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Canadian Intellectual Property Office

CA 3003148 A1 2017/05/26

(21) 3 003 148

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

(86) Date de dépôt PCT/PCT Filing Date: 2016/11/18
(87) Date publication PCT/PCT Publication Date: 2017/05/26
(85) Entrée phase nationale/National Entry: 2018/04/24
(86) N° demande PCT/PCT Application No.: US 2016/062663
(87) N° publication PCT/PCT Publication No.: 2017/087741
(30) Priorité/Priority: 2015/11/18 (US62/257,008)

(51) Cl.Int./Int.Cl. *A47K 5/14* (2006.01)

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(54) Titre : UNITE DE RECHARGE POUR DISTRIBUTEUR DE MOUSSE
(54) Title: A REFILL UNIT FOR A FOAM DISPENSER

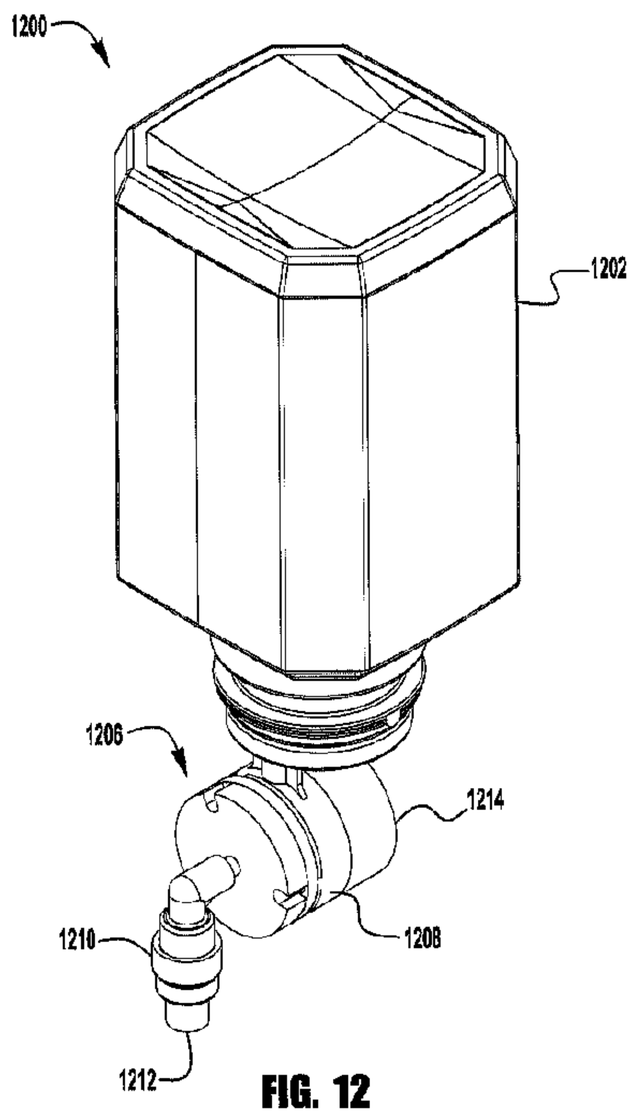

FIG. 12

(57) Abrégé/Abstract:
Refill units for foam dispensers include a container for holding foamable liquid, a foam pump secured to the container, a foaming cartridge, an outlet and an actuation mechanism. The foam pump includes a housing, a liquid pump diaphragm, a plurality of air pump diaphragms, and a mixing chamber. An actuation mechanism releasably connects to a drive system in the dispenser. The actuation mechanism sequentially activates the liquid pump diaphragm and the air pump diaphragms when the refill unit is connected to the dispenser and the drive system. Sequential activation of the liquid pump diaphragm and air pump diaphragms causes the liquid pump diaphragm to pump at least a partial dose of liquid into the mixing chamber and the air pump diaphragms to pump at least a partial dose of air into the mixing chamber.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
26 May 2017 (26.05.2017)

WIPO | PCT

(10) International Publication Number
WO 2017/087741 A1

(51) International Patent Classification:
A47K 5/14 (2006.01)

(21) International Application Number:
PCT/US2016/062663

(22) International Filing Date:
18 November 2016 (18.11.2016)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/257,008 18 November 2015 (18.11.2015) US

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,

[Continued on next page]

(54) Title: A REFILL UNIT FOR A FOAM DISPENSER

(57) Abstract: Refill units for foam dispensers include a container for holding foamable liquid, a foam pump secured to the container, a foaming cartridge, an outlet and an actuation mechanism. The foam pump includes a housing, a liquid pump diaphragm, a plurality of air pump diaphragms, and a mixing chamber. An actuation mechanism releasably connects to a drive system in the dispenser. The actuation mechanism sequentially activates the liquid pump diaphragm and the air pump diaphragms when the refill unit is connected to the dispenser and the drive system. Sequential activation of the liquid pump diaphragm and air pump diaphragms causes the liquid pump diaphragm to pump at least a partial dose of liquid into the mixing chamber and the air pump diaphragms to pump at least a partial dose of air into the mixing chamber.

