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(54) **Title:** MULTIPLE-VENTURI NOZZLE, SYSTEM, METHOD OF MANUFACTURE AND METHOD OF USE

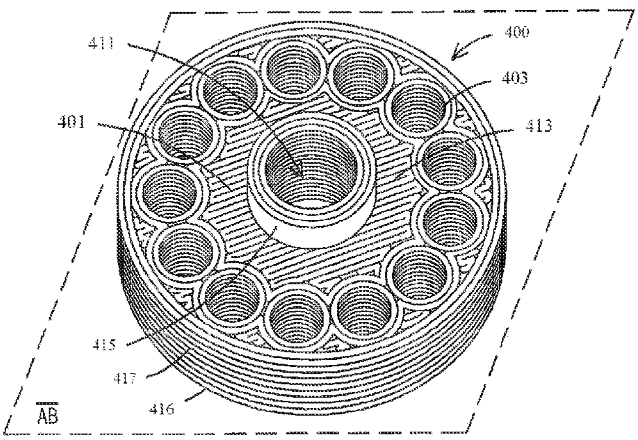

FIG. 11A

(57) **Abstract:** The first object of the present invention is directed to a High Flow Venturi Nozzle capable of diffusing gas into a large quantity of fast-moving liquid. Another object of the present invention is directed to a two-piece High Flow Venturi Nozzle assembly. Another object of the present invention is directed to a method of manufacturing and using the two embodiments noted above. The second object of the instant invention includes a multiple-Venturi nozzle and a system, method of manufacture and method of using same.

WO 2022/236191 A2

MULTIPLE-VENTURI NOZZLE, SYSTEM, METHOD OF MANUFACTURE AND METHOD OF USE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Application No. 17/585,541 filed January 26, 2022, which is a continuation-in-part of U.S. patent application serial number 17/308,742 filed on May 5, 2021, which the present application also claims priority.

[0002] The entire disclosure of both U.S. Application No. 17/585,541 and U.S. Application No. 17/308,742 are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

[0003] First discovered by the Italian physicist Giovanni Battista Venturi in 1797, the "Venturi effect" is the name for a natural phenomenon that sees a reduction in fluid pressure when a fluid flows through a constricted section (or choke) of a pipe. In an idealize state, an incompressible fluid's: (a) velocity must increase as it passes through a constriction under the principle of mass continuity; and (b) static pressure must decrease as it passes through a constriction under the principle of conservation of mechanical energy (i.e., Bernoulli's principle). Put another way, any "gain" in kinetic energy a fluid attains by its increased velocity through a constriction is balanced by a "drop" in pressure.

[0004] The Venturi effect has a number of practical applications wherein a Venturi nozzle takes advantage of the above-mentioned pressure drop to mix gas and liquid; including: aerators, atomizers, and carburetors. In the case of mixing oxygen into water, a Venturi microbubble generator can be used to create a large number of very small bubbles; accomplishing several things. First, the size of the bubbles allows such bubbles to remain suspended in the water for longer periods - increasing the amount of oxygen which will dissolve into the water. Second, the small sized bubbles have a very high surface area to volume ratio - increasing the amount of oxygen which will dissolve into the water by increasing the total effective surface area of air in contact with water.

[0005] Historically, various attempts were made to use more than one Venturi nozzle in combination with one another. One such attempt is disclosed in UK Patent Application GB2439380A (Priest) which teaches an aeration apparatus which makes use of the Venturi effect.

[0006] Another such attempt is disclosed in CN 202492409U (Jia) which teaches a Venturi-type radial jet aerator which makes use of more than one Venturi nozzle.

[0007] Another such attempt is disclosed in US 4,966,001 (Beebe) which teaches a multiple Venturi tube gas fuel injector for a catalytic combustor.

[0008] Another such attempt is disclosed in US 7,854,637 (Schultz) which teaches a multiple Venturi nozzle system for watercraft.

[0009] Another such attempt is disclosed in US 2,797,904 (Voorheis) which teaches a multiple Venturi air scrubber.

[0010] Another such attempt is disclosed in US 2,760,371 (Borden) which teaches a multiple Venturi tube.

[0011] Another such apparatus for exploring oxygenation effect of multiple Venturi air ejectors CN203869853U (Xiangju) which discloses a test apparatus for exploring the oxygenation effect of multiple Venturi air ejectors.

SUMMARY OF THE INVENTION

[0012] The first main object of the present invention is directed to a High Flow Venturi Nozzle ("HFVN") apparatus capable of diffusing gas into a large quantity of fast-moving liquid. The HFVN has a high flow relative to the Multiple-Venturi Nozzle (as discussed below). For example, in many water-treatment and aquacultural applications, it is necessary to diffuse air (or other gasses) into a fast-moving stream of water. As noted above, Traditional Venturi Nozzles generally are unable to do this;

however, the present invention is capable of accommodating a high flow rate while still accomplishing the task of diffusing gas into the high-flow liquid.

[0013] Another object of the present invention is an embodiment of the HFVN generally comprising: (a) a body having at least one choke extending through said body; (b) a manifold (to which an outside gas supply can be connected); (c) at least one manifold outlet connected to each choke; and (d) an internal "path" system connecting the manifold to each manifold outlet (and, thus, to each choke). In this way, when a gas is connected to the manifold (e.g., by connecting a gas supply to the manifold via a tube and using a manifold nipple), the gas will flow from the manifold, through the internal "path" system and out into the choke through the manifold outlets. Thus, when a fluid (especially a fluid which is flowing quickly) is passed through the chokes, a Venturi effect will occur at each manifold outlet.

[0014] Another object of the present invention is an HFVN Assembly generally comprising: (a) a female cap; and a (b) male cap; which is designed to be inserted into a pipe with a tee having a tee opening (commonly known as a "reducing tee"). The female cap has a body and a protruding flange. The female cap also has a centrally located hole which extends throughout both the body and the flange. The male cap likewise has a body, a protruding flange and a centrally located hole which extends throughout both the body and the flange. However, the male body further comprises at least one (preferably a plurality) of fins and manifold outlets. When the male and female caps are joined together inside a pipe: (i) they define a pocket of space whereby the tee opening is in fluid communion with the manifold outlets; and (ii) they form a type of "choke" since the female cap opening and the male cap opening align to form one continuing opening. This allows water (or some other liquid) to flow through the pipe – creating a Venturi effect at the manifold outlets. When the tee is connected to a gas source (e.g., air), such gas will be drawn into the pocket and through the manifold outlets where it will be diffused into the water (or other liquid).

[0015] Another object of the present invention is an HFVN Assembly wherein the manifold outlets further comprise a plurality of pinhole manifold outlets.

[0016] The second main object of the present invention is directed to a Multiple-Venturi Nozzle ("MVN") apparatus having: (a) a plurality of Venturi nozzles spaced around a central recess; (b) the central recess having pinhole oxygen lines to each of the Venturi nozzles so that a fluid passed through the MVN is mixed with a gas which flows out of the central recess through the pinhole oxygen lines - forming small bubbles. This increases the quantity of gas bubbles and reduces the size of gas bubbles (allowing for better dissolution of the gas into the liquid than traditional Venturi nozzles). The instant multiple-Venturi nozzle has a generally cylindrical body with a generally flat bottom surface and a generally flat distal outer surface and a generally arcuate vertical surface parallel to the bottom and outer surfaces. The instant multiple- Venturi nozzle further includes a plurality of chokes generally perpendicular to the bottom and outer surfaces, each of said chokes extending through the body and having a choke inlet and a choke outlet. The instant multiple-Venturi nozzle further includes a manifold extending from the outer surface partially into the body and a plurality of manifold channels connecting the manifold to each choke, each of said manifold channels being generally perpendicular to a corresponding choke, having a manifold outlet and a distal manifold inlet and being offset in a helical distribution from other manifold outlets corresponding to the same choke.

[0017] Importantly, many conventional Venturi systems have a relatively high liquid/gas mixture velocity at the nozzle-outlet. This can limit the usefulness of such Venturi systems for many applications including the use of such systems in aquaculture or agricultural projects (e.g., hydroponics, aquaponics, etc.) since the high velocity can damage plant (especially root structures) and marine life. The instant invention allows for a lower exit flow rate by making use of: (a) multiple Venturi nozzles; and (b) the plurality of pinhole oxygen lines.

[0018] An additional object of the present invention is directed to an MVN with a plurality of chokes, manifold outlets, manifold channels and manifold inlets (as defined in the "Detailed Description" section below) in a generally helical structure (i.e., the distribution of manifold outlets is made in a corkscrew like pattern). This allows for: (a) the placement of Venturi nozzles in "layers" such that the gas inlet is perpendicular to the flow of the fluid; and (b) a far greater density of Venturi nozzles than has ever been possible before. By heaving each of the manifold channels offset from one another, the space between each "layer" can be made thinner, i.e., less material can be used to construct the MVN and a greater effective density of Venturi nozzles can be obtained for a given "width" of the MVN.

[0019] The number of Venturi nozzles in each "layer" is controlled by the number of chokes contained in each such layer (to which there is no theoretical limit). Moreover, such number of Venturi nozzles increases linearly with the number of "layers" which are present. This is only limited by the materials used and the manufacturing techniques employed to separate each "layer". To maximize the number of chokes in any given layer, additional manifold rings and manifold passages can be used as illustrated herein.

[0020] Indeed, the device shown in the drawings (e.g., **FIGS. 13A** through **13L)** has been actually prototyped and tested. This device has thirteen (13) chokes each of which has at least nine (9) pinhole oxygen lines. Thus, each device has the effective capacity of at least 117 (i.e., 13 x 9) Venturi nozzles. In the prototyping done thus far, such device is approximately one inch in diameter. This high effective "density" of Venturi nozzles in such a small device has yielded unexpected results. Experimentation has shown that the use of an MVN in connection with oxygenating water allows for a greater rate of oxygen dissolution (i.e., a better rate of oxygenation of the water) using a less powerful pump as compared with traditional Venturi aerators. In another embodiment, a plurality of manifolds could be used - thus allowing the MVN to simultaneously draw more than one gas into the liquid stream passing through the chokes. For example, in a two- manifold MVN system, a first gas and a second gas could be simultaneously diffused into a single stream of liquid using only one pump for such liquid. This has particular application in waste- water treatment applications where multiple gasses may be diffused into waste water at a given time.

[0021] An additional object of the present invention is directed to a system containing: (a) at least one MVN; and (b) a pipe; and (c) a gas line. More specifically, the instant invention includes a system in which a plurality of MVNs are used in an external manifold to increase the effective flow rate and the effective gas dissolution rate within such a system. For example, a one to four external manifold could be used in connection with four MVNs (one at each outlet of the external manifold). By doing say, the fluid flow rate at each of the external manifold's outlets would be one fourth the flow rate at the external manifold's inlet. Such a system can be used as a preliminary means of "stepping down" the flow of fluids.

[0022] An additional object of the present invention is directed to a method of manufacturing an MVN using three-dimensional ("3D") printing technology. More specifically, because of: (a) the plurality of pinhole gas lines (also called "manifold channels" herein); and (b) the generally helical structure of such manifold channels; the most effective way to construct an MVN is through the use of 3D printers. Thus, the size of each pinhole (i.e., manifold channel) can be made as small as the minimum thickness of material which a given 3D printer can extrude (often fractions of a millimeter). In the preferred embodiment, each manifold channel is offset both vertically and at a slight angle to the horizontal - resulting in a helical distribution of manifold channels. This is done to add further strength and to ensure that the pressure through each manifold channel does not result in a deformation of the material or a breach from one manifold channel to another. As illustrated in the figures below and as borne out by experimentation, this allows for creating an MVN with any desired number of Venturi or any desired flow/ dissolution characteristics. Thus, for example, an MVN can be made with relatively few chokes for a low-flow rate application or with relatively many chokes for a higher-flow rate application.

[0023] An additional object of the present invention is directed to a method of using an MVN. As discussed elsewhere herein, the MVN is connected within an outer housing (e.g., a pipe) and a liquid (or a gas) is passed through same (through the chokes). A second liquid or gas is fed to a manifold within the MVN and drawn through the plurality of pinholes. Where a gas is diffused into a liquid, a micro-cavitation of the gas occurs - resulting in a high rate of dissolution of the gas into the liquid.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] **FIG. 1** is a side view of an HFVN having a height $\boldsymbol{h}$ showing a plane $\overline{\boldsymbol{AB}}$ through the body of the HFVN.

[0025] **FIG. 2** is a front perspective view of an HFVN segment (taken along plane $\overline{\boldsymbol{AB}}$ from **FIG. 1**) having a height $\boldsymbol{h_s}$ and having a plurality of chokes and a single manifold.

[0026] **FIG. 3A** is a rear perspective view of an HFVN segment (taken along plane $\overline{\boldsymbol{AB}}$ from **FIG. 1**) showing the interior structure of the HFVN.

[0027] **FIG. 3B** is a rear view of an HFVN segment (taken along plane $\overline{\boldsymbol{AB}}$ from **FIG. 1**) showing the interior structure of the HFVN.

[0028] **FIG. 4A** is a front perspective view of an HFVN having a plurality of chokes and a single manifold.

[0029] **FIG. 4B** is a rear view of an HFVN having a plurality of chokes and a single manifold.

[0030] **FIG. 5** is a compilation showing several views of an HFVN having a plurality of chokes and a single manifold.

[0031] **FIG. 6A** is a side view of an HFVN assembly having a plurality of fins and manifold outlets.

[0032] **FIG. 6B** is a front view of a female cap portion of an HFVN assembly.

[0033] **FIG. 6C** is a side vide of a female cap portion of an HFVN assembly

[0034] **FIG. 6D** is a rear view of a male cap portion of an HFVN assembly.

[0035] **FIG. 6E** is a side vide of a male cap portion of an HFVN assembly.

[0036] **FIG. 7A** is a side exploded view of an HFVN assembly and a pipe having a tee.

[0037] **FIG. 7B** is a perspective exploded view of an HFVN assembly and a pipe having a tee.

[0038] **FIG 7C** is a perspective view of an HFVN assembly attached to a Pipe having a Tee.

[0039] **FIG. 8A** is a side cutaway view of an HFVN assembly (comprising a female cap and a male cap.

[0040] **FIG. 8B** is a perspective cutaway view of an HFVN assembly (comprising a female cap and a male cap).

[0041] **FIG. 9A** is a compilation showing different views of two embodiments of HFVN assemblies.

[0042] **FIG 9B** is a compilation showing several different view of three embodiments of HFVN assemblies.

[0043] **FIG 10A** is a compilation of different front, side and perspective views of a top piece of a two-piece HFVN.

[0044] **FIG 10B** is a compilation of different front, side and perspective view of a bottom piece of a two-piece HFVN.

[0045] **FIG 10C** is a compilation of a side and perspective cutaway view of a two-piece HFVN.

[0046] **FIG 10D** is a compilation of different side, perspective and rear views of an assembled two-piece HFVN.

[0047] **FIG. 11A** is a top perspective view of an MVN having at least one choke and a manifold.

[0048] **FIG. 11B** is a perspective cutaway view of an MVN taken along the plane ***AB*** shown in **FIG. 11A.**

[0049] **FIG. 12A** is a stylized side view of a MVN having at least one choke.

[0050] **FIG. 12B** is a stylized side view of an MVN which has been inserted into an outer pipe.

[0051] **FIGS. 13A** through **13L** depict sequential perspective views of the process of manufacturing a MVN using 3D printing.

[0052] **FIG. 14A** through **FIG. 14C** depict sequential perspective views of the process of manufacturing an alternative embodiment of an MVN using 3D printing.

[0053] **FIG. 15** is an enlargement of a MVN showing enlarged details of a finished choke and manifold.

[0054] **FIG. 16** shows a top perspective view of a MVN having a plurality of manifolds each having a manifold nipple and a plurality of chokes.

[0055] **FIG. 17** shows top perspective views of two MVNs having differently sized chokes.

[0056] **FIG. 18** shows top perspective views of seven different sizes of MVNs each having a different number / distribution pattern of chokes.

REFERENCE NUMERAL CHART

[0057] For purposes of describing the preferred embodiment, the terminology used in reference to the number components in the drawings is as follows:

100	High Flow Venturi Nozzle ("HFVN")
100a	High Flow Venturi Nozzle ("HFVN") Segment
h_s	Segment Height
101	Body

102	Top Surface
103	Choke
105	Choke Inlet
107	Choke Outlet
109	Manifold
111	Manifold Nipple
113	Manifold Inlet
115	Manifold Channel
117	Manifold Outlet
119	Manifold Passage
121	Bottom Surface
H	Height
200	HFVN Assembly
201	Female Cap
202	Female Cap Opening
203	Male Cap
204	Male Cap Opening
205	Fins
207	Manifold Outlets
209	Female Body
211	Female Flange
213	Male Body
215	Male Flange
216	Pocket
217	Pipe
219	Tee
221	Tee Opening
223	Pinhole Manifold Outlets
300	Two-Piece HFVN
301	Top Piece
302	Top Surface
303	Bottom Piece

304	Bottom Surface
305	Manifold
307	Manifold Nipple
309	Top Chamber
311	Bottom Chamber
313a	Top Choke
313b	Bottom Choke
315	Manifold Outlet
400	Multiple-Venturi Nozzle ("MVN")
401	Medium
403	Choke
403a	Choke Inlet
403b	Choke Outlet
405	Manifold Outlet
407	Manifold Channel
409	Manifold Inlet
411	Manifold
413	Outer Surface
415	Manifold Nipple
416	Bottom Edge
417	Vertical Surface
418	Bottom Surface
419	Manifold Back
421	Pipe
423	Manifold Ring
425	Manifold Passage
P_{1A}	Initial Pressure
P_{1B}	Choke Pressure
P_{1C}	Final Pressure
P_2	Second Pressure

DETAILED DESCRIPTION OF THE INVENTION

[0058] **FIG. 1** is a side view of an HFVN **100** having a Body **101** and a height $\boldsymbol{h}$. The HFVN **100** shown in **FIG. 1** includes a centrally located Manifold **109**. **FIG. 1** further depicts a plane through the Body **101** of the HFVN **100** and parallel to the Manifold **109**.

