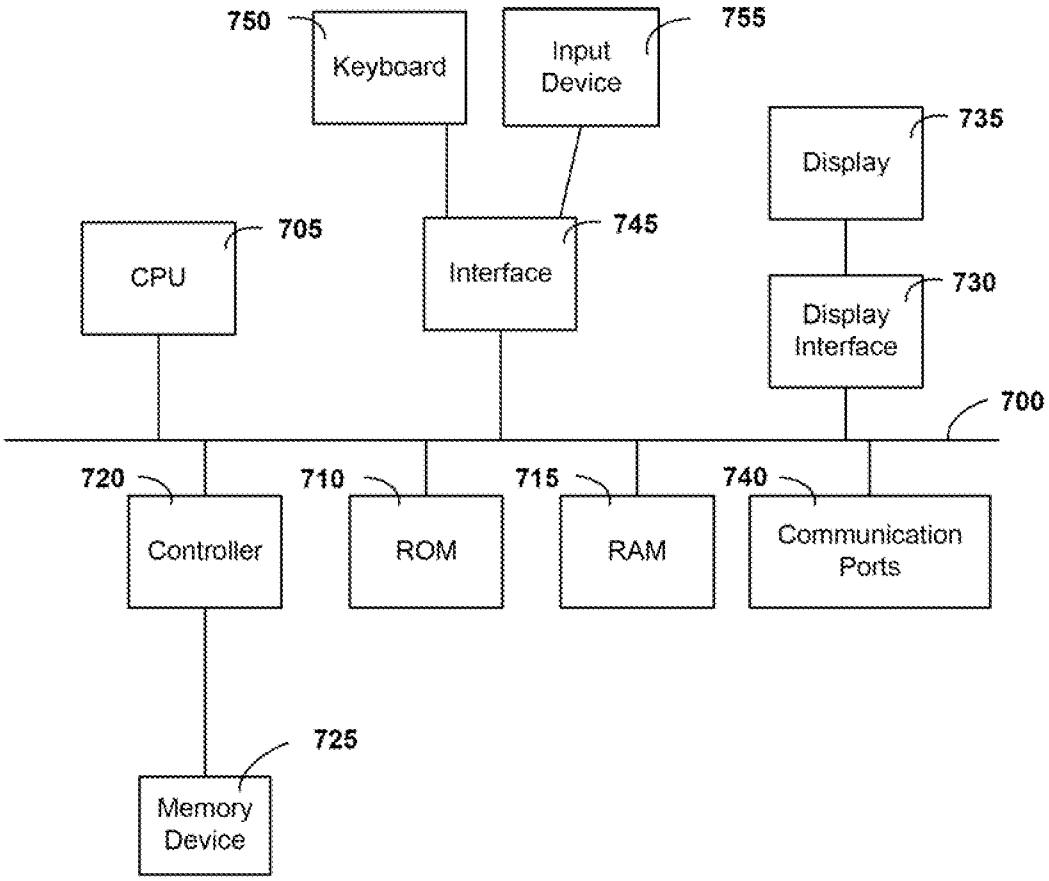

750
Keyboard
Input Device
755
Display
735
CPU
705
Interface
745
Display Interface
730
700
720
Controller
710
ROM
715
RAM
740
Communication Ports
725
Memory Device

FIG. 33