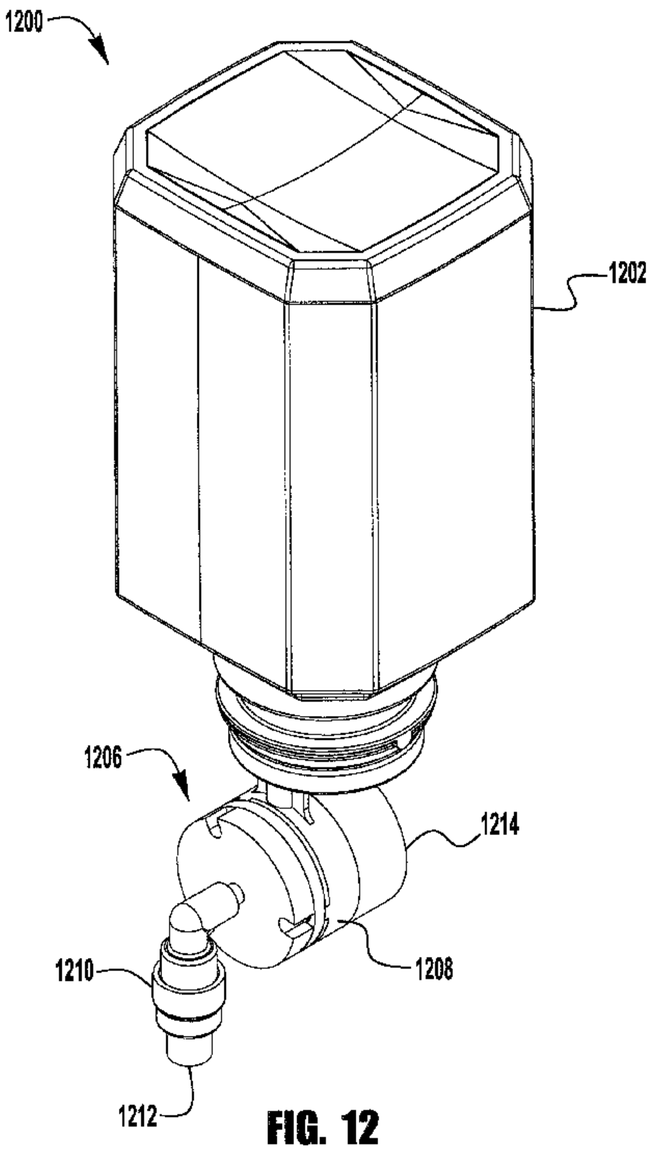

FIG. 12

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TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*

A REFILL UNIT FOR A FOAM DISPENSER

RELATED APPLICATIONS

[0001] This application claims priority to, and the benefits of, U.S. Non-Provisional Patent Application Serial No. 62/257,008 filed on November 18, 2015 and titled SEQUENTIALLY ACTIVATED MULTI-DIAPHRAGM FOAM PUMPS, REFILL UNITS AND DISPENSER SYSTEMS, which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] The present invention relates generally to pumps, refill units for dispenser systems, and more particularly to pumps, refill units, and dispensers having sequentially activated multi-diaphragm foam pumps for mixing liquid soap, sanitizer, or lotion with air to create and dispense a foam product.

BACKGROUND OF THE INVENTION

[0001] Liquid dispenser systems, such as liquid soap and sanitizer dispensers, provide a user with a predetermined amount of liquid upon actuation of the dispenser. In addition, it is sometimes desirable to dispense the liquid in the form of foam by, for example, injecting air into the liquid to create a foamy mixture of liquid and air bubbles.

SUMMARY

[0002] The present application discloses exemplary embodiments of sequentially activated multi-diaphragm foam pumps, refill units and dispenser systems and refill units sequentially activated multi-diaphragm foam pumps.

[0003] An exemplary refill unit for a foam dispenser includes a container for holding foamable liquid, a foam pump secured to the container, a foaming cartridge, an outlet and an actuation mechanism. The foam pump includes a housing, a liquid pump diaphragm, a plurality of air pump diaphragms, and a mixing chamber. Liquid from the liquid pump diaphragm and air from the air pump diaphragms mix in the mixing chamber to form a foamy mixture. The foaming cartridge is in fluid communication with the mixing chamber, and the foamy mixture travels through the foaming cartridge. A dose of foam exits the foaming cartridge, and the dose of foam is dispensed out of the outlet of the refill unit. An actuation mechanism releasably connects to a drive system that is permanently attached to a dispenser. The actuation mechanism sequentially activates the liquid pump diaphragm and the air pump diaphragms when the refill unit is connected to the dispenser and the drive system is activated. The sequential activation of the liquid pump diaphragm and air pump diaphragms causes the liquid pump diaphragm to pump at least a partial dose of liquid into the mixing chamber and the air pump diaphragms to pump at least a partial dose of air into the mixing chamber.

[0004] Another exemplary refill unit for a foam dispenser includes a container for holding foamable liquid, a foam pump connected to the container, a mixing chamber, a foaming cartridge, an outlet, and a plate. The foam pump has a plurality of diaphragm pumping chambers. At least one diaphragm pumping chamber pumps liquid, and at least two diaphragm pumping chambers pump air. The mixing chamber is located downstream of the plurality of diaphragm pumping chambers for mixing liquid and air to form a foamy mixture. The foaming cartridge is located downstream of the mixing chamber, and the foamy mixture travels through the foaming cartridge and exits the foaming cartridge as an enriched foam. The foam is dispensed through the outlet of the refill unit. The plate is connected to the plurality of diaphragm pumping chambers. The plate is configured to engage with a drive system that is permanently secured to the foam dispenser when the refill unit is installed in the foam dispenser and disengage with the drive system when the refill unit is removed from the foam dispenser. Movement of the plate about an axis causes at least a partial dose of liquid to be pumped into the mixing chamber, followed by at least a partial dose of a first dose of air being pumped into the mixing chamber, followed by at least a partial dose of a second dose of air being pumped into the mixing chamber.

[0005] Another exemplary refill unit for a foam dispenser includes a container for holding foamable liquid, a sequentially activated multi-diaphragm foam pump secured to the container, a wobble plate, a pin, a foaming cartridge, and a foam outlet. The sequentially activated multi-diaphragm foam pump has a liquid pump diaphragm for pumping liquid into a mixing chamber, a first air pump diaphragm for pumping air into the mixing chamber, and a second air pump diaphragm for pumping air into the mixing chamber. The wobble plate is secured to the liquid pump diaphragm, the first air pump diaphragm, and the second air pump diaphragm. The pin has a first end that is connected to the wobble plate and a second end that is free. Movement of the second end of the pin in a circular path causes a sequential compression of the liquid pump diaphragm, the first air pump diaphragm, and the second air pump diaphragm. The second end of the pin is releasably connected to an eccentric drive system that is permanently connected to the foam dispenser. The foaming cartridge is downstream from the mixing chamber, and the foam outlet is downstream of the foaming cartridge. Foam is dispensed from the foam outlet.