[0059] **FIG. 2** is a front perspective view of an HFVN Segment **100a** (taken along plane $\overline{\boldsymbol{AB}}$ from **FIG. 1**) having a height $\boldsymbol{h_s}$. The HFVN **100** has at least one Manifold **109**. In the embodiment shown in **FIG. 2**, the HFVN **100** includes a single Manifold **109** which is centrally located in the HFVN **100**. The HFVN **100** further comprises a plurality of Chokes **103**; each of which has a Choke Inlet **105** and a Choke Outlet **107** (not shown in **FIG. 2**) and extends from a Top Surface **102** of the HFVN **100** to a Bottom Surface **121** (not shown in **FIG. 2**) of the HFVN **100**. In the embodiment shown in **FIG. 2**, the HFVN **100** includes four Chokes **103** which are equidistantly distributed in a radial pattern about the Manifold **109**. A Manifold Nipple **111** extends outwardly from the Top Surface **102** of the HFVN **100**. This manifold Nipple **111** may be dimensionally sized to accommodate a variety of hoses / tubing which, in turn, can be connected to a gas supply such as an air supply or an oxygen supply.

[0060] **FIG. 3A** is a rear perspective view of an HFVN segment **100a** (taken along plane $\overline{\boldsymbol{AB}}$ from **FIG. 1**) showing the interior structure of the HFVN **100**. The Manifold **109** is in fluid connection with a Manifold Inlet **113** which, in turn, is in fluid connection with a plurality of Manifold Passages **119**. Each Manifold Passage **119** is connected to at least one Manifold Channel **115**. Each Manifold Channel **115** is connected to one of the Chokes **103**. Thus, gas being passed through the Manifold **109** is able to travel through the Manifold **109**, into the Manifold Inlet **113**, through a manifold passage **119** down a manifold channel **115** come on and out into the choke **103** through a manifold outlet **117**. Thus, there is a continuous fluid connection between the manifold **109** and each of the chokes **103**. In this way, a gas may be connected to the Manifold **109** and diffused into a liquid (not shown) which is passing through the Chokes **103**. When the Manifold **109** is connected to a gas supply (e.g., air), the small opening of the Manifold Outlets **117** creates a Venturi effect as liquid (e.g., water) flows through the Chokes **103**. Given the relatively large diameter of the Chokes **103**, a high liquid flow rate can be achieved through the Chokes **103** while, thus, still diffusing gas into the liquid by means of the Venturi effect generated at the Manifold Outlets **117** inside the Chokes **103**. For example, if the HFVN **100** is placed inside a pipe (not shown in **FIG. 3A**), water or another liquid could flow through the pipe and through the HFVN **100**.

[0061] **FIG. 3B** is a rear view of an HFVN segment **100a** (taken along plane $\overline{\boldsymbol{AB}}$ from **FIG. 1**) showing the interior structure of the HFVN **100**. This figure is included to more clearly show the fluid collections between the Manifold **109**, Manifold Inlet **113**, Manifold Passages **119**, Manifold Channels **115**, Manifold Outlets **117** and Chokes **103**.

[0062] **FIG. 4A** is a front perspective view of an HFVN **100** having a plurality of Chokes **103** and a single Manifold **109**. As can be seen in **FIG. 4A**, the plurality of Manifold Inlets **113** inside the Manifold **109** has the appearance of “grooves” or “fins.” As discussed earlier herein, each of these Manifold Inlets **113** is fluidly connected to one of the Chokes **103**. This allows air or another gas to pass through the Manifold **109** and into the Chokes **103**.

[0063] **FIG. 4B** is a rear view of an HFVN **100** having: (a) a plurality of Chokes **103** extending from the Top Surface **102** (not shown in **FIG. 4B**) to the Bottom Surface **121**); and (b) and a single Manifold **109** (not shown in **FIG. 4B**). As noted elsewhere herein, each Choke **103** includes at least one Manifold Outlet **117** which is fluidly connected to the Manifold **109**. Fluid travels from the Choke inlet **105** (not shown in **FIG. 4B**) through the Choke **103** and exits through the Choke Outlet **107**.

[0064] **FIG. 5** is a compilation showing several views of an HFVN **100** having a plurality of Chokes **103** (not labeled in **FIG. 5**) and a single Manifold **109** (not shown in **FIG. 5**).

[0065] **FIG. 6A** is a side view of an HFVN Assembly **201** comprising: (a) a Female Cap **201** having a Female Cap Opening **202** (not shown in **FIG. 6A**); and (b) a Male Cap **203** having a Male Cap Opening **204** (not shown in **FIG. 6A**). Said Female Cap **201** further comprises a Female Body **209** connected to a Female Flange **211** that extends radially beyond the edges of the Female Body **209**. Said Male Cap **203** further comprises a Male Body **213** and a Male Flange **215** that extends radially beyond the edges of the

Male Body **213**. The Male Body **213** further comprises a series of Fins **205** interspaced with openings (i.e., Manifold Outlets **207**). When the Female Cap **201** and the Male Cap **203** are placed together, they define the boundaries of an area of space (i.e., a Pocket **216**). Thus, as shown in **FIG. 6A**, the Pocket **216** is in fluid communion with the Manifold Outlets **207**.

[0066] **FIG. 6B** is a front view of a Female Cap **201** of an HFVN Assembly **200**. As shown in **FIG. 6B**, the Female Cap Opening **202** is centrally located in the Female Flange **211** and extends through the width of both the Female Flange **211** and the Female Body **209** (not shown in **FIG. 6B**).

[0067] **FIG. 6C** is a side vide of a Female Cap **201** of an HFVN Assembly **200** having a Female Body **209** and a Female Flange **211**.

[0068] **FIG. 6D** is a front view of a Male Cap **203** of an HFVN Assembly **200**. As shown in **FIG. 6D**, the Male Cap Opening **204** is centrally located in the Male Flange **215** and extends through the width of both the Male Flange **215** and the Male Body **213** (not shown in **FIG. 6D**).

[0069] **FIG. 6E** is a side vide of a Male Cap **203** of an HFVN Assembly **200** having: (a) a Male Body **213** comprising at least one Fin **205** and at least one Manifold Outlet **207**; and (b) a Male Flange 215 extending radially beyond the edges of the Male Body **213.**

[0070] **FIGS. 7A and 7B** are side and perspective exploded views, respectively, of: (a) an HFVN Assembly **200** comprising a Female Cap **201** and a Male Cap **203** and; (b) a Pipe **217** having a Tee **219** approximately midway along the length of the Pipe **217**. The HFVN Assembly **200** is dimensionally sized to securely fit telescopingly inside the Pipe **217** by a friction fit. The Tee **219** is hollow, i.e., having a Tee Opening **221**. As shown in **FIG. 7A** and **7B**, the Pipe **217** having a Tee **219** is commonly referred to as a "reducing tee." As noted above, the Manifold Outlets **207** are in fluid communion with the Pocket **216**. Thus, when the Female Cap **201** is affixed on one end of the Pipe **217** and the Male Cap **203** is affixed on a distal end of the Pipe **217**, the Pocket **216** will be in fluid communion with the Tee Opening **221**.

[0071] **FIG. 7C** is a perspective view of an HFVN Assembly **200** attached to a Pipe **217** having a Tee **219**. As shown in **FIG. 7C**, the Female Body **209** is shown fitted inside the Pipe **217**. The Female Flange **211** is located entirely inside the Pipe **217**. From the perspective view depicted in **FIG. 8**, the Female Flange **211** of the HFVN Assembly **200** is visible inside of the Pipe **217**. Here, the Tee **219** may be connected to a gas supply (e.g., air) and a liquid (e.g., water) passed through the Pipe **217** (and, thus, through the HFVN Assembly **200** through both the Female Cap Opening **202** and the Male Cap Opening **204** which, collectively, form a sort of "choke"). As liquid flows through the HFVN Assembly **200** and the Pipe **217**, the Manifold Outlets **117** create a Venturi effect as liquid (e.g., water) flows past the gas (which, in tum, flowed from the Tee Opening **221** into the Pocket **216** and into the Manifold Outlets **207**). This embodiment comprises a significant improvement over prior Venturi systems inasmuch as it allows for a relatively high liquid flow rate through the Pipe **217**. The perspective view shown in **FIG. 7C** also illustrates the plurality of Fins **205** and Manifold Outlets **207** present in the Male Cap 203. In particular, the perspective view shown in **FIG. 7C** shows the pitch or angle associated with the Fins **205** and the Manifold Outlets **207**.

[0072] **FIG. 8A** is a side cutaway view of an HFVN Assembly **200** (comprising a Female Cap **201** and a Male Cap **203**) attached to a Pipe **217** having a Tee **219**. This is a side cutaway view of the same HFVN Assembly **200** and Pipe **217** shown in **FIGS. 7A** through **7C** above. As shown in **FIG. 8A**, the HFVN Assembly **200** is fully fitted into the Pipe **217** in such a way that the Tee **219** and the Tee Opening **221** are located in-between the Female Flange **211** and the Male Flange **215**. This space forms a Pocket **216** defined by the Female Flange **211**, the Female Body **209**, the Male Body **213** and the Male Flange **215** In the configuration shown in **FIG. 8A**, the Pocket **216** is in the general shape of a hollow cylindrical segment but could be generally toroidal in other configurations. Thus, there is a fluid connection between the Pocket **216** and the Tee Opening **221** which allows a gas (e.g., air) to be supplied to the Tee **219** and flow into the Picket **216**.

[0073] The Male Cap **203** has a plurality of Fins **204** and Manifold Outlets **207**. These Fins **204** have a Fin Pitch **205a**. Each Manifold Outlet **207** is also in fluid communion with the Pocket **216**. This allows a liquid (e.g., water) to be passed through the HFVN Assembly **200** while a gas (e.g., air) supplied to the Tee **219**, to flow into the Pocket **216** and through each Manifold Outlet **207** where a Venturi effect occurs - thereby causing cavitation of the gas into small bubbles in the liquid - allowing for more ready diffusion of the gas into the liquid.

[0074] **FIG. 8B** is a perspective cutaway view of an HFVN Assembly **200** (comprising a Female Cap **201** and a Male Cap **203**) attached to a Pipe **217** having a Tee **219**. This is a perspective cutaway view of the same HFVN Assembly **200** and Pipe **217** shown in FIG. SA above (and, thus, also the same as shown in **FIGS. 7A** through **7C** above). As shown in **FIG. 8B**, the Pocket **216** is in fluid communion with the Tee Opening **221**. This allows a gas (e.g., air) to be introduced into the Tee **219** via the Tee Opening **221** which will then flow into the Pocket **216** and out of the plurality of Manifold Outlets **207** defined as the space in-between two adjacent Fins **205**. Thus, as a liquid (e.g., water) flows through a first end of the Pipe **217**, through the Female Cap Opening **202**, through the Male Cap Opening **204** and through a second end of the Pipe **217**, it will come in contact with a gas (e.g., air) introduced into the Tee **219** which gas will flow from the Tee Opening **221**, through the Pocket **216** and out of the Manifold Outlets **207**.

[0075] **FIG. 9A** is a compilation showing several different views of two embodiments of HFVN Assemblies **200**, namely: (a) a first embodiment having a plurality of Fins **205** in the Male Body **213** (i.e., the same HFVN Assembly **200** noted in **FIGS. 6A** through **8B** above); and (b) a second embodiment having a plurality of Pinhole Manifold Outlets **223** in the Male Body **213**. These Pinhole Manifold Outlets **223** are relatively small and act as miniature Venturis as water or some other fluid passes through the HFVN Assembly **200**. A variety of front, back and perspective views of these two HFVN Assembly **200** embodiments are shown in **FIG. 9A**.

[0076] **FIG. 9B** is a compilation showing several different views of three embodiments of HFVN Assemblies **200**, namely: (a) a first embodiment having a plurality of small Fins **205b** in the Male Body **213**; (b) a second embodiment having a plurality of Pinhole Manifold Outlets **223** in the Male Body **213**; and (c) a third embodiment having a plurality of Large Fins **205c** in the Male Body 213. In one embodiment, the HFVN Assembly **200** may be manufactured through the use of three-dimensional printing ("3D Printing"). In particular, the manufacture of the Pinhole Manifold Outlets **223** in a Male Body **213** are ideal candidates for 3D Printing given the small side of the Pinhole Manifold Outlets **223**.

[0077] **FIG. 10A** is a compilation of different front, side and perspective views of a Top Piece **301** of a Two-Piece HFVN **300** (not labeled in **FIG. 10A**). The Top Piece **301** has a Top Surface **302** and includes a Manifold **305** and a Manifold Nipple **307** protruding outward from the Top Surface **302**. This Manifold **305** is in fluid communion with a hollow Top Chamber **309** located on a reverse side of the Top Piece **301** distal from the Manifold Nipple **307**. The Top Piece **301** further includes at least one Top Choke **313a**. In the embodiment shown in **FIG. 10A**, the Top Piece **301** includes a plurality of Top Chokes **313a**. Each Top Choke **313a** is an orifice which extends through the width of the Top Piece **301** and into the Top Chamber **309**. At least one Manifold Outlet **315** is formed into the reverse side of the Top Piece **301** distal from the Manifold Nipple **307**. Each Manifold Outlet **315** is connected to a Top Choke **313b**.

[0078] **FIG. 10B** is a compilation of different front, side and perspective views of a Bottom Piece **303** of a Two-Piece HFVN **300** (not labeled in **FIG. 10B**). As shown in **FIG. 10B**, the Bottom Piece **303** has a Bottom Surface 304 and includes a hollow Bottom Chamber **311**. The Bottom Piece **303** also includes at least one Bottom Choke **313b**. In the embodiment shown in **FIG. 10B**, the Bottom Piece **303** includes a plurality of Chokes **313b**. Each Bottom Choke **313b** is an orifice which extends through the width of the Bottom Piece **303** beyond the Bottom Chamber **311**.

[0079] **FIG. 10C** is a compilation of a side and perspective cutaway view of a Two-Piece HFVN **300** (not labeled in **FIG. 10C**) comprising: (a) a Top Piece **301**; and (b) a Bottom Piece **303**. As shown in **FIG. 10C**, the Top Piece **301** (shown to the left of line $\overline{\boldsymbol{AB}}$) and the Bottom Piece **303** (shown to the right of line $\overline{\boldsymbol{AB}}$) detachably join together to form a single Two-Piece HFVN **300**. The Top Piece **301** and the Bottom Piece **303** may be permanently joined together by attachment means such as adhesive, PVC cement, ultrasonic welding, welding or brazing depending on the material from which they are constructed. In one embodiment, the Top Piece 301 and the Bottom Piece **303** may be constructed out of plastic using 3D printing technology. As shown in **FIG. 10C**, the Top Chamber **309** of the Top Piece **301** and the Bottom Chamber **311** of the Bottom Piece **303** are dimensionally sized such that the Top Chamber **309** and the Bottom Chamber **311** are in fluid communion and form a unified compartment when the Top Piece **301** and the Bottom Piece **303** are joined together. The Manifold **305** of the Top Piece **301** is, thus, also in fluid communion with the unified compartment comprised of the Top Chamber **309** and the Bottom Chamber **311**. As further shown in **FIG. 10C**, each Top Choke **313a** is aligned with a corresponding Bottom Choke **313b**, such that a Top Choke **313a** and a Bottom Choke **313b** join together to form a unified choke. When a gas (e.g., air or oxygen) is fed into the Manifold **305** and a fluid (e.g., water) passes through the unified choke (comprised of the Top Choke **313a** and a Bottom Choke **313b**), a Venturi effect occurs within the unified choke at each Manifold Outlet **315**. Given the layout and relative size of the unified chokes and compared to the body of the Two-Piece HFVN **300**, the apparatus shown in **FIGS. 10A-10D** has the ability to handle a high flow rate of fluid through the chokes while maintaining a high rate of gas diffusion through the Manifold **305** and into the fluid from the Manifold Outlets **315**.

[0080] **FIG. 10D** is a compilation of different side, perspective and rear views of an assembled Two-Piece HFVN **300** showing how the exterior of the Two-Piece HFVN **300** appears when the Top Piece **301** and the Bottom Piece **303** are joined together.

[0081] **FIG. 11A** is a top perspective view of an MVN **400** having at least one Choke **403** and a Manifold **411.** In the embodiment shown in **FIG. 11A**, there are a plurality of Chokes **403**. The MVN **400** is then inserted into the end of a pipe or other conduit (not shown in **FIG. 11A**). The MVN **400** has a body consisting of an impervious Medium **401.** In certain embodiments, the Medium **401** could be plastic (including Polyvinyl chloride ("PVC")), rubber, or metal. The MVN **400** has: (a) a front end having an Outer Surface **413** and a Manifold Nipple **415** which protrudes from the Outer Surface **413** of the MVN **400;** and (b) a back end having a Bottom Edge **416.** Thus, the Bottom Edge **416** is distal from the Outer Surface **413.** The MVN **400** also has a Vertical Surface **417.** The Vertical Surface **417** is smooth and uniform. **FIG. 11A** further shows a plane ***AB*** approximately half-way between the Bottom Edge **416** and the Outer Surface **413**.

[0082] Each Choke **403** is a small opening extending through the body of the MVN **400.** Thus, because each Choke **403** is both: (a) more narrow that the diameter of the MVN **400** (and of the pipe or other conduit into which the MVN is inserted) at the Bottom Edge **416;** and (b) more narrow than the diameter of the MVN **400** at the Outer Surface **413,** each Choke **403** creates a Venturi effect (i.e., a reduction in fluid pressure) between: (a) the distal front and back ends of the MVN **400;** and (b) the Choke **403.** In one embodiment, the Manifold **411** is generally centrally located within the MVN **400** in order to ensure a uniform distribution of gas or liquid to each of the Chokes **403**.

[0083] **FIG. 11B** is a perspective cutaway view of an MVN **400** taken along the plane ***AB*** shown in **FIG. 11A** having a plurality of Chokes **403,** a Manifold **411,** a body consisting of an impervious Medium **401** and a Bottom Edge **416.** The Manifold **411** is a cavity and has a Manifold Nipple **415** (not shown in **FIG. 11B)** and terminates in a Manifold Back **419** distal from the Manifold Nipple **415.** The Manifold **411** has at least one Manifold Inlet **409** connected to a Manifold Channel **407**. In the embodiment shown in **FIGS. 11A** and **11B,** the MVN **400** has a plurality of Manifold Inlets **409.** The Manifold Channel **407** has a Manifold Outlet **405** distal from the Manifold Inlet **409.** The Manifold Inlet **409** is connected to a Choke **403**. Thus, gas or liquid is allowed to freely pass from the Manifold **411** through the Manifold Inlet **409** through the Manifold Channel **407** through the Manifold Outlet **405** and into the Choke **403**. A hose, tube, pipe or other piping (not shown in **FIG. 11A**) dimensionally sized to mate with the Manifold Nipple **415** is used to connect the Manifold **411** to a first gas or a liquid. The gas or liquid could be pressurized or could be at standard atmospheric pressure. The first gas or liquid could be any number of substances depending on the application for which the MVN is being used. A second gas or liquid is passed through the pipe or other conduit which then flows through the Chokes **403.**

[0084] Common first gasses / liquids and their corresponding applications include:

Gas(es) / Liquids	MVN Application
Air or Oxygen Gas	Aeration, oxygenation and atomization (e.g., dispersing perfume or spray paint)
Ozone	Ozonation of a liquid; ozonating water; ozonating blood
Carbon Dioxide Gas	Carbonating a liquid
Fluorine Gas	Fluorinating a liquid; water fluoridation
Chlorine Gas	Chlorinating a liquid; water chlorination
Flammable Gas	Inspirating air
Fuel (e.g., Gasoline or Diesel)	Carburetor

[0085] Thus, when a first gas or liquid is connected to the Manifold **411** and a second gas or liquid is connected to the MVN **400** and passes through the Choke **403,** the Venturi effect caused within the Choke **403** will cause the first gas or liquid and the second gas or liquid to mix together.

[0086] The MVN **400** shown in **FIGS. 11A** and **11B** is made using a three-dimensional ("3D") printer. Thus, the Medium **401** is shown as consisting of "rows" of material as is common for 3D printed articles. 3D printing the MVN **400** allows for the MVN **400** to be precision constructed; particularly with respect to the various Manifold Inlets **409,** Manifold Channels **407** and Manifold Outlets **405** (depending on the size of which traditional casting/ drilling methods could prove cost prohibitive or impossible).

[0087] **FIG. 12A** is a stylized side view of a MVN **400** having at least one Choke **403,** each Choke **403** having a Choke Inlet **403a** and a Choke Outlet **403b.** The MVN **400** also has a Manifold **411** having a Manifold Nipple **415** and a distal Manifold Back **419.** The Manifold **411** is connected to the Choke **403** by a Manifold Channel **407,** each Manifold Channel **407** having a Manifold Inlet **409** and a Manifold Outlet **405.** The MVN **400** further has a Bottom Surface **418** with a Bottom Edge **416** distal from the Manifold Nipple **415**.

[0088] **FIG. 12B** is a stylized side view of an MVN **400** which has been inserted into a Pipe **421.** In the embodiment shown in **FIG 12B,** a fluid (such as water) is passed through the Pipe **421** at an Initial Pressure of $\mathbf{P_{1A}}$. As this fluid encounters the Choke Inlets **403a,** the fluid undergoes a Venturi effect, resulting in a changed static fluid pressure within the Choke **403,** i.e., the Choke Pressure of $\mathbf{P_{1B}}$. In the embodiment shown in **FIG 12B,** a gas (such as air) is passed through the Manifold **411** at a Second Pressure of $\mathbf{P_2}$. Thus, the gas is drawn through each Manifold Channel **407** and mixes with the fluid in the Chokes **403.** The gas/fluid mixture then exits the Chokes **403** through their Choke Outlets **403b** at a Final Pressure $\mathbf{P_{1C}}$.

[0089] **FIGS. 13A** through **13L** depict sequential perspective views of the process of manufacturing a MVN **400** using 3D printing. As can be seen in **FIG. 13A,** a MVN **400** is at an early stage of 3D printing with only the initial "layers" of Medium **401** having been 3D printed. The MVN **400** has the beginnings of a centrally located Manifold **411** with a Manifold Back **419** and a plurality of Manifold Inlets **409,** each of which is connected to a Manifold Channel **407** with a Manifold Outlet **405** distal from the Manifold Inlet **409.** Each Manifold Outlet **405** is connected to a Choke **403.**

[0090] **FIG. 13B** shows the same MVN **400** from **FIG. 13A** with several additional "layers" of Medium **401** having been 3D printed. As can be seen in **FIG. 13B,** the central Manifold **411** and each of the Chokes **403** has been further formed in the same positions. However, each of the Manifold Outlets **405,** Manifold Channels **407** and Manifold Inlets **409** from **FIG. 13A** have been fully formed and "capped off," while new Manifold Outlets **405,** Manifold Channels **407** and Manifold Inlets **409** have been partially formed which are "rotated" with respect to an axis defined by the Manifold **411.** This rotational process is cyclically repeated throughout the 3D layering process as shown in the remaining **FIGS. 13C** through **13L.** In particular, **FIG. 13D** shows a "capping" layer in which all of the Manifold Outlets **405,** Manifold Channels **407** and Manifold Inlets **409** in a particular layer have been "capped". Thus, in the embodiment shown in **FIGS. 13A** through **13L,** the plurality of Manifold Outlets **405,** Manifold Channels **407** and Manifold Inlets **409** form a generally helical structure.

[0091] **FIG. 14A** through **FIG. 14C** depict sequential perspective views of the process of manufacturing an alternative embodiment of an MVN **400** using 3D printing. In **FIG. 14A,** an MVN **400** is shown having a plurality of Chokes **403** which are located in two concentric groupings about a central Manifold **411** (which Manifold **411** has a Manifold Back **419).** The Chokes **403** are connected to the Manifold **411** by a system of concentric Manifold Rings **423** and radial Manifold Passages **425.** The innermost Manifold Ring **425** is connected to the Manifold **411** by at least one Manifold Passage **425.** The outermost Manifold Ring **423** is connected to the innermost Manifold Ring **423** by at least one Manifold Passage **425.**

[0092] In **FIG. 14B,** the same MVN **400** is sown from **FIG. 14A** after several additional layers of Medium **401** have been 3D printed. In **FIG. 14B,** the same structure of Manifold Inlets **409,** Manifold Channels **407** and Manifold Outlets **405** as previously disclosed herein may be seen connecting each Choke **403** to a nearby Manifold Ring **423.** In the design shown in **FIG. 14B,** however, each Choke **403** has two Manifold Outlets **405** since the Manifold Channels **407** are used to help further connect the Manifold Rings **423** to the Manifold **411.**

[0093] **FIG. 14C** shows the MVN **400** from **FIGS. 14A** and 14**B** after the final layers of Medium **401** have been applied thereto. As can be seen in **FIG. 14C,** the MVN **400** has a plurality of finished Chokes **403** and an Outer Surface **413** with a Manifold Nipple **415** extending outwards from such Outer Surface **413.** The Manifold Nipple **415** shown in **FIG. 14C** is a "male" attachment means. However, "female" attachment means such as an interior hole dimensionally sized to accommodate a pipe or tube could also be used.

[0094] **FIG. 15** is an enlargement of a MVN **400** showing enlarged details of a finished Choke **403** and Manifold **411.** As can be seen in this enlarged detail, within the Choke **403** there are a plurality of helically distributed Manifold Outlets **405.** As can also be seen in this enlarged detail, within the Manifold **411** there are a plurality of helically distributed Manifold Inlets **409.** A method of constructing an MVN **400** resulting in such helically distributed Manifold Outlets **405** and Manifold Inlets **409** is described above in **FIGS. 13A** through **13L.**

[0095] **FIG. 16** shows a top perspective view of a MVN **400** having a plurality of Manifolds **411** each having a Manifold Nipple **415** and a plurality of Chokes **403.** In essence, this is like having a plurality of MVNs **400** surrounded by Medium **401.** As noted above, each of the Manifolds **411** could be connected to a single gas or liquid source or be connected to separate gas or liquid sources allowing the MVN **400** to effectively "mix" and simultaneously dissolve different compounds into the primary gas or liquid.

[0096] **FIG. 17** shows top perspective views of two MVNs **400** having differently sized Chokes **403.** The size of the Choke **403** can be adjusted based on the desired flow of fluid or gas through the Chokes **403** and the desired ratio of mixing the two fluids or gases together within the Chokes **403**.

[0097] **FIG. 18** shows top perspective views of seven different sizes of MVNs **400** each having a different number/ distribution pattern of Chokes **403**. As can be seen in **FIG. 18,** the four leftmost MVNs **400** do not have a Manifold Nipple **415** but instead simply have an opening in the Manifold **411** which is flush with the Outer Surface **413**. This creates a "female" opening for inserting a pipe or a hose into the Manifold **411**. In certain embodiments, threading could be used in either such a "female" opening or in a Manifold Nipple **415** to further engage the Manifold **411** to a pipe or hose.

[0098] It is to be understood that while a preferred embodiment of the invention is illustrated, it is not to be limited to the specific form or arrangement of parts herein described and shown. It was be apparent to those skilled in the art that various changes may be made without departing from the scope of the invention and the invention is not to be considered limited to what is shown and described in the specification and drawings.

CLAIMS

1. A High Flow Venturi Nozzle comprising:

(a) a body having a top surface and a distal, bottom surface;

(b) at least one generally cylindrical choke extending through the body from the top surface to the bottom surface; each choke having a choke inlet through the top surface and a choke outlet through the bottom surface;

(c) a manifold extending from the top surface into the body and terminating within the body; and

(d) a connection between each choke and the manifold.

2. The High Flow Venturi Nozzle of **Claim 1** further comprising:

a plurality of chokes.

3. The High Flow Venturi Nozzle of **Claim 1** further comprising:

(a) the body being generally cylindrical in shape and dimensionally sized to telescopingly engage within a pipe;

(b) at least four chokes, each of which are located equidistant from one another;

(c) the manifold being centrally located with respect to the top surface; said manifold having a manifold nipple extending outwardly from the top surface;

(d) said connection between each choke and the manifold comprising:

(i) at least one manifold channel having a manifold inlet and a manifold outlet; said manifold inlet connected to the manifold and said manifold outlet connected to a choke; and

(ii) at least one manifold channel having a manifold inlet and a manifold outlet; said manifold inlet connected to a manifold passage and said manifold outlet connected to a choke; said manifold passage connected to the manifold.

4. The High Flow Venturi Nozzle of **Claim 1** further comprising:

(a) the body further comprising:

(i) a top piece having a top chamber; and

(ii) a bottom piece;

the top surface being on the top piece and the bottom surface being on the bottom piece;

(b) each choke further comprising:

(i) a top choke which extends through the top piece; and

(ii) a bottom choke which extends through the bottom piece; and

(c) the manifold extending from the top surface into the body and terminating within the top chamber.

5. The High Flow Venturi Nozzle of **Claim 4** further comprising:

the bottom piece having a bottom chamber.

6. The High Flow Venturi Nozzle of **Claim 4** further comprising:

the connection between each choke and the manifold comprising a plurality of manifold outlets.

7. A High Flow Venturi Nozzle assembly comprising:

(a) a female cap having:

(i) a female body;

(ii) a female flange; and

(iii) a female cap opening extending through the female flange and through the female body;

(b) a male cap having:

(i) a male body;

(ii) a male flange;

(iii) a male cap opening extending through the male flange and through the male body; and

(iv) at least one orifice in the male body; and

(c) a pocket defined by the female cap and the male cap when the female cap and male cap are joined together.

8. The High Flow Venturi Nozzle assembly of **Claim 7** further comprising:

the at least one orifice comprising a plurality of manifold outlets; the male body comprising a plurality of fins each having a fin pitch.

9. The High Flow Venturi Nozzle assembly of **Claim 7** further comprising:

the High Flow Venturi Nozzle assembly dimensionally sized to telescopingly fit inside a pipe; the pipe having a tee with a tee opening which is in fluid communion with the pocket.

10. The High Flow Venturi Nozzle assembly of **Claim 7** further comprising:

the at least one orifice comprising a plurality of small fins each having a fin pitch;

11. The High Flow Venturi Nozzle assembly of **Claim 7** further comprising:

the at least one orifice comprising a plurality of large fins each having a fin pitch;

12. The High Flow Venturi Nozzle assembly of **Claim 7** further comprising:

the at least one orifice comprising a plurality of pinhole manifold outlets;

13. The High Flow Venturi Nozzle assembly of **Claim 12** further comprising:

the plurality of pinhole manifold outlets arranged in a helical distribution;

14. A method of using a High Flow Venturi Nozzle having a manifold and at least one choke comprising:

(a) step one: placing the High Flow Venturi Nozzle in a pipe;

(b) step two: connecting a gas supply to the manifold of the High Flow Venturi Nozzle; and

(c) step three: passing a liquid through the at least one choke to cause a Venturi effect therein.

15. A multiple-Venturi nozzle comprising:

(a) a generally cylindrical body having a generally flat bottom surface and a generally flat distal outer surface and a generally arcuate vertical surface parallel to the bottom and outer surfaces;

(b) a plurality of chokes generally perpendicular to the bottom and outer surfaces, each of said chokes extending through the body and having a choke inlet and a choke outlet;

(c) a manifold extending from the outer surface partially into the body; and

(d) a plurality of manifold channels connecting the manifold to each choke, each of said manifold channels:

(i) being generally perpendicular to a corresponding choke;

(ii) having a manifold outlet and a distal manifold inlet; and

(iii) being offset in a helical distribution from other manifold outlets corresponding to the same choke.

16. The multiple-Venturi nozzle of **Claim 15** further comprising:

said multiple-Venturi nozzle being constructed by means of:

(i) 3D printing said multiple-Venturi nozzle in layers of a 3D printing material; and

(ii) each manifold channel which corresponds to a given choke being offset from one another by the thickness of at least one 3D printed layer of material.

17. The multiple-Venturi nozzle of **Claim 15** further comprising:

said manifold being generally central with respect to the body; and said manifold having a manifold nipple.

18. The multiple-Venturi nozzle of **Claim 17** further comprising:

each of said chokes are evenly distributed radially about an axis defined by the manifold.

19. The multiple-Venturi nozzle of **Claim 17** further comprising:

(e) a first manifold ring;

(f) at least one additional, concentric manifold ring;

(g) at least one manifold channel connecting the manifold to the first manifold ring;

(h) at least one manifold channel connecting the additional manifold ring to the first manifold ring; and

(i) additional chokes connected to the manifold rings by additional manifold channels.

20. The multiple-Venturi nozzle of **Claim 17** further comprising:

each of said additional chokes are evenly distributed radially about an axis defined by the manifold in concentric groupings.

21. The multiple-Venturi nozzle of **Claim 20** further comprising:

a fluid being passed through the chokes; and

a gas source connected to the manifold.

22. The multiple-Venturi nozzle of **Claim 15** further comprising:

a plurality of manifolds extending from the outer surface partially into the body and being associated with its own respective chokes; and

a plurality of manifold channels connecting each such manifold to its own respective chokes, each of said manifold channels:

(i) being generally perpendicular to a corresponding choke;

(ii) having a manifold outlet and a distal manifold inlet; and

(iii) being offset in a helical distribution from other manifold outlets corresponding to the same choke.