[0006] Another exemplary refill unit for a foam dispenser includes a container for holding foamable liquid, a sequentially activated multi-diaphragm foam pump, a plate, a foaming cartridge, and an outlet. The sequentially activated multi-diaphragm foam pump includes a housing, a liquid pump portion secured to the housing, an air pump portion secured to the housing, a mixing chamber, and a pump outlet. The liquid pump portion has a liquid inlet, a liquid inlet valve, a liquid pump diaphragm, a liquid outlet valve, and a liquid outlet. The air pump portion has a first and second air inlet, a first and second air inlet valve, a first and second air pump diaphragm, a first and second air outlet valve, and a first and second air outlet. The mixing chamber is in fluid communication with the liquid outlet, the first air outlet, and the second air outlet. The liquid pump diaphragm pumps a shot of liquid into the mixing chamber. The first air pump diaphragm pumps a shot of air into the mixing chamber to mix with the liquid to form a liquid air mixture. The second air pump diaphragm pumps a shot of air into the mixing chamber to mix with the liquid air mixture to form a foamy mixture. The foamy mixture is dispensed from the pump outlet. The plate is connected to the liquid pump diaphragm, the first air pump diaphragm, and the second air pump diaphragm. The plate is configured to engage with a drive system that is permanently secured to the foam dispenser when the refill unit is installed in the foam dispenser and disengage with the drive system when the refill unit is removed from the foam dispenser. Movement of the plate about an axis causes the shot of liquid to be pumped from the liquid

pump diaphragm into the mixing chamber, followed by the shot of air to be pumped from the first air pump diaphragm into the mixing chamber, followed by the shot of air to be pumped from the second air pump diaphragm into the mixing chamber. The foaming cartridge is in fluid communication with the pump outlet, and the outlet of the refill unit is in fluid communication with the foaming cartridge. Foam is dispensed from the outlet of the refill unit. In addition, some exemplary refill units do not contain a plate and the drive mechanism on the foam dispenser is configured to sequentially compress the diaphragms without the need for the plate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 is an exemplary embodiment of a refill unit for a foam dispenser;

[0008] FIG. 2 is an exemplary embodiment of a foam dispenser;

[0009] FIG. 2A is the exemplary foam dispenser of FIG. 2 with the exemplary refill unit of FIG. 1 installed;

[0010] FIG. 3 is an exploded view of an exemplary embodiment of a sequentially activated multi-diaphragm foam pump and motor taken from a first perspective;

[0011] FIG. 4 is an exploded view of the exemplary embodiment of the sequentially activated multi-diaphragm foam pump and motor of FIG. 3 taken from a second perspective;

[0012] FIG. 5 is a top view of an exemplary diaphragm assembly for the exemplary embodiment of the sequentially activated multi-diaphragm foam pump of FIG. 3;

[0013] FIG. 6 is a bottom view of the exemplary diaphragm assembly of FIG. 5;

[0014] FIG. 7 is a top view of an exemplary valve seat for the exemplary embodiment of the sequentially activated multi-diaphragm foam pump of FIG. 3;

[0015] FIG. 8 is a bottom view of the exemplary valve seat of FIG. 7;

[0016] FIG. 9 is a top view of an exemplary diaphragm assembly seat for the exemplary embodiment of the sequentially activated multi-diaphragm foam pump of FIG. 3;

[0017] FIG. 10A is a cross-sectional view taken along the lines A-A of FIGs. 5-9 of a liquid pump portion of the sequentially activated multi-diaphragm foam pump of FIG. 3;

[0018] FIG. 10B is a cross-sectional view taken along the lines B-B of FIGs. 5-9 of a first air pump portion of the sequentially activated multi-diaphragm foam pump of FIG. 3;

[0019] FIG. 10C is a cross-sectional view taken along the lines C-C of FIGs. 5-9 of a second air pump portion of the sequentially activated multi-diaphragm foam pump of FIG. 3;

[0020] FIG. 11 is a cross-sectional view of another exemplary embodiment of a sequentially activated multi-diaphragm foam pump;

[0021] FIG. 12 is a perspective view of an exemplary embodiment of a refill unit having a sequentially activated multi-diaphragm foam pump;

[0022] FIG. 13 is a rear view of the exemplary embodiment of the refill unit having a sequentially-activated multi-diaphragm foam pump of FIG. 12 with a back cover;

[0023] FIG. 14 is a perspective view of the exemplary embodiment of the refill unit having a sequentially-activated multi-diaphragm foam pump of FIG. 12 without the back cover;

[0024] FIG. 15 is a back view of the exemplary embodiment of the refill unit having a sequentially-activated multi-diaphragm foam pump of FIG. 12 without the back cover;

[0025] FIG. 16 is an exemplary foam dispenser with the refill unit having a sequentially-activated multi-diaphragm foam pump installed therein;

[0026] FIG. 17 is the exemplary foam dispenser with the refill unit removed; and

[0027] FIG. 18 is an exemplary motor and drive system for the exemplary foam dispenser of FIG. 16.

DETAILED DESCRIPTION

[0028] The present application discloses exemplary embodiments of foam dispensers, and refill units that having sequentially activated multi-diaphragm foam pumps. Some exemplary embodiments include a wobble plate and three or more pump diaphragms. The

three or more pump diaphragms include at least one liquid pump diaphragm and at least two air pump diaphragms. Each liquid pump diaphragm has a liquid inlet for receiving liquid, such as, for example, a soap, a sanitizer, or a lotion, and each air pump diaphragm has an air inlet for receiving gas, such as, for example, ambient air. The three or more pump diaphragms operate sequentially, and each pump diaphragm operates once in an operating cycle. An exempleary operating cycle begins with the operation of a liquid pump diaphragm. Additionally, the sequentially activated multi-diaphragm foam pump includes a mixing chamber. Each liquid pump diaphragm pumps liquid into the mixing chamber, and each air pump diaphragm pumps air into the mixing chamber. The liquid mixes with the air in the mixing chamber to create a foam mixture that is dispensed out of the pump outlet. In some embodiments, the foam mixture has an air to liquid ratio of between about 7 to 1 and about 10 to 1. In some embodiments, the air to liquid ratio is greater than 10 to 1, and in some embodiments is less than 7 to 1.

[0029] The sequentially activated multi-diaphragm foam pumps may be used in foam dispensers. An exemplary foam dispenser comprises a housing, a motor, a refill unit, a sequentially activated multi-diaphragm foam pump, and a foaming cartridge. The pump receives a foamable liquid from the refill unit, mixes the foamable liquid with air to create a foam mixture, forces the foam mixture through the foaming cartridge to enrich the foam, and dispenses the foam to a user.

[0030] FIG. 1 illustrates a refill unit 100 for a foam dispenser. The refill unit 100 includes a collapsible container 102. Collapsible container 102 includes a neck 103 and a drip-free quick connector 104. Exemplary drip-free quick connectors are disclosed in U.S. Patent No. 6,871,679 titled Bag and Dispensing System Comprising Such A Bag, and U.S. Pat. No. 7,647,954 titled Connector Apparatus And Method For Connecting The Same For Controlling Fluid Dispensing, which are incorporated herein by reference in their entirety. Refill units contain a supply of a foamable liquid. In various embodiments, the contained foamable liquid could be for example a soap, a sanitizer, a cleanser, a disinfectant, a lotion or the like. The container is a collapsible container and can be made of thin plastic or a flexible bag-like material. In other embodiments, the container may be a non-collapsing container formed by a rigid housing member, or any other suitable configuration for containing the foamable liquid without leaking. In the case of a non-collapsing container, a vent system may be included. Exemplary venting systems are disclosed in U.S. Patent Applications

Publication No. 2015/0266657 titled Closed system for venting a dispenser reservoir; Publication No. 2015/025184 titled Pumps With Container Vents and Application No. 14/811,995, titled Vented Refill Units And Dispensers Having Vented Refill Units, which are incorporated herein by reference.

[0031] FIG. 2 illustrates an exemplary embodiment of a touch-free foam dispenser 200. The touch-free foam dispenser 200 includes a housing 202, a motor 204, a foam pump 206, a refill unit connector 208, a foaming cartridge 210, and a nozzle 212. Exemplary embodiments of foaming cartridges 210 are shown and described in U.S. Publication No. 20140367419, which is incorporated herein in its entirety by reference. A refill unit 100 may be connected to the refill unit connector 208 as shown in FIG. 2A. The refill unit 100 contains a foamable liquid, such as a soap, a sanitizer, a lotion, a cleanser, a disinfectant or the like. The touch-free foam dispenser 200 is activated when sensor 214 detects the presence of a user or object. Upon detection of an object or user, the sensor 214 provides a signal to the processor (not shown) in the electronic control board 216. The electronic control board 216 provides an output signal that causes the motor 204 to rotate an eccentric wobble plate actuator drive mechanism 301. The sensor 214 and the electronic control board 216 receive power from a power source 218. In some embodiments, the motor 204 receives power from the power source 218, and, in other embodiments, the refill unit includes a power source (not shown) that provides power to a rechargeable power source (not shown). Exemplary embodiments of refill units with power supplies that provide power to the wobble plate actuator drive mechanism 301 (FIG. 3) are shown and described in U.S. Publication No. 2014/0234140 titled Power Systems For Touch Free Dispensers And Refill Units Containing A Power Source, which is incorporated herein in its entirety by reference. Providing power to the motor 204 causes wobble plate actuator drive mechanism 301 to rotate. Rotation of eccentric wobble plate actuator drive mechanism 301 sequentially compresses and expands the diaphragms of foam pump 206 and pumps liquid and air into mixing chamber. The liquid and air mix together and form a foamy mixture. The foamy mixture is forced through the foaming cartridge 210, which enhances the foam into a rich foam. The rich foam is dispensed from the foam dispenser 200 through the nozzle 212.

[0032] The refill unit 100 and the foam dispenser 200 illustrated in FIGs. 1 and 2, respectively, are drawn generically because a variety of different components may be used for many of the refill unit 100 and the foam dispenser 200. Although foam pump 206 is

illustrated generically above, it is described in detail below. Some exemplary dispenser components that may be used in accordance with the present invention are shown and described in U.S. Patent No, 8,960,498 titled Touch-Free Dispenser With Single Cell Operation And Battery Banking; U.S. Pat. Pub. No. 2014/00543.22 titled Off-Axis Inverted Foam Dispensers And Refill Units and Pub. No. 2014/0234140 titled Power Systems For Touch Free Dispensers And Refill Units Containing a Power Source, which are incorporated herein by reference in their entirety.

[0033] FIG. 3 is an exploded view of an exemplary embodiment of foam pump 206. Foam pump 206 is driven by motor 204. Foam pump 206 includes a pump base 324, a wobble plate 314, a diaphragm assembly seat 312, a diaphragm assembly 310, a valve seat 308, outlet valves 323A, 323B, 323C, screws 302, and a cover 348. The valve seat 308, diaphragm assembly seat 312, and pump base 324 are secured together by screws 302 in screw holes 308A, 312A, 324A. The cover 348 is attached to the valve seat 308. Outlet valves 323A, 323B 323C are secured to and seated in the valve seat 308.

[0034] The diaphragm assembly 310 includes three pump diaphragms 310A, 310B, 310C, and each pump diaphragm 310A, 310B, 310C has a connector 311A, 311B, 311C. The diaphragm assembly 310 is located in the diaphragm assembly seat 312. The pump diaphragms 310A, 310B, 310C are disposed in the receiving holes 313A, 313B, 313C of the diaphragm assembly seat 312, and the three connectors 311A, 311B, 311C connect to the wobble plate 314 by inserting the three connectors 311A, 311B, 311C in the three wobble plate links 314A, 314B, 314C.

[0035] Air enters the foam pump 206 through pump air inlet 424B (FIG. 4), and liquid, such as for example, foamable soap or sanitizer enters the foam pump 206 through liquid inlet 352. Two of the pump diaphragms 310B, 310C receive air, and the other pump diaphragm 310A receives foamable liquid, such as, for example soap or sanitizer.

[0036] FIG. 4 is another exploded view of the exemplary foam pump 206 from a different perspective. As described above, the diaphragm assembly 310 includes three pump diaphragms 310A, 310B, 310C. Each pump diaphragm 310A, 310B, 310C has a corresponding inlet valve 316A, 316B, 316C (better seen in FIGs. 5 and 6). FIG. 4 also provides a view of the bottom of the valve seat 308. The bottom of valve seat 308 has three areas that correspond to the three pump diaphragms 310A, 310B, 310C. Each area has three

fluid outlet apertures 309A, 309B, 309C that extend through valve seat 308, a valve stem retention aperture 329A, 329B, 329C (FIG. 7), and a fluid inlet groove 319A, 319B, 319C. The fluid inlet grooves 319A, 319B, 319C do not extend through valve seat 308.