23. The multiple-Venturi nozzle of **Claim 22** further comprising:

a fluid being passed through the chokes;

a first manifold connected to a first gas source; and

a second manifold connected to a second gas source.

24. A method of using a multiple-Venturi nozzle comprising:

(a) inserting said multiple-Venturi nozzle into a pipe;

(b) connecting a manifold nipple on the multiple-Venturi nozzle to a gas source;

(c) allowing a fluid to flow through a plurality of chokes in the multiple-Venturi nozzle.

25. The method of using a multiple-Venturi of **Claim 24** further comprising:

wherein said fluid is water and said gas is chosen from a group comprising air and oxygen.

26. The method of using a multiple-Venturi of **Claim 24** further comprising:

wherein said fluid is water and said gas is Fluorine gas.

27. A method of manufacturing a multiple-Venturi nozzle using 3D printing comprising

(a) printing at least one initial layer of material to form a bottom surface, said bottom surface having a plurality of choke inlets formed therein;

(b) printing subsequent layers of material each having:

(i) a plurality of choke cross-sectional openings;

(c) printing further layers of material each having:

(i) a plurality of choke cross-sectional openings; and

(ii) at least one manifold cross-sectional opening;

(d) printing additional layers of material each having a plurality of

(i) choke cross-sectional openings;

(ii) at least one manifold cross-sectional opening; and

(iii) a plurality of manifold channel openings each of which is offset the manifold channel openings of the next layer by the thickness of at least one 3D printed layer of material; and

(e) printing other layers of material having a plurality of

(i) a plurality of choke cross-sectional openings; and

(ii) at least one manifold cross-sectional opening;

28. The method of manufacturing a multiple-Venturi nozzle using 3D printing of **Claim 27** further comprising:

(f) printing final layers of material having a at least one manifold nipple cross-sectional opening.