[0037] FIGs. 5 and 6 illustrate a top view and a bottom view, respectively, of the exemplary diaphragm assembly 310 for foam pump 206. In some embodiments, the diaphragm assembly is made of natural rubber, EPDM, Silicone, Silicone rubber TPE, TPU, TPV, vinyl, or the like. The diaphragm assembly 310 includes three molded pump diaphragms 310A, 310B, 310C and three corresponding inlet valves 316A, 316B, 316C. The top of the diaphragm assembly 310 acts as a sealing gasket. The top of the diaphragm assembly 310 has a flat section 310F, and each pump diaphragm 310A, 310B, 310C has gasket walls 327A, 327B, 327C that surround the respective valves 316A, 316B, 316C and pump diaphragms 310A, 310B, 310C. The gasket walls 327A, 327B, 327C seal against the bottom of the valve seat 308 (FIG. 4 and FIG. 8) to prevent fluid, such as, air and liquid soap or sanitizer from leaking out of the foam pump 206 at a location other than the pump outlet 350 (FIG. 3). One-way inlet valves 316A, 316B, 316C allow air, liquid soap, or sanitizer to enter the pump diaphragms 310A, 310B, 310C when the pump diaphragms 310A, 310B, 310C have a negative pressure (i.e., when the pump diaphragms 310A, 310B, 310C are expanding), and seal against inlet apertures 321A, 321B, 321C when the pump diaphragms 310A, 310B, 310C have a positive pressure (e.g. when the pump diaphragms 310A, 310B, 310C are compressing). The one-way inlet valves 316A, 316B, 316C are formed by flexible tabs and are made of the same material as the diaphragm assembly 310.

[0038] FIG. 7 is a top view of an exemplary valve seat 308 for the foam pump 206. One-way liquid outlet valve 323A is shown transparently to more clearly illustrate the flow of liquid 331A through liquid outlet apertures 309A and into mixing chamber 325. One-way liquid outlet valve 323A includes a valve stem 357A (FIG. 3) that is inserted into aperture 329A to secure one-way liquid outlet valve 323A to valve seat 308. One-way liquid outlet valve 323A is normally closed and prevents air or liquid from flowing from the mixing chamber 325, back through liquid outlet apertures 309A, and into liquid pump diaphragm 310A. One-way liquid outlet valve 323 opens when liquid pump diaphragm 310A is being compressed to pump fluid.

[0039] Simalarly, one-way air outlet valves 323B, 323C are shown transparently to more clearly illustrate the flow of air 331B, 331C through air outlet apertures 309B, 309C and into mixing chamber 325. One-way air outlet valves 323B, 323C each include a valve stem 357B, 357C (FIG. 3) that are inserted into corresponding apertures 329B, 329C to secure the one-way air outlet valves to valve seat 308. One-way air outlet valves 323B, 323C are normally closed and prevent air or liquid from flowing from the mixing chamber 325, back through air outlet apertures 323B, 323C, and into air pump diaphragms 310B, 310C. One-way air outlet valves 323B, 323C open when corresponding air pump diaphragms 310B, 310C are being compressed to pump air.

[0040] The valve seat 308 also includes flow directional control walls 308E. The flow directional control walls 308E provide flow paths that aid in the mixing of liquid and air. In this embodiment the flow directional control walls 308E are curved and cause the liquid and air to intersect in a tangential relationship. In some embodiments, flow directional control walls 308E are designed and arranged to cause the liquid an air to intersect at a desired angle, such as, for example, each flow path may intersect at a 120 degree angle. In some embodiments, the flow directional control walls 308E are arranged so that the two air paths intersect the liquid flow path at about 180 degrees. The design of the flow path intersection may be different for different types of liquids, for example, a higher quality of foam may be obtained by causing the liquid soap to be intersected head on (180 degrees) by the two air flow paths, while a higher quality foam may be obtained for foamable sanitizer by having the air paths tangentially intersect with the liquid path.

[0041] FIG. 8 is a bottom view of the exemplary valve seat 308 for the foam pump 206. The valve seat 308 includes three liquid outlet apertures 309A that pass through valve seat 308 and a liquid outlet valve aperture 329A for retaining one-way liquid outlet valve 323A. Valve seat 308 also includes a liquid inlet groove 319A that extends partially into valve seat 308 to provide a liquid path from one-way liquid inlet valve 316A to the interior of liquid pump diaphragm 310A. In addition, the valve seat 308 includes a first set of three air outlet apertures 309B that pass through valve seat 308, and a second set of three air outlet apertures 309C that pass through valve seat 308. Also, valve seat 308 includes air outlet valve apertures 329B, 329C for retaining one-way air outlet valves 323B, 323C, and air inlet grooves 319B, 319C that extend partially into valve seat 308 to provide an air path from one-way air inlet valves 316B, 316C to the interior of air pump diaphragms 310B, 310C.

[0042] FIG. 9 is a top view of an exemplary diaphragm assembly seat 312 for the exemplary embodiment of a foam pump 206. The diaphragm assembly seat 312 includes three receiving holes 313A, 313B, 313C and three inlet apertures 321A, 321B, 321C. In fluid communication with inlet aperture 321A is liquid inlet 352 which may be coupled to the liquid outlet of container 102. Each receiving hole 313A, 313B, 313C is sized to receive a diaphragm 310A, 310B, 310C. Each inlet aperture 321A, 321B, 321C extends through diaphragm assembly seat 312 and allows either air, liquid soap, or sanitizer to enter one of the diaphragms 310A, 310B, 310C.

[0043] In some embodiments, the foam mixture has an air to liquid ratio of between about 7 to 1 and about 10 to 1. In some embodiments, the air to liquid ratio is greater than 10 to 1, and in some embodiments is less than 7 to 1.