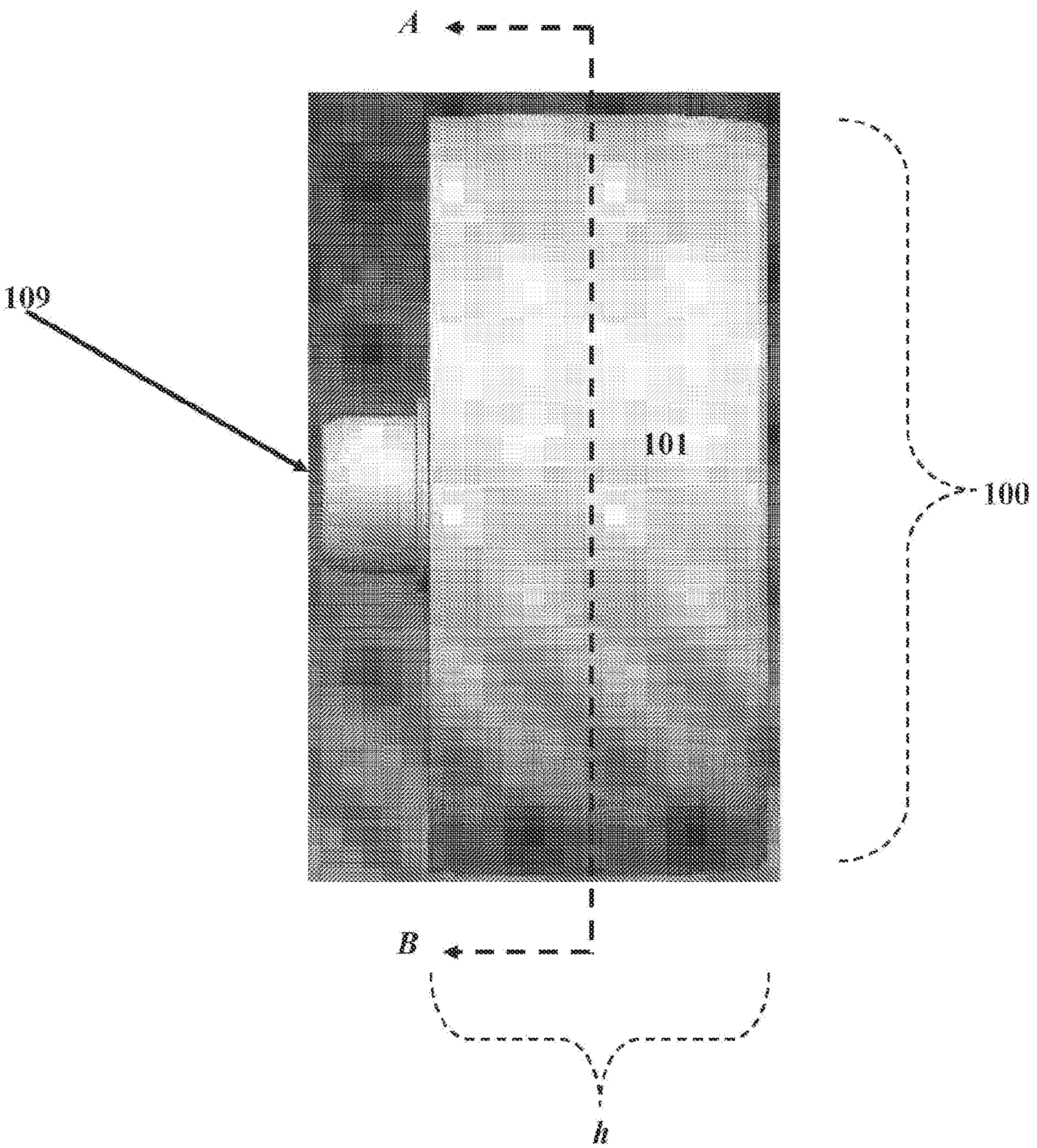

Figure 1

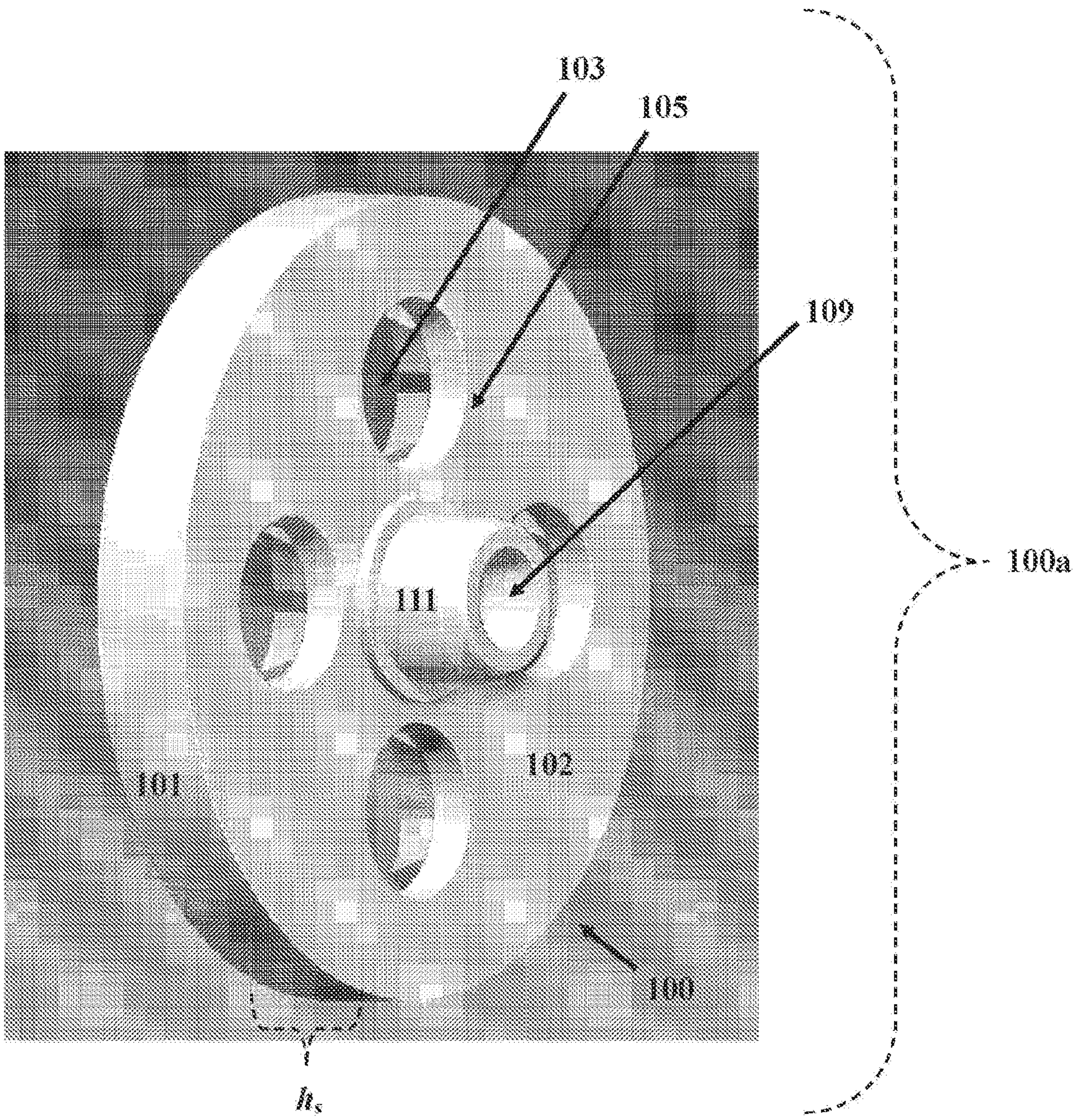

Figure 2

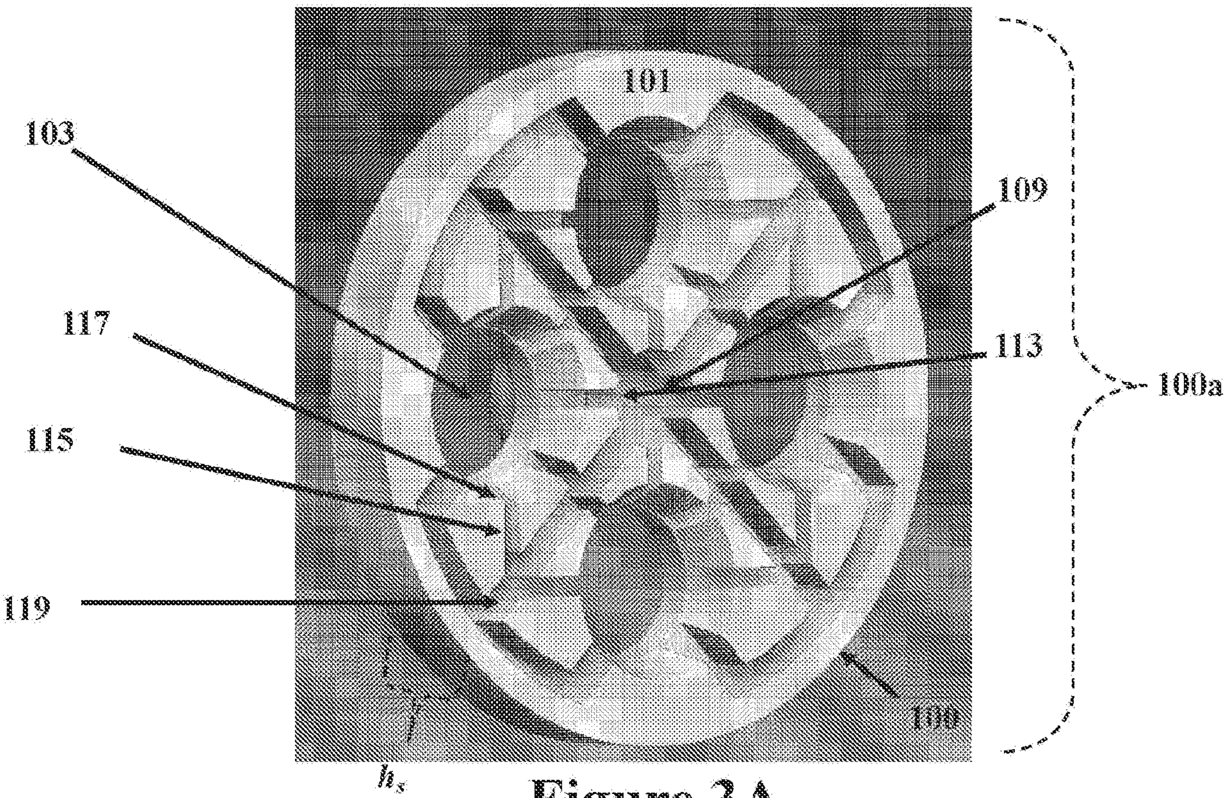

Figure 3A

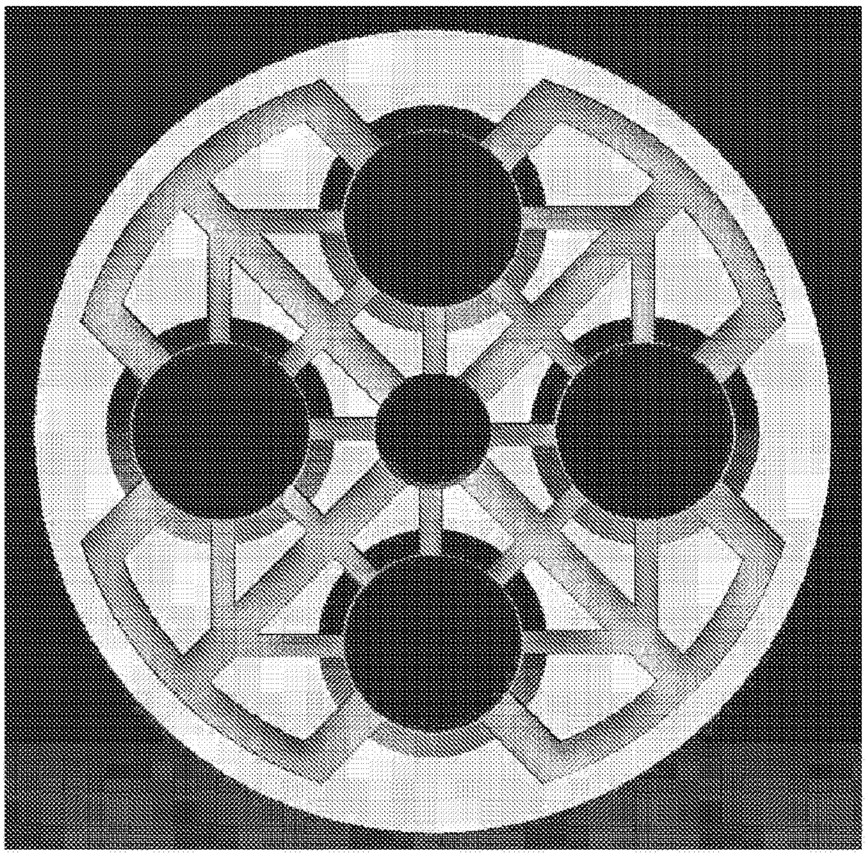

Figure 3B

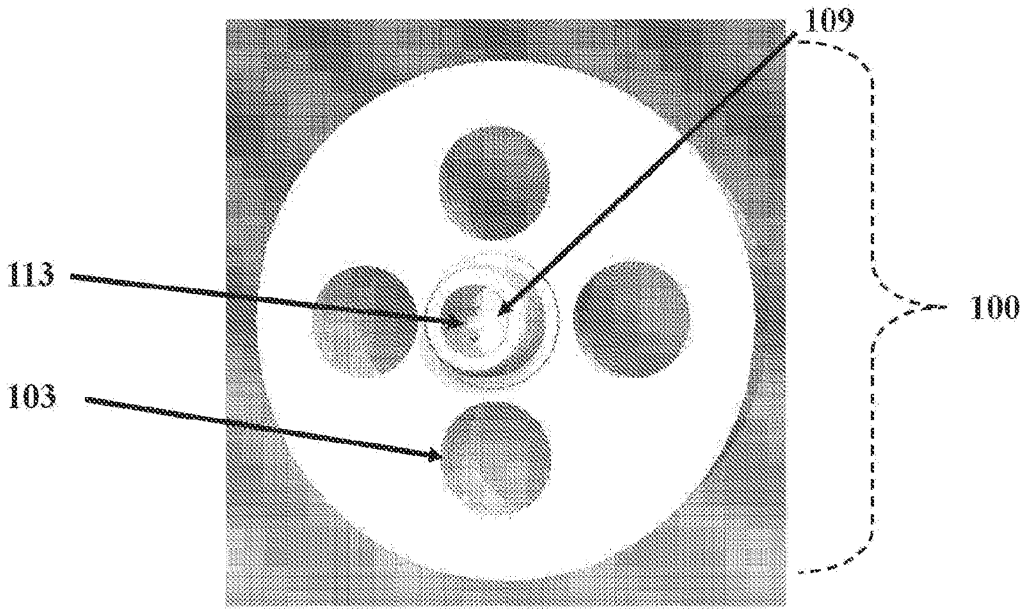

Figure 4A

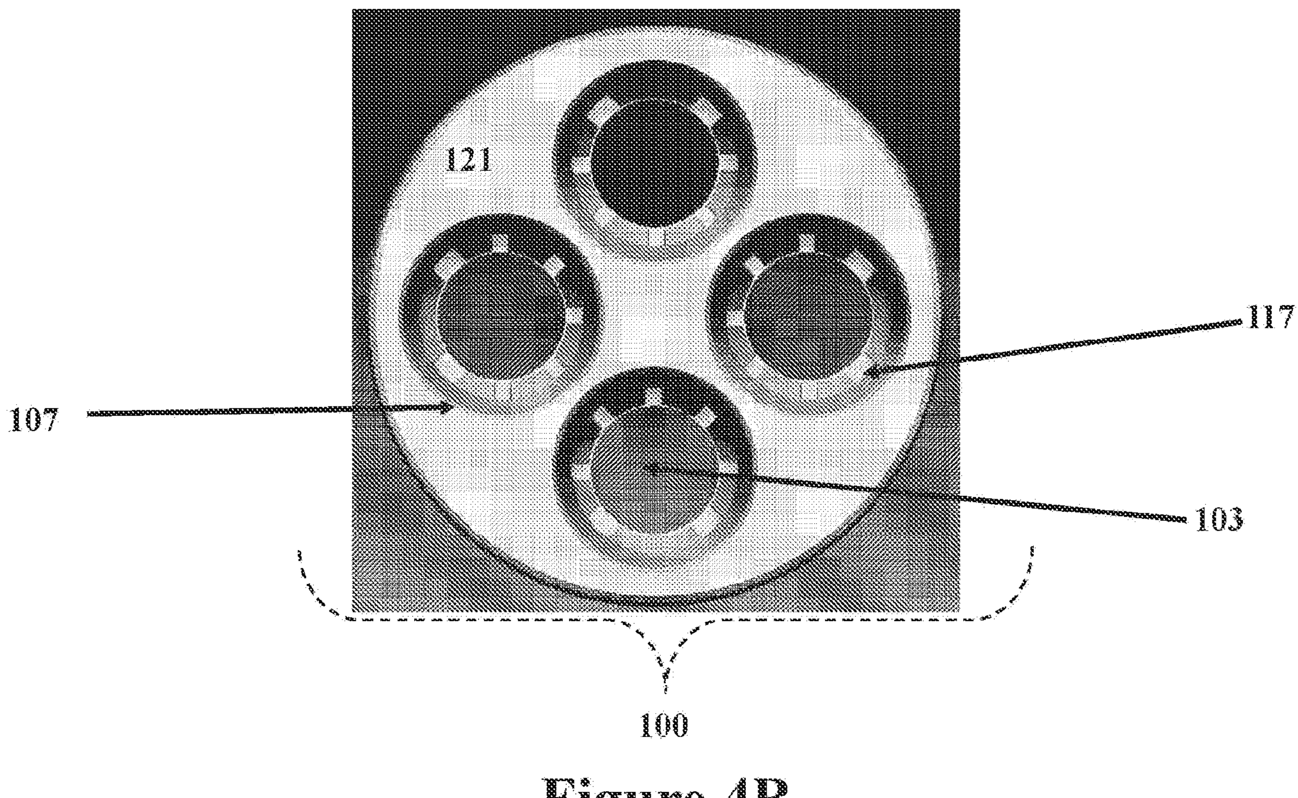

Figure 4B

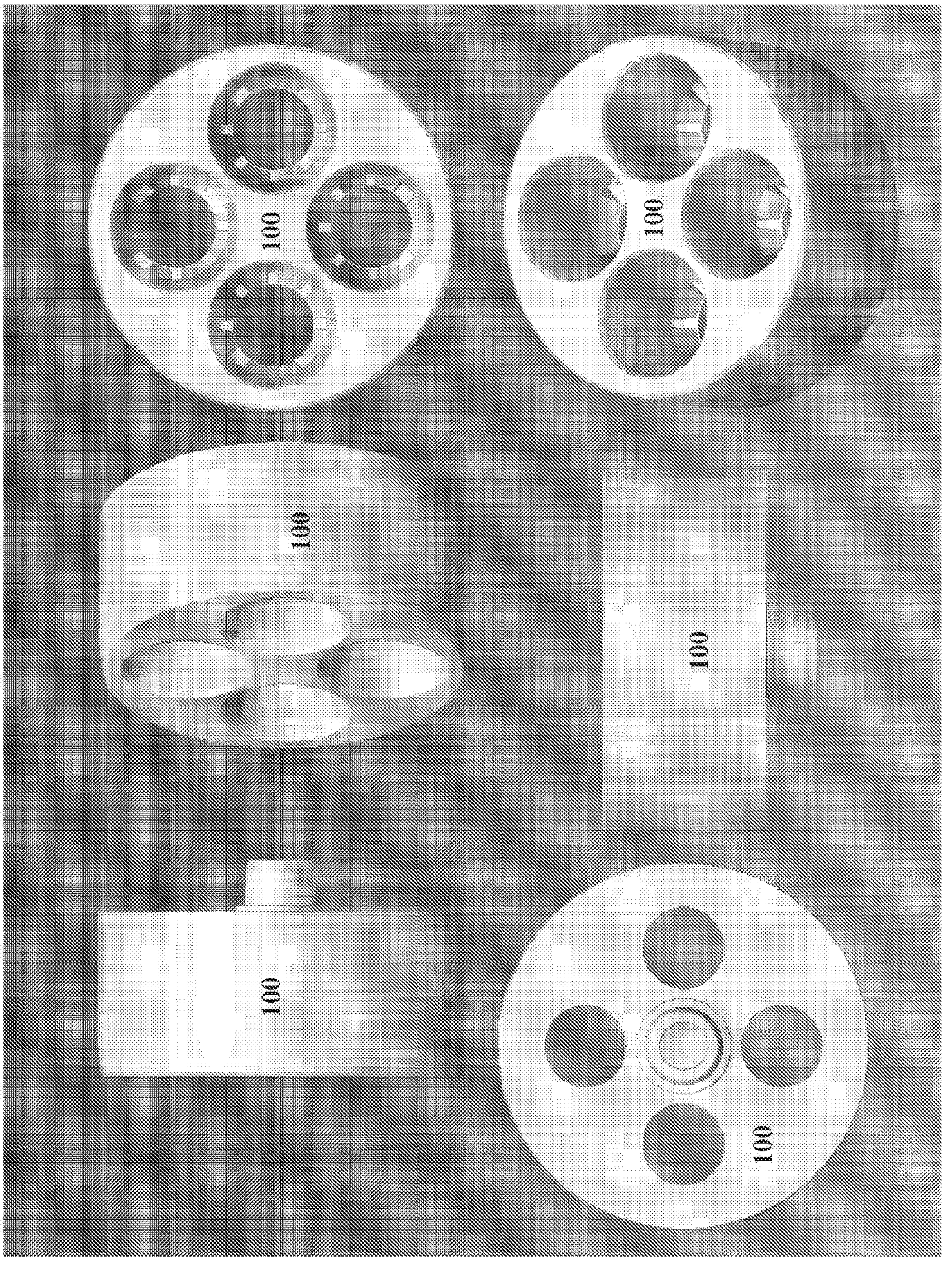

Figure 5

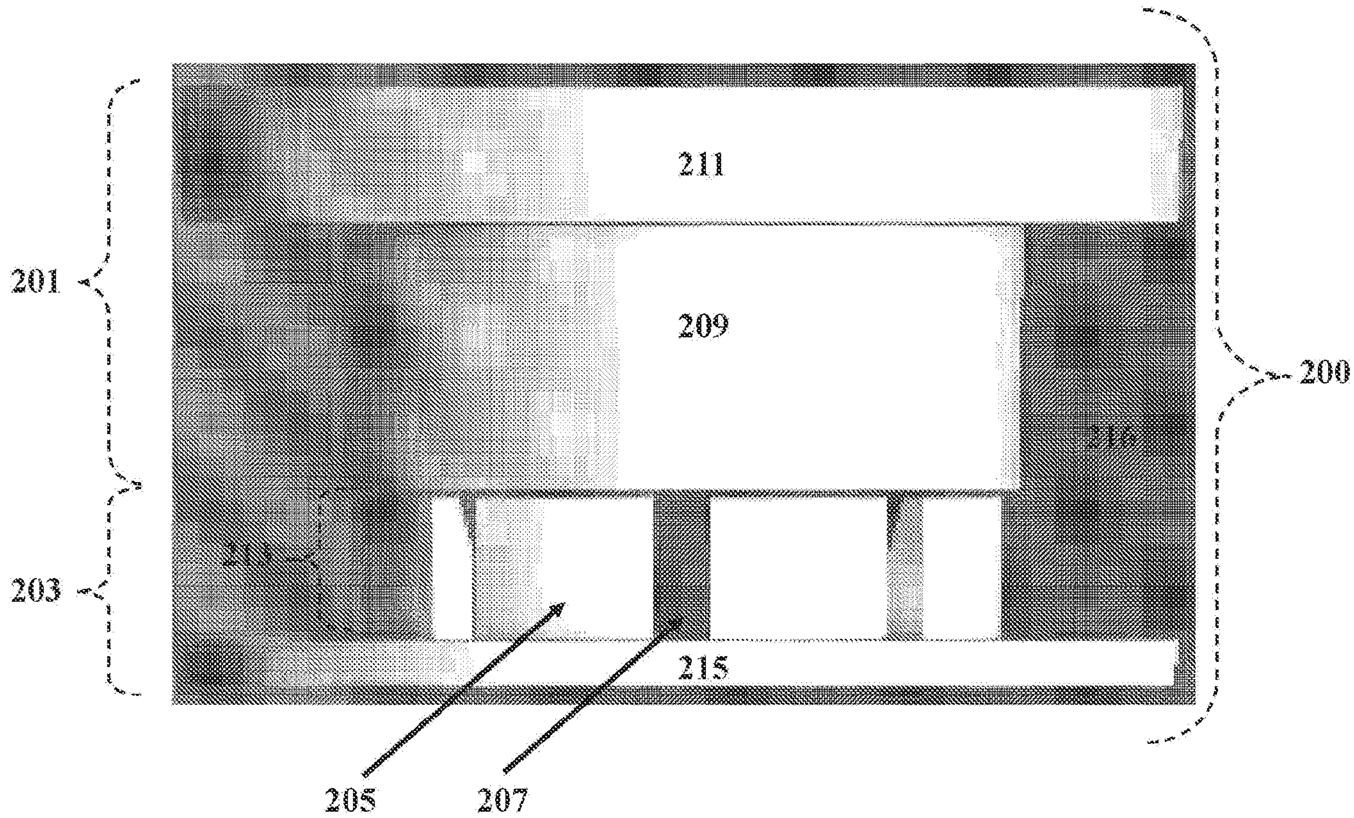

Figure 6A

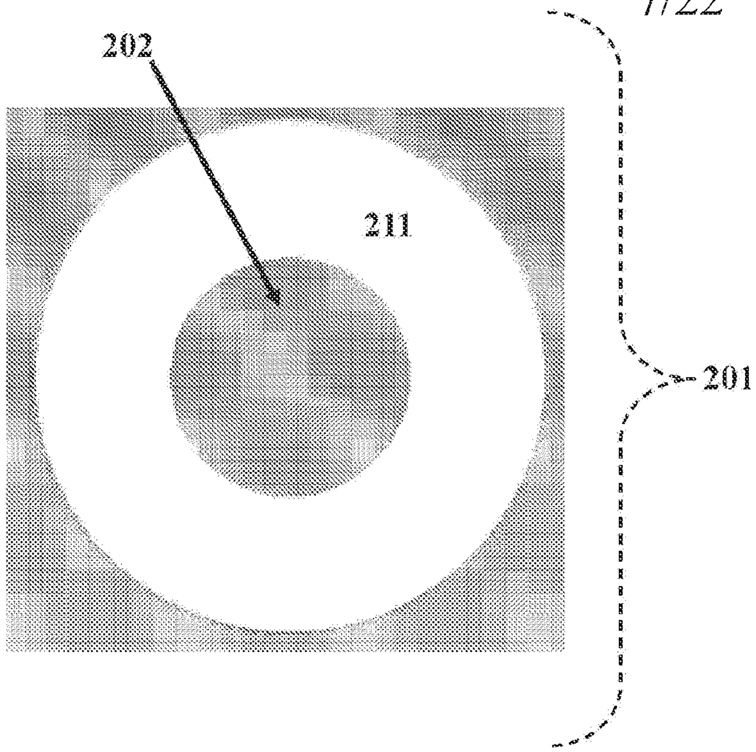

Figure 6B

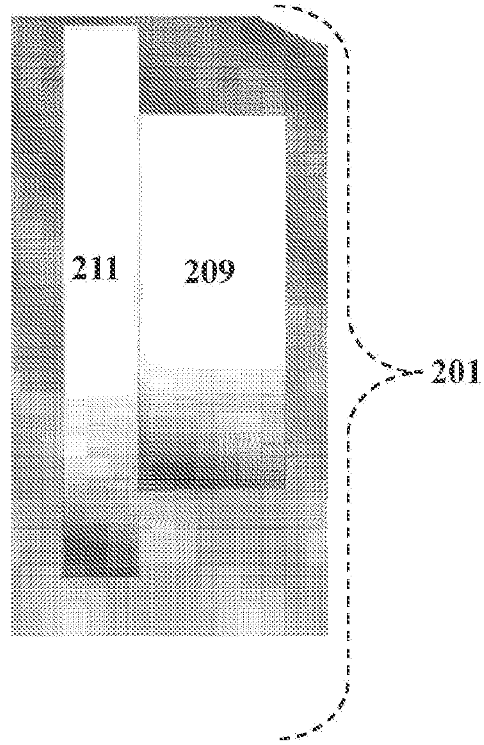

Figure 6C

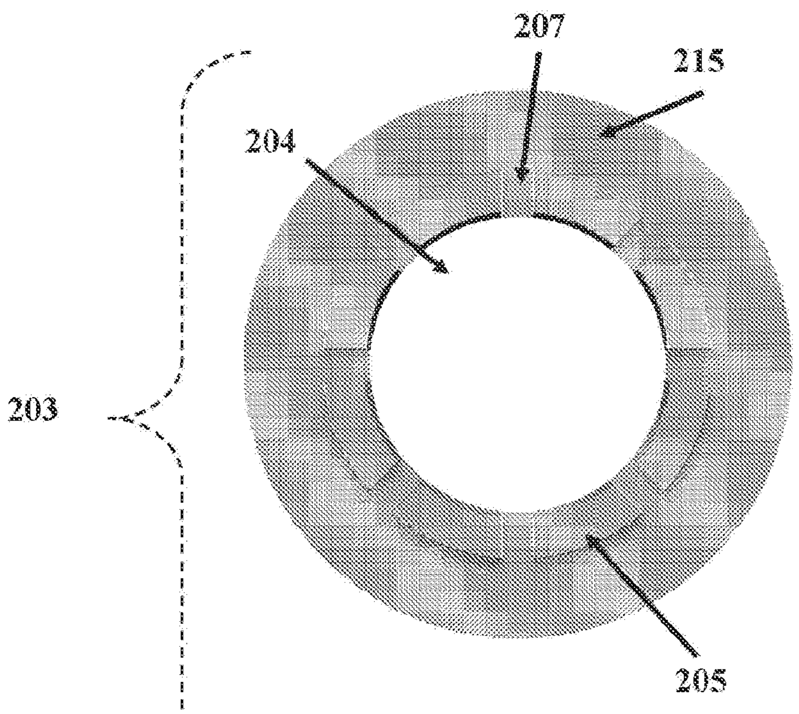

Figure 6D

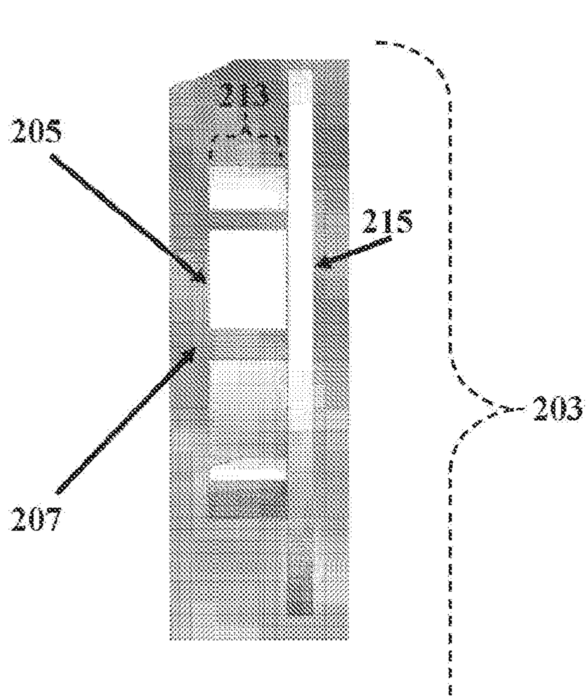