[0044] In some exemplary embodiments, a flow control valve (not shown) is located between the container 102 of foamable liquid and pump 206. The flow control valve may be used to adjust the liquid to air ratio. If a higher liquid to air ratio is desired, the flow control valve is set at a lower flow rate that starves the liquid pump diaphragm 310A. Conversely, to increase the liquid to air ratio, the flow control valve may be opened wider allowing more liquid to flow into pump 206. In some embodiments, the liquid pump diaphragm 310A may have a different volume than the air pump diaphragms 310B, 310C to adjust the ratio of liquid to air. In some embodiments, the volume of the liquid pump diaphragm 310A is reduced by inserting a sponge (not shown) in the liquid pump diaphragm 310A. Not only does the sponge (not shown) reduce the volume, but in some embodiments, the sponge slows the flow of liquid through the liquid pump diaphragm 310A.

[0045] FIG. 10A is a cross-sectional view taken along the lines A-A of FIGs. 5-9 showing the liquid pump portion of foam pump 206. In operation, liquid pump diaphragm 310A is moved downward, as shown by reference number 350B, to expand pump chamber 1002, which causes liquid inlet valve 316A to open allowing liquid to be drawn into pump chamber 1002 through liquid inlet 352, inlet aperture 321A, and liquid inlet groove 319A. Once the pump chamber 1002 is expanded it is primed with liquid, such as, for example, liquid soap or sanitizer. When the liquid pump diaphragm 310A is compressed (i.e. the liquid pump diaphragm 310A moves in the direction shown by reference number 350A), the liquid is pumped in the direction shown by reference number 340A. The liquid travels through liquid

outlet apertures 309A, past one-way liquid outlet valve 323A and into mixing chamber 325. One-way liquid outlet valve 323A is normally closed, but one-way liquid outlet valve 323A opens due to pressure caused by compressing liquid pump chamber 1002. One-way liquid outlet valve 323A prevents air or liquid from flowing back through liquid outlet apertures 309A and into liquid pump diaphragm 310A. Subsequently, the liquid pump diaphragm 310A begins to expand, which starts the process again by causing liquid inlet valve 316A to open, and liquid is drawn into liquid pump chamber 1002 through liquid inlet aperture 321A and liquid inlet groove 319A. A operating cycle of foam pump 206 includes one pump of liquid from liquid pump diaphragm 310A through liquid outlet apertures 309A, past liquid outlet valve 323A, and into mixing chamber 325 (FIG. 7) (followed by two pumps of air as described below).

[0046] FIGs. 10B and 10C are a cross-sectional view taken along the lines B-B and C-C, respectively, of FIGs. 5-9 showing the air pump portions of foam pump 206. In operation, air pump diaphragms 310B, 310C are moved downward, as shown by reference number 350B, to expand air pump chambers 1004, 1006, which causes air inlet valves 316B, 316C to open allowing air to be drawn into pump chambers 1004, 1006 through air inlet apertures 321B, 321C and air inlet grooves 319B, 319C. Once the pump chambers 1004, 1006 are primed with air, the air pump diaphragms 310B, 310C may be compressed (moved in the direction shown by reference number 350A). Compression of air pump diaphragms 310B, 310C pump the air in the direction shown by reference number 340A. The air travels through air outlet apertures 309B, 309C, past one-way air outlet valves 323B, 323C, and into mixing chamber 325 to mix with the foamable liquid. One-way air outlet valves 323B, 323C are normally closed, but one-way air outlet valves 323B, 323C open due to pressure caused by compressing air pump chambers 1004, 1006. One-way air inlet valves 323B, 323C prevent air or liquid from flowing back through air outlet apertures 309B, 309C and into air pump diaphragms 310B, 310C. Subsequently, the air pump diaphragms 310B, 310C begin to expand, which starts the process again by causing air inlet valves 316B, 316C to open, and air is drawn into air pump chambers 1004, 1006 through air inlet apertures 321B, 321C and air inlet grooves 319B, 319C. An operating cycle of foam pump 206 includes one pump of liquid (as described above) followed by one pump of air from air pump diaphragm 310B through air outlet apertures 309B, past air outlet valve 323B, and into mixing chamber 325 (FIG. 7). In addition, an operating cycle of foam pump 206 includes one pump of air from air

pump diaphragm 310C through air outlet apertures 309C, past air outlet valve 323C, and into mixing chamber 325 (FIG. 7).

[0047] The diaphragms 310A, 310B, 310C operate sequentially, in which one sequence of operation includes one pump of liquid, such as, for example, soap or sanitizer, or air by each of the three pump diaphragms 310A, 310B, 310C. The order of operation of the pump diaphragms 310A, 310B, 310C is dependent upon the configuration of the wobble plate 314 (FIG. 3). As shown in FIG. 3, each pump diaphragm 310A, 310B, 310C has a connector 311A, 311B, 311C, and the three pump diaphragms 310A, 310B, 310C connect to the wobble plate 314 by inserting the three connectors 311A, 311B, 311C in the three wobble plate links 314A, 314B, 314C. Wobble plate 314 connects to an eccentric wobble plate actuator that causes the wobble plate 314 to undulate. As the wobble plate 314 undulates, the wobble plate links 314A, 314B, 314C move in upward and downward motions. The upward motion causes the pump diaphragms 310A, 310B, 310C to compress, and the downward motion causes the pump diaphragms 310A, 310B, 310C to expand. The configuration of the wobble plate 314 causes one pump diaphragm 310A, 310B, 310C to compress at a time, which causes the pump diaphragms 310A, 310B, 310C to pump sequentially. The configuration of the wobble plate 314 also causes one pump diaphragm 310A, 310B, 310C to expand at a time, which causes the pump diaphragms 310A, 310B, 310C to prime sequentially. In the exemplary sequence of operation, the liquid pump diaphragm 310A pumps a shot of fluid, followed by air pump diaphragm 310B pumping a shot of air, and the sequence of operation ends with air pump diaphragm 310C pumping a second shot of air. The sequence may be repeated any number of times depending on the desired output dose of foam. The air from the air pump diaphragms 310B, 310C mixes with either the liquid or sanitizer from the liquid pump diaphragm 310A in the mixing chamber 325 (FIG. 7), which creates a foam mixture. The foam mixture exits the foam pump 206 through the pump outlet 350.