Figure 6E

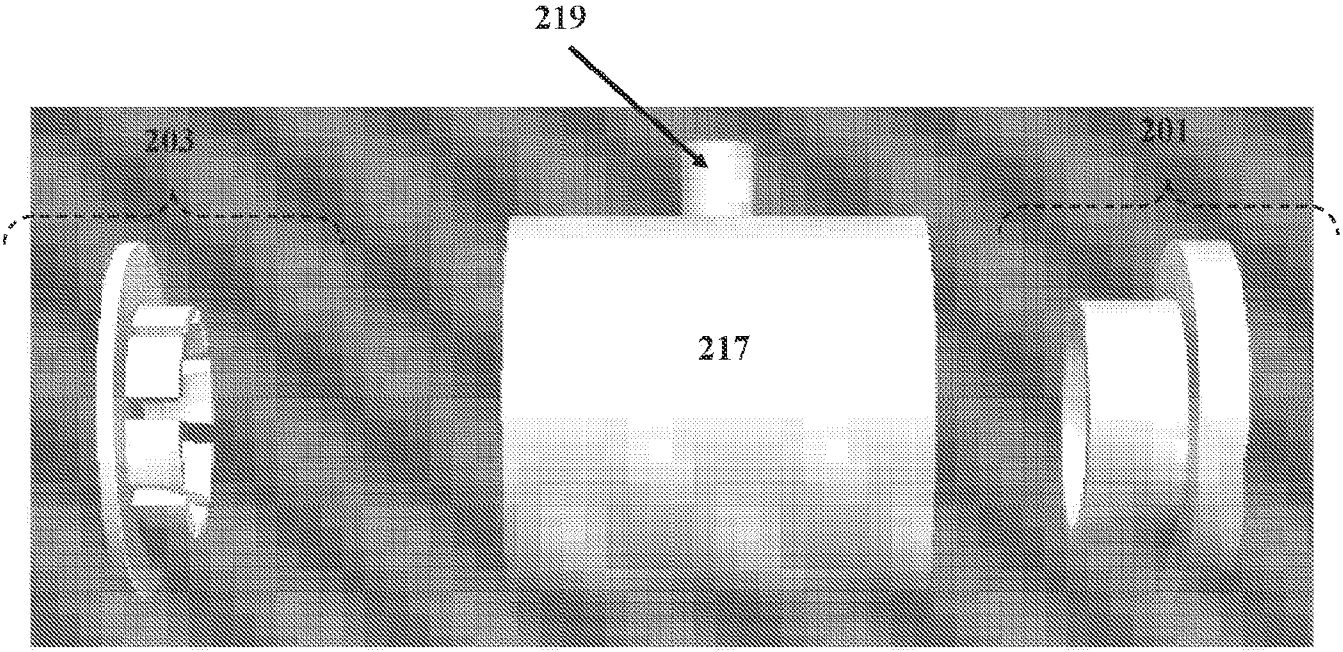

Figure 7A

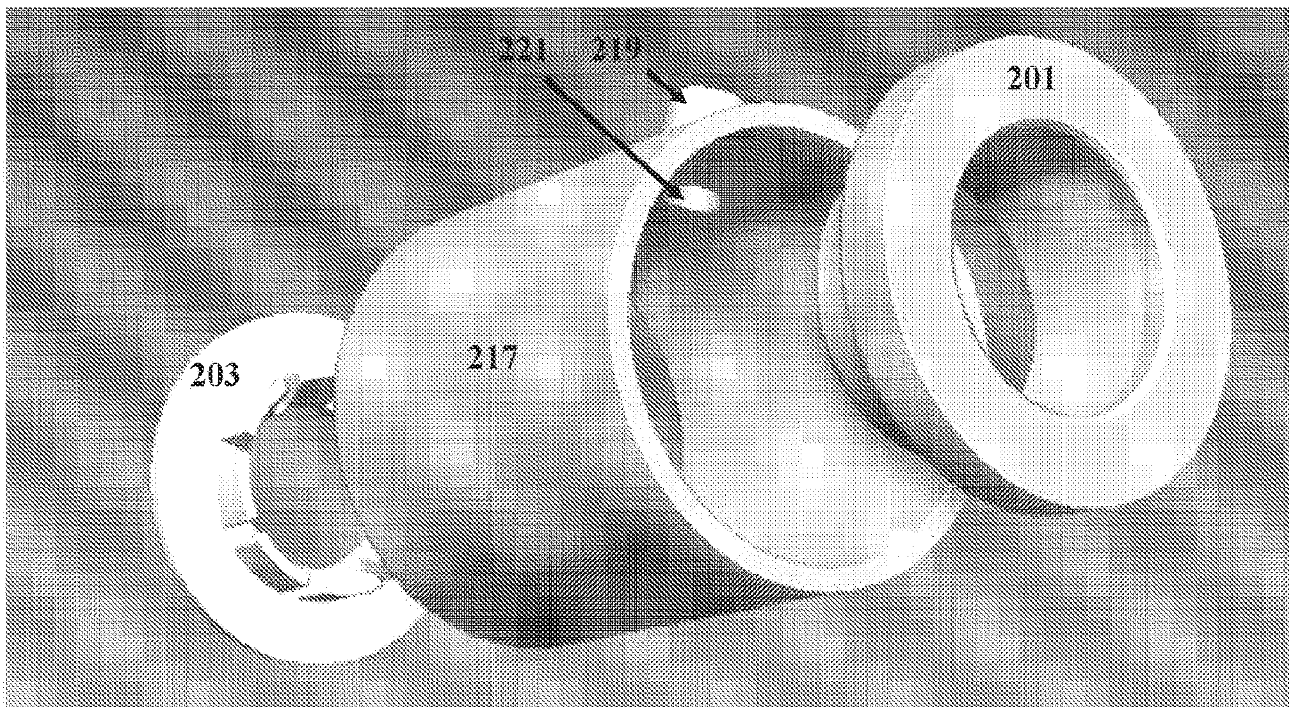

Figure 7B

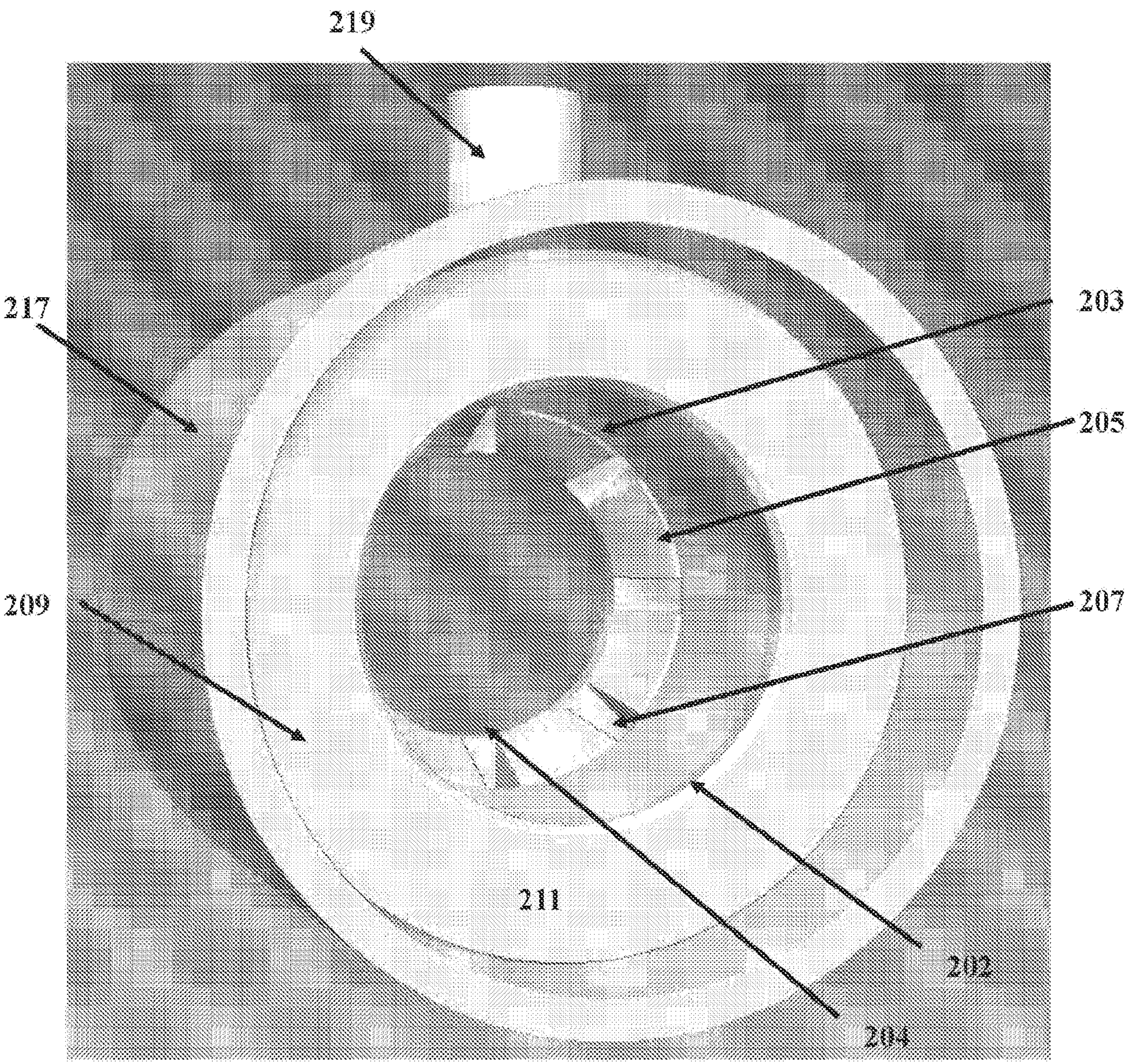

Figure 7C

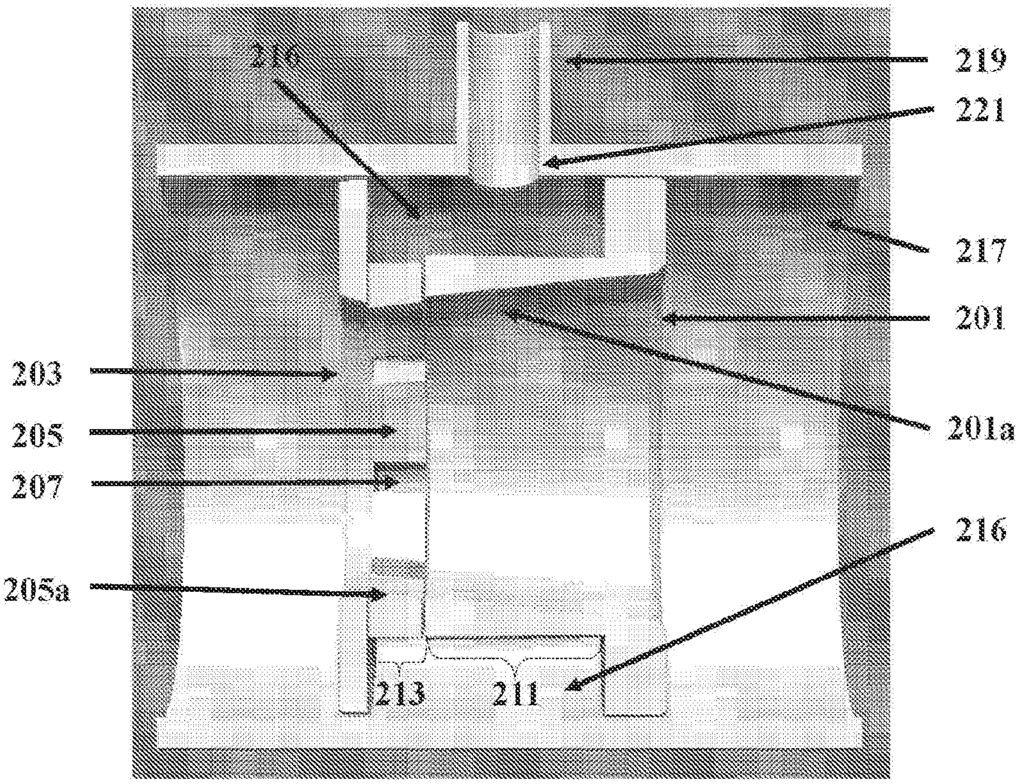

Figure 8A

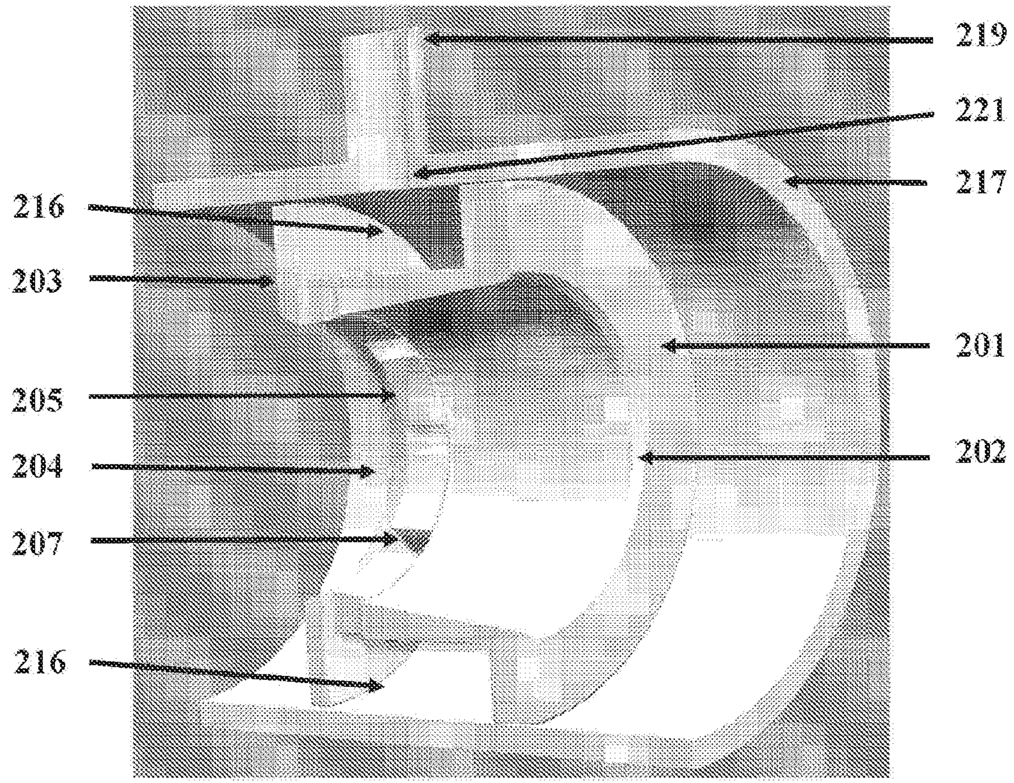

Figure 8B

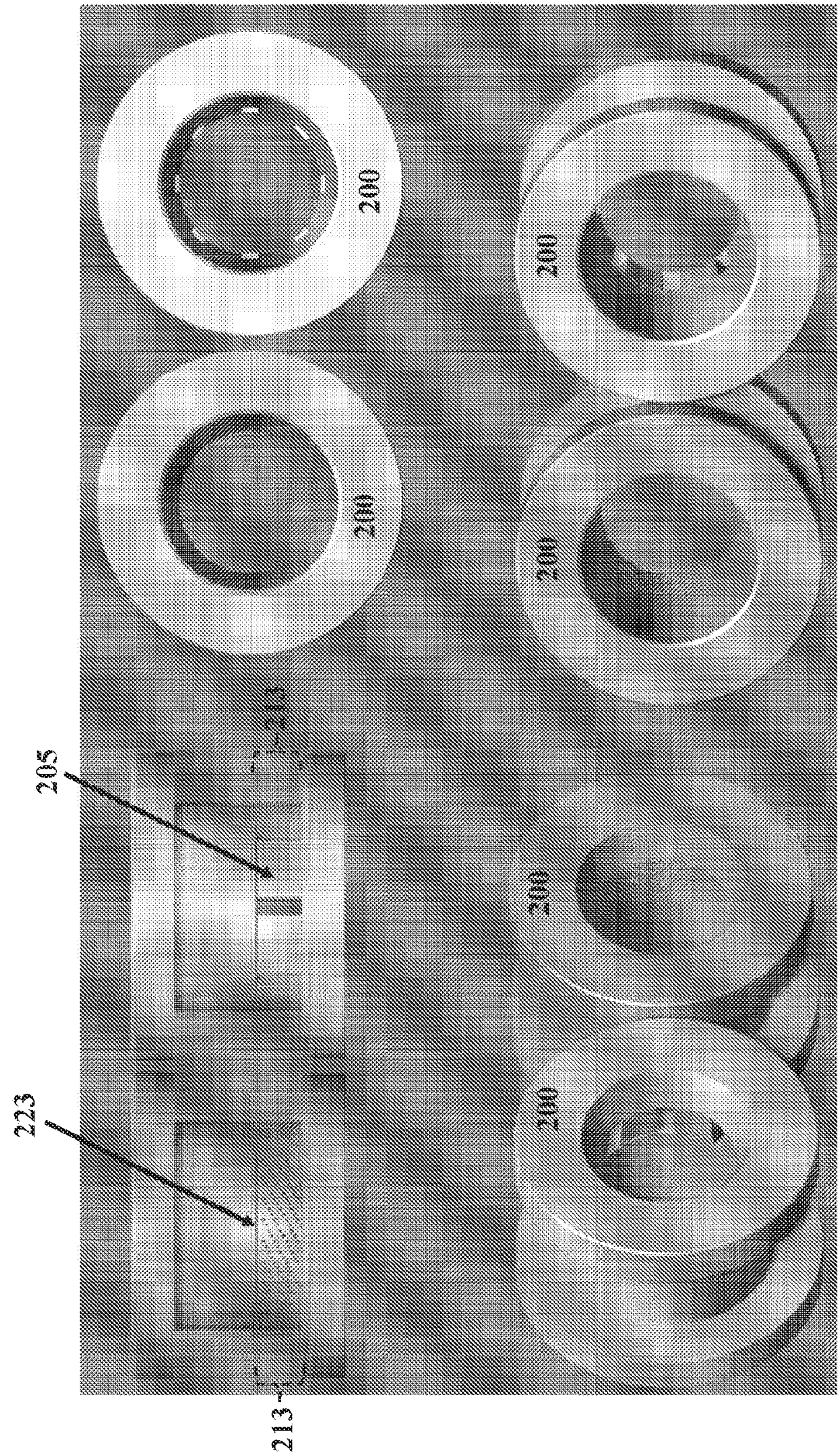

Figure 9A

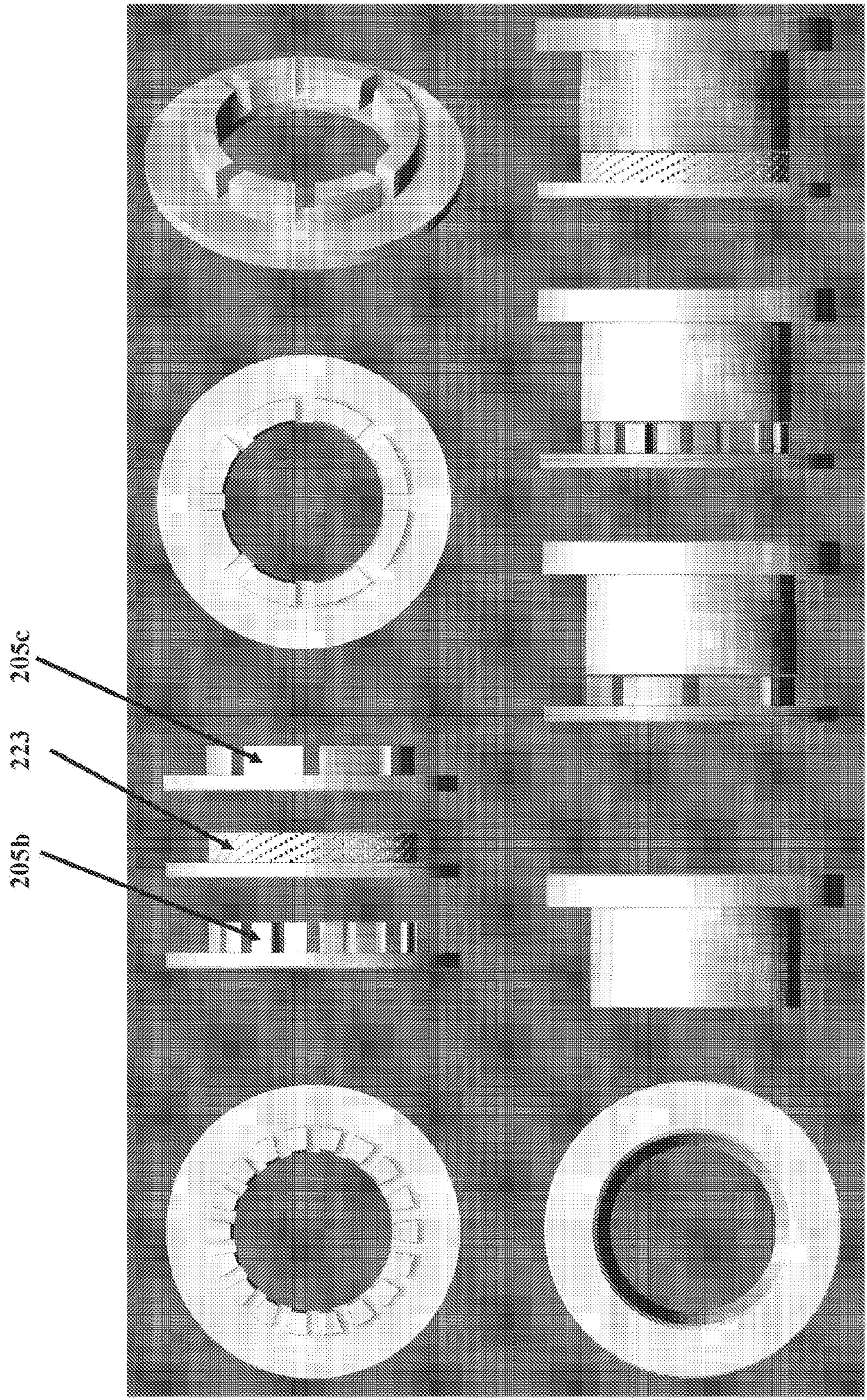

Figure 9B

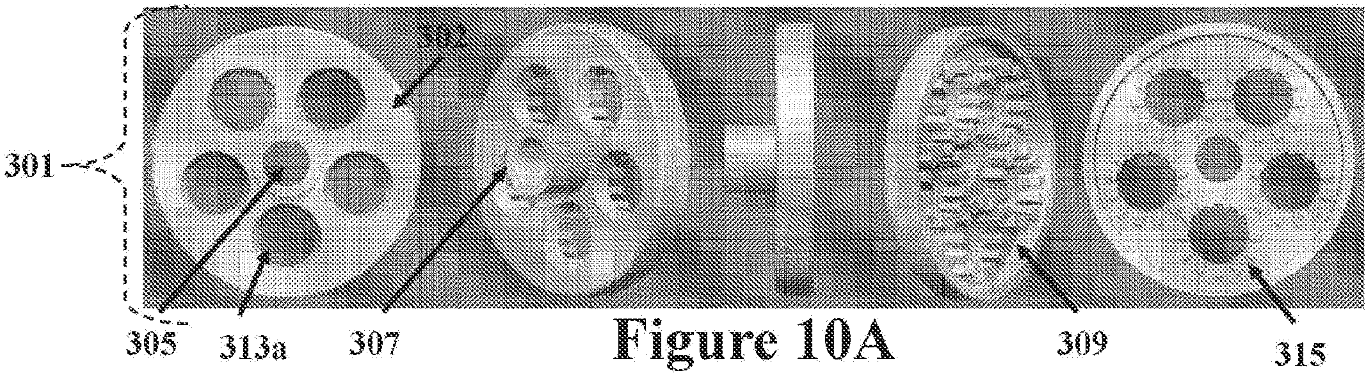

Figure 10A

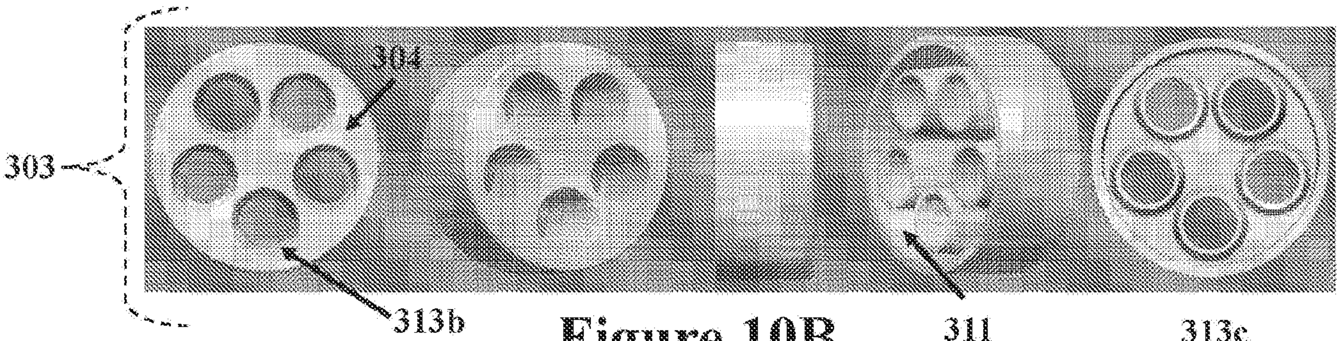

Figure 10B

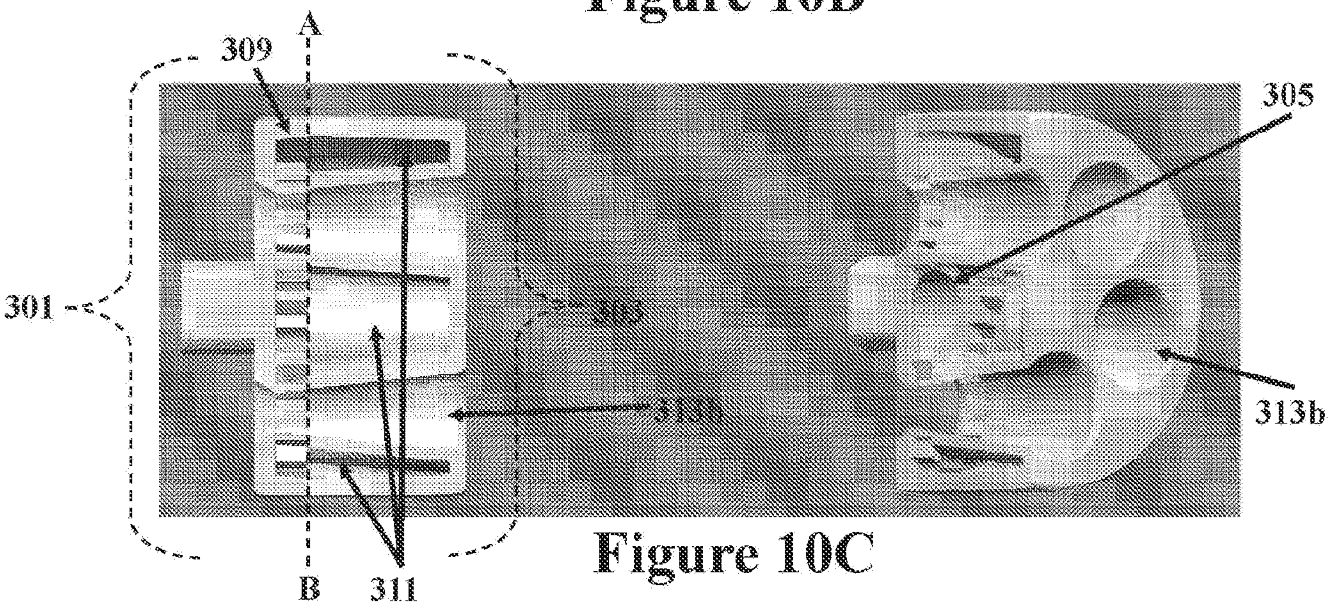

Figure 10C

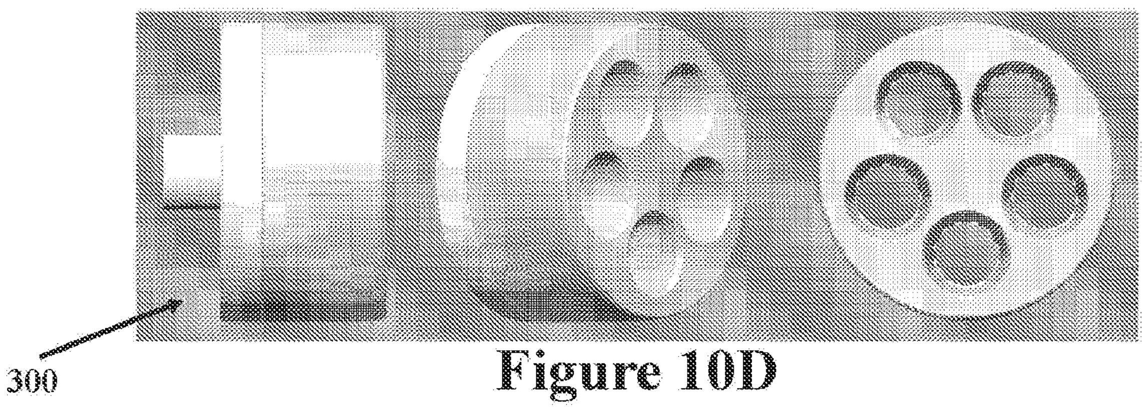