[0048] FIG. 4 illustrates the flow path of the liquid soap or sanitizer through the exploded view. When the liquid pump diaphragm 310A expands, liquid enters the foam pump 206 through liquid inlet 352, which is shown by reference number 330A. The liquid travels through aperture 321A in the diaphragm assembly seat 312, and past liquid one-way inlet valve 316A, as shown by reference number 330B. Inlet valve 316A opens, the liquid travels through groove 319A and into liquid pump diaphragm 310A, which is shown by reference numbers 330D and 330E.

[0049] The liquid pump diaphragm 310A compresses and pumps the liquid through liquid outlet aperture 309A, past one-way liquid outlet valve 323A, and into the mixing chamber 325 (FIG. 7), which is shown by reference number 340A. Air follows a similar path for air pump diaphragms 310B, 310C. When air pump diaphragms 310B, 310C expand, air is drawn into air inlet 424B, travels through apertures 321B, 321C (FIG. 9) in diaphragm seat assembly 312, travels through one-way air inlet valves 316B, 316C (FIGs. 5 and 6), travels into grooves 319B, 319C, in the bottom of valve seat 308, and travels into air pump diaphragms 310B, 310C. When air pump diaphragms 310B, 310C compress, air is forced through apertures 309B, 309C, past one-way air outlet valves 323B, 323C (FIG. 7), and into mixing chamber 325 where it mixes with the liquid to form a foam mixture. The foam mixture is dispensed through outlet 350, which is shown by reference number 304B.

[0050] FIG. 11 is a cross-sectional view of another exemplary embodiment of a sequentially activated multi-diaphragm foam pump 1100. The sequentially activated multi-diaphragm foam pump 1100 includes a motor 1112, a motor shaft 1113, a wobble plate 1110, a wobble plate pin 1127 an eccentric wobble plate drive 1120, a liquid pump diaphragm 1106, two air pump diaphragms 1108 (only one is shown), mixing chamber 1130, and pump outlet 1114. The motor 1112 drives the motor shaft 1113, which causes the motor shaft 1113 to rotate. The rotation of the motor shaft 1113 causes the eccentric wobble plate drive 1120 to rotate, and rotation of the eccentric wobble plate drive 1120 causes the wobble plate pin 1127 to move along a circular path, which causes the wobble plate 1110 to undulate. In some embodiments, wobble plate 314 includes a ball 1128 that rides in a socket (not shown) on the pump housing and wobble plate pin 127 extends outward and connects to an eccentric wobble plate actuator 1120 that causes the pin to move along a circular path which causes the wobble plate 1110 to undulate. As the wobble plate 1110 undulates, the ends connected to the three pump diaphragms 1106, 1108 move in upward and downward motions, and the three pump diaphragms 1106, 1108 are compressed sequentially. One sequence of operation of the mixing pump 1100 includes one pump by each of the three pump diaphragms 1106, 1108. The liquid pump diaphragm 1106 operates first in the cycle of operation, followed by sequential distributions by the two air pump diaphragms 1108.

[0051] Similar to the embodiments described above, during operation, the liquid pump diaphragm 1106 expands and contracts to pump liquid, and the air pump diaphragms 1108 (only one is shown) expand and contract to pump air. The expansion of the liquid pump

diaphragm 1106 opens the liquid inlet valve 1105 and allows liquid, such as, for example, soap or sanitizer to enter liquid pump chamber 1124 through liquid inlet 1102. The expansion of the air pump diaphragms 1108 opens the air inlet valves 1107 (only one is shown) and allows air to enter air pump chambers 1126 (only one is shown) through air inlets 1104. Circular movement of the wobble plate pin 1127 causes the ends of the wobble plate 1110 to sequentially undulate. The undulation causes liquid pump diaphragm to compress, which causes liquid outlet valve 1116 to open, and liquid to flow into the mixing chamber 1130 through liquid outlet apertures 1122. Subsequently, one of the air pump diaphragms 1108 is compressed by the undulating wobble plate 1110, which causes air outlet valve 1118 to open, and air to flow the mixing chamber 1130 through air outlet apertures 1123. Then, the other air pump diaphragm (not shown) will compress and pump air into mixing chamber 1130. The air and liquid soap or sanitizer mix in the mixing chamber 1130 to create a foam mixture. The foam mixture exits the mixing pump 1100 through pump outlet 1114.

[0052] Figures 12-15 illustrate and exemplary embodiment of a refill unit 1200. Figure 12 is a perspective view of an exemplary embodiment of a refill unit 1200 having a sequentially activated multi-diaphragm foam pump 1206, and FIG. 14 is another perspective view of the exemplary refill unit 1200, having a back plate 1214 removed to illustrate the plurality of diaphragms 1510A, 1510B and 1510C. Figure 13 is a rear elevational view of the refill unit 1200 and FIG 15 is a rear elevational view of the refill unit 1200 with the back plate 1214 removed to illustrate the plurality of diaphragms 1510A, 1510B and 1510C. The refill unit 1200 connects to a foam dispenser 1600 (FIGS 16, 17). The refill unit 1200 includes a container 1202, a foam pump 1206, a actuation mechanism 1304 (FIG. 13), a foaming cartridge 1210, and a nozzle 1212. Refill unit 1200 contains a supply of a foamable liquid. In various embodiments, the contained foamable liquid could be for example a soap, a sanitizer, a cleanser, a disinfectant, a lotion or the like. The container 1202 is a non-collapsing container formed by a rigid, or semi-rigid housing member, or any other suitable configuration for containing the foamable liquid without leaking. In the case of a non-collapsing container, a vent system may be included, such as, for example, any of the venting systems in the patents/application incorporated above. In some embodiments, the container 1202 is a collapsible container and can be made of thin plastic or a flexible bag-like material.