Figure 10D

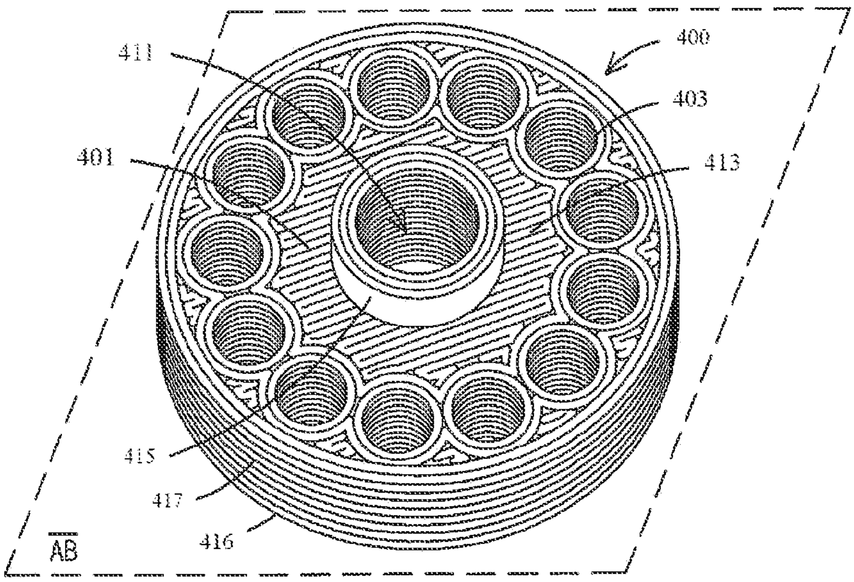

FIG. 11A

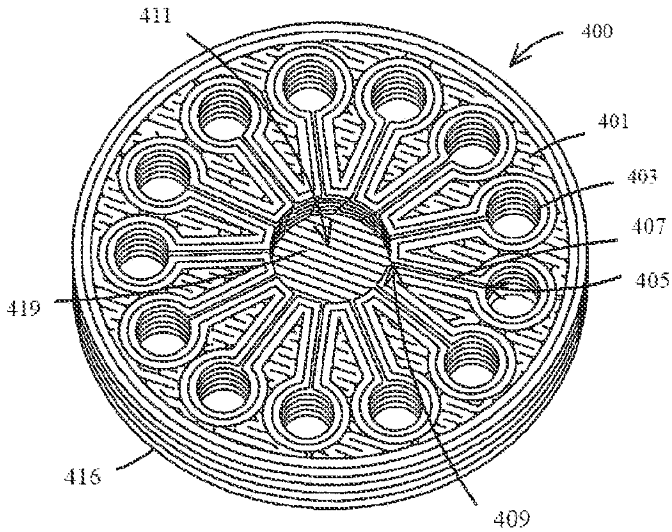

FIG. 11B

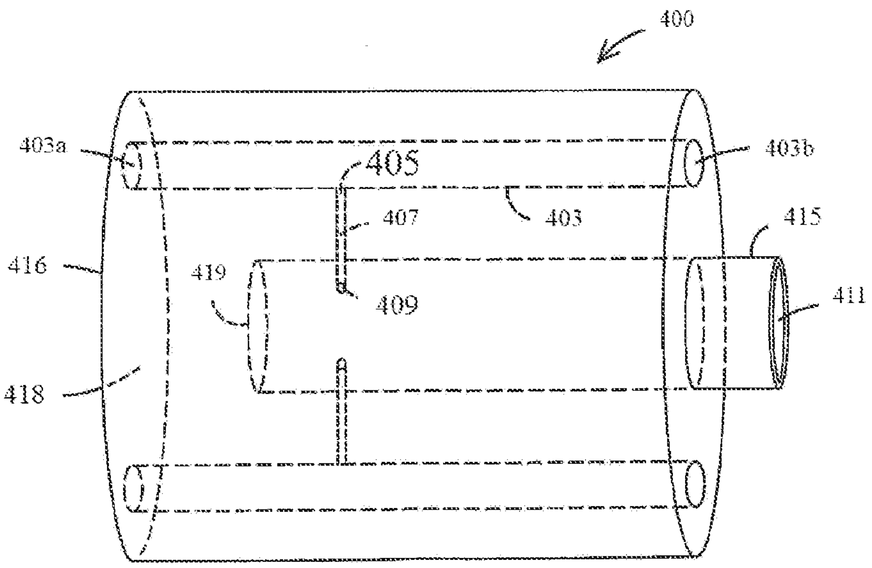

FIG. 12A

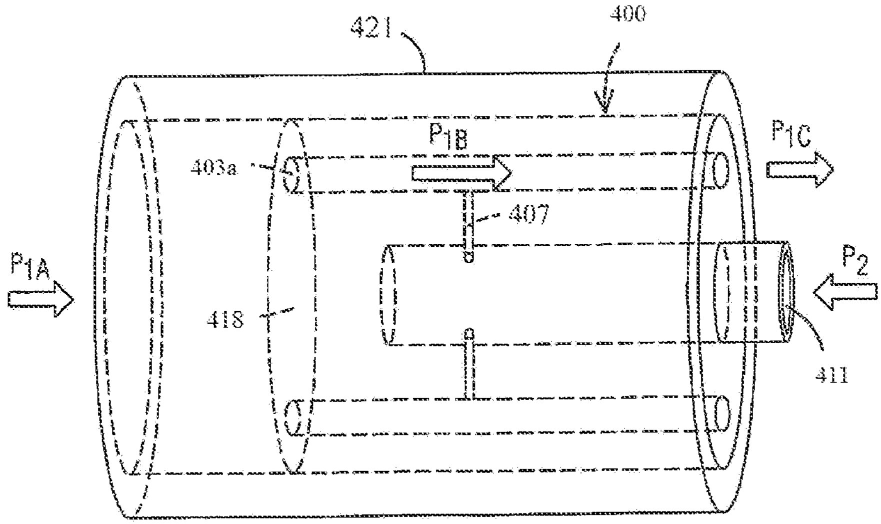

FIG. 12B

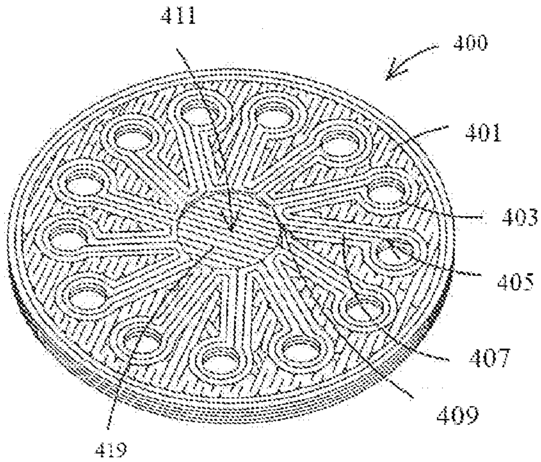

FIG. 13A

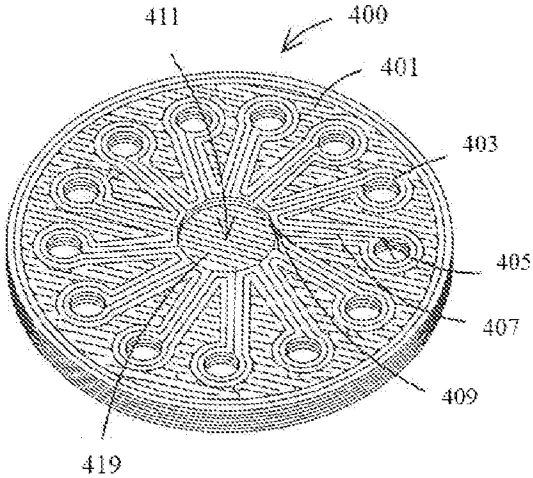

FIG. 13B

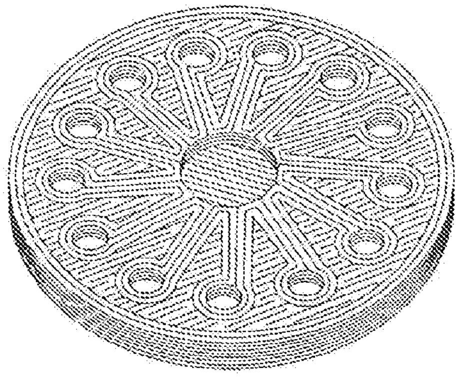

FIG. 13C

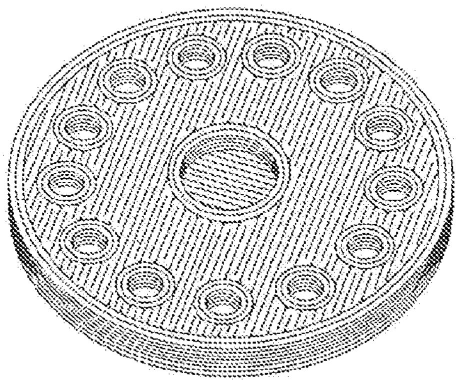

FIG. 13D

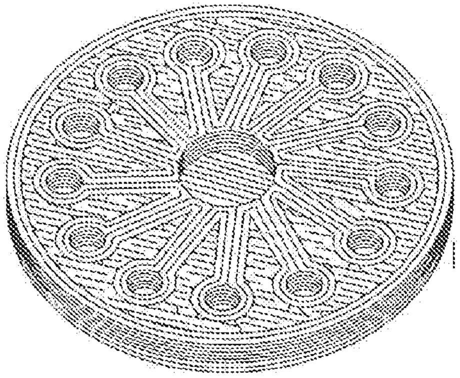

FIG. 13E

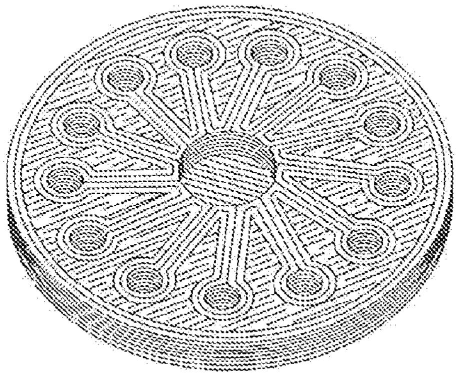

FIG 13F

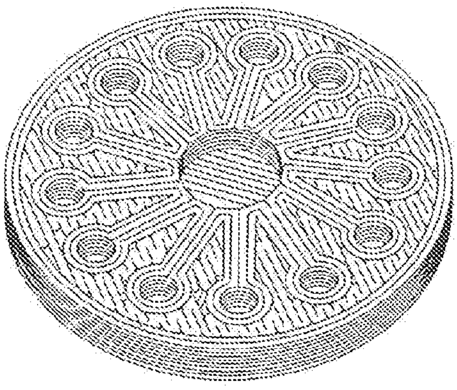

FIG 13G

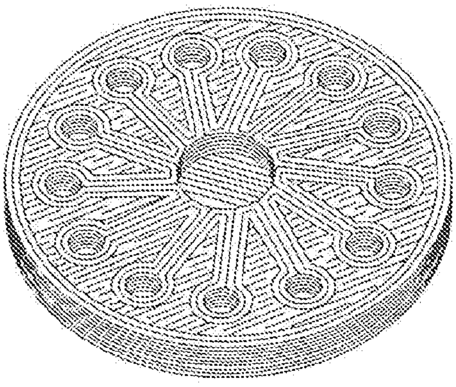

FIG 13H

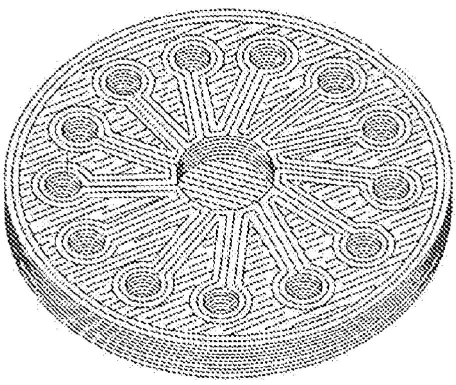

FIG. 13I

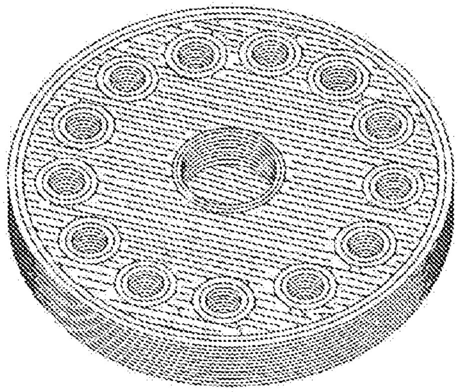

FIG. 13J

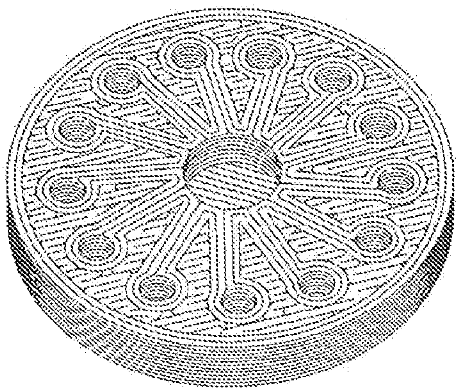

FIG 13K

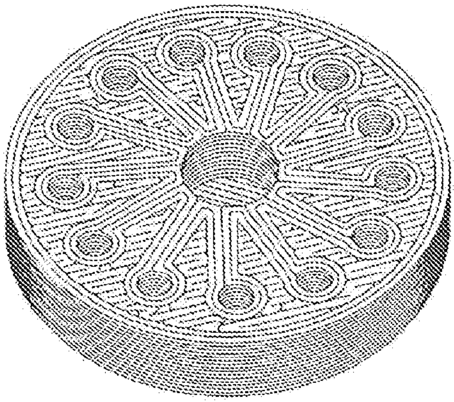

FIG. 13L

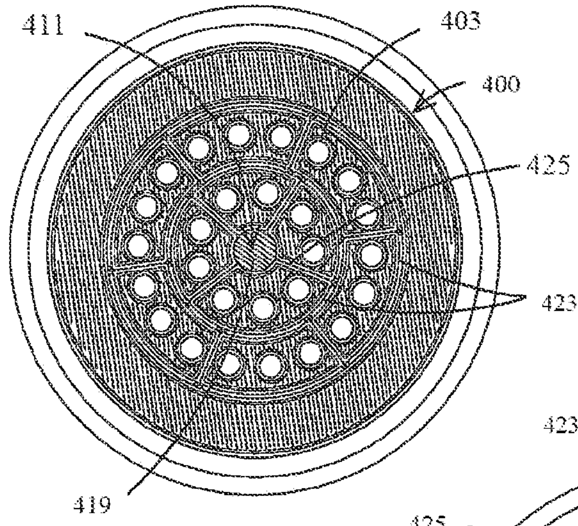

FIG. 14A

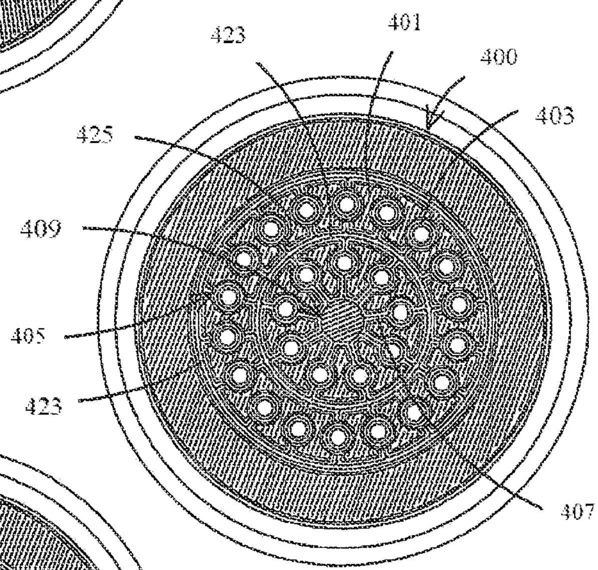

FIG. 14B

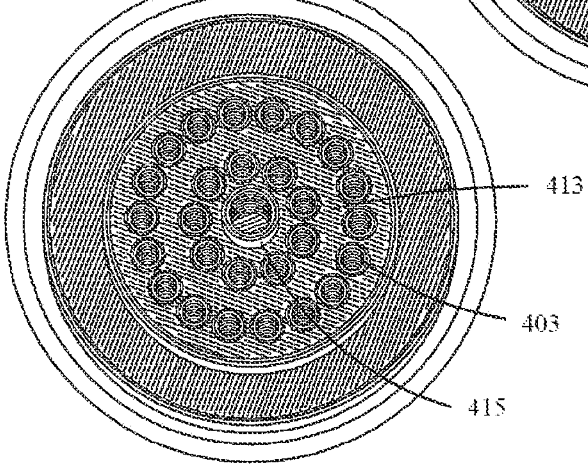

FIG. 14C

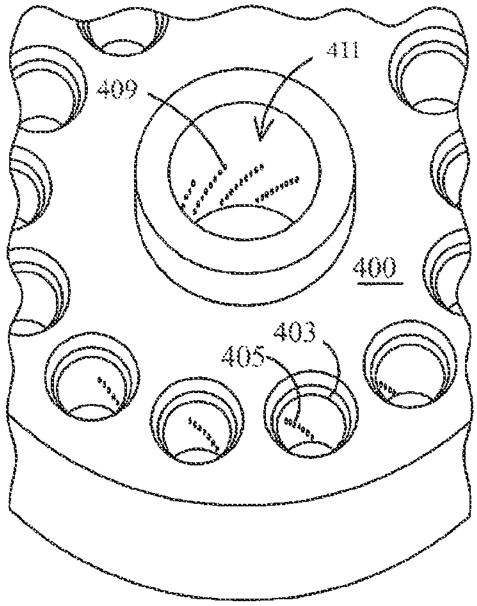

FIG. 15

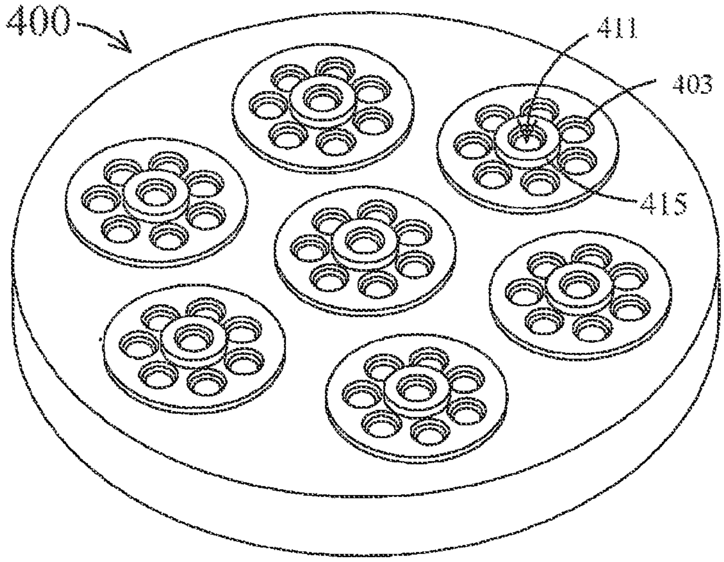

FIG. 16

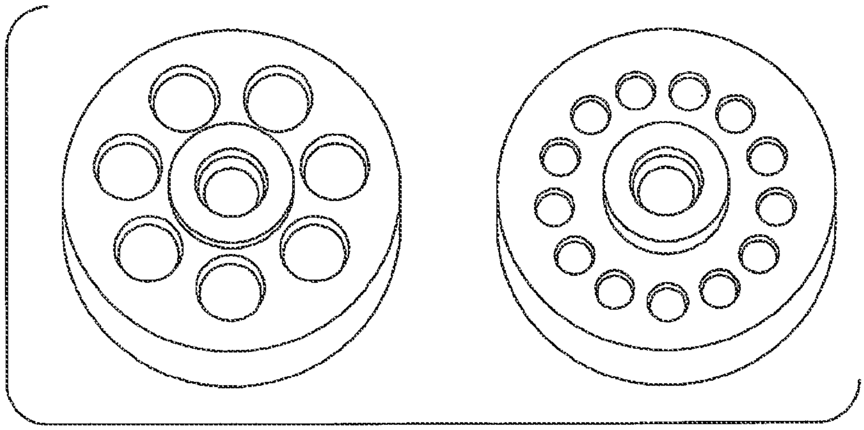

FIG. 17

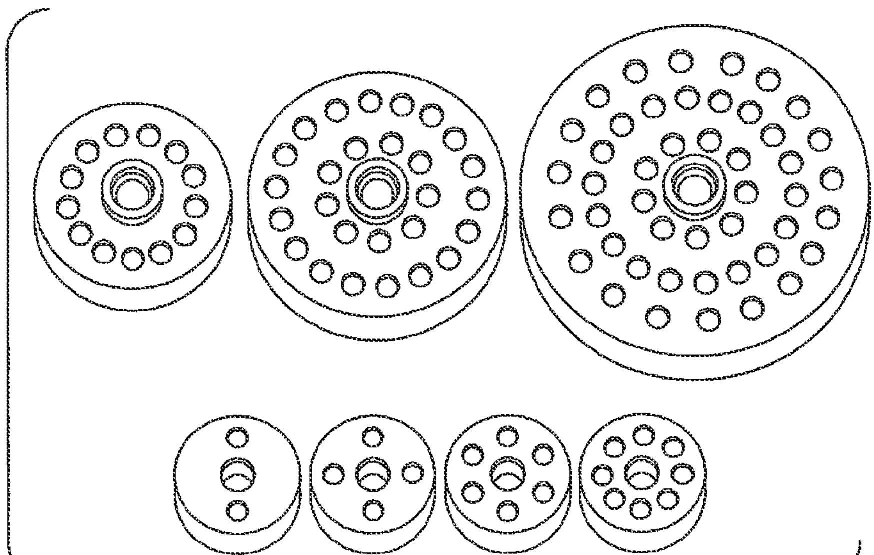

FIG. 18