[0053] Foam pump 1206, is similar to the pumps described above, and includes a housing 1208, a liquid pump diaphragm 1510A (FIG. 15), air pump diaphragms 1510B, 1510C, and a

mixing chamber (not shown). The liquid pump diaphragm 1510A and the air pump diaphragms 1510B, 1510C are disposed in housing 1208. The liquid pump diaphragm 1510A receives liquid from the container 1202 through liquid inlet 1552 and liquid inlet apertures 1509A, and liquid pump diaphragm 1510A pumps the liquid into the mixing chamber. The air pump diaphragms 1510B, 1501C receive air through at least one air inlet (not shown) and air inlet apertures 1509B, 1509C, and air pump diaphragms 1510B, 1510C pump the air into the mixing chamber. The liquid pump diaphragm 1510A and the air pump diaphragm 1510B are sequentially activated by actuation mechanism 1304 (FIG. 13). An operating cycle of the foam pump 1206 includes one pump of liquid from liquid pump diaphragm 1510A into mixing chamber 325 and one pump of air from air pump diaphragms 1510B, 1510C into the mixing chamber. The operating cycle begins with the one shot of liquid from liquid pump diaphragm 1510A, which is followed by a first shot of air form air pump diaphragm 1510B and a second shot of air from air pump diaphragm 1510C. The liquid and air mix in mixing chamber (not shown) to form a foamy mixture, and the foamy mixture passes through foaming cartridge 1210 and exits the foam pump 1206 through the outlet 1212. A dispense of foam typically requires one or more operating cycles or revolutions. In some embodiments of the present invention, the foam mixture has an air to liquid ratio of between about 7 to 1 and about 10 to 1. In some embodiments, the air to liquid ratio is greater than 10 to 1, and in some embodiments is less than 7 to 1.

[0054] In some exemplary embodiments, a flow control valve (not shown) is located between the container 1202 of foamable liquid and pump 1206. The flow control valve may be used to adjust the liquid to air ratio. If a higher liquid to air ratio is desired, the flow control valve is set at a lower flow rate that starves the liquid pump diaphragm 1510A. Conversely, to increase the liquid to air ratio, the flow control valve may be opened wider allowing more liquid to flow into pump 1206. In some embodiments, the liquid pump diaphragm 1510A may have a different volume than the air pump diaphragms 1510B, 1510C to adjust the ratio of liquid to air. In some embodiments, the volume of the liquid pump diaphragm 1510A is reduced by inserting a sponge (not shown) in the liquid pump diaphragm 1510A. Not only does the sponge (not shown) reduce the volume, but in some embodiments, the sponge slows the flow of liquid through the liquid pump diaphragm 1510A. In some exemplary embodiments, the sponge aids in expanding the volume of the liquid pump diaphragm.

[0055] The foam pump 1206 may include some or all of any of the embodiments described herein. Moreover, the foam pump 1206 may have more than one liquid pump diaphragm and one or more air pump diaphragms.

[0056] The actuation mechanism 1304 (FIG. 13) releasably connects to a drive system of motor 1706 (FIG. 17) that is permanently attached to a foam dispenser 1600. Actuation mechanism 1304 is covered by back plate 1214.

[0057] In some embodiments, the actuation mechanism 1304 does not include a wobble plate 1405, but may include a circular plate (not shown) and one or more springs (not shown). The circular plate is connected to the liquid pump diaphragm 1510A and the air pump diaphragms 1510B, 1510C. The one or more springs bias the circular plate outward thereby urging the liquid pump diaphragm 1510A and the air pump diaphragms 1510B, 1510C to their extended position. The drive system (not shown) on the dispenser includes a wheel that travels around the perimeter of the circular plate. The point of contact between the wheel and the circular plate pushes that portion of the circular plate downward or inward to compress the diaphragm. As the wheel rotates around the perimeter it sequentially compresses the liquid pump diaphragm 1510A and the air pump diaphragms 1510B, 1510C. As the wheel moves past the diaphragms 1510A, 1510B, 1510C, the diaphragms 1510A, 1510B, 1510C expand to draw in fluid, as they are biased toward the expanded position by the diaphragm material as well as the one or more springs. In some embodiments, the springs are not needed and the diaphragm material is sufficient to bias the diaphragms 1510A, 1510B, 1510C to their expanded positions.

[0058] The above-mentioned embodiments are only exemplary, and the actuation mechanism 1304 may be configured in any manner that causes sequential operation of the liquid pump diaphragm 1510A and air pump diaphragms 1510B, 1510C of foam pump 1206.

[0059] FIG. 13 is a back view of the exemplary embodiment of the refill unit 1200 having a sequentially-activated multi-diaphragm foam pump 1206 of FIG. 12 with back plate 1214. Back plate 1214 has an aperture 1301. The refill unit 1200 attaches to a foam dispenser 1600 (FIG. 16) by connecting the attachment mechanism 1304 to the drive system of motor 1706 through the aperture 1301 of back plate 1214.

[0060] FIGs. 14 and 15 are views of the exemplary embodiment of the refill unit 1200 having the sequentially-activated multi-diaphragm foam pump 1206 with the back plate 1214 removed. The actuation mechanism 1304 includes a wobble plate 1405, wobble plate connection links 1407, and pin 1409. Each wobble plate link 1407 connects to pump diaphragms 1510A, 1510B, 1510C. In this exemplary embodiment, the pin 1409 of actuation mechanism 1304 releasably connects the actuation mechanism 1304 to an eccentric drive system 1707 (FIGs. 17 and 18) of motor 1706. Referring to FIGs. 17 and 18, a portion of pump 1206 of refill unit 1200 is received in socket 1701 of foam dispenser 1600, and the actuation mechanism 1304 releasably connects to the eccentric drive system 1707. Eccentric drive system 1707 is attached to shaft 1809 of motor 1706. The pin 1409 of actuation mechanism 1304 releasably engages with eccentric drive system 1707 pin 1409 engaging notch 1811. In some embodiments, the eccentric drive system 1707 is connected to actuation mechanism 1304 and is part of the refill unit 1200 and releasably connects to the shaft 1809 of motor 1706. The above-mentioned embodiments are only exemplary. The refill unit 1200 and motor 1706 may be configured in any manner that allows the refill unit 1200 to releasably attach to motor 1706 and allows motor 1706 to operate foam pump 1206. In some exemplary embodiments, the refill unit and motor releasably attach to one another by Velcro, in some embodiments by metal Velcro, in some embodiments by a hook and loop connection, in some embodiments by one or more magnets. In some embodiments, each diaphragm is individually compressed and/or expanded by a plurality of cylinders, or movable members.

[0061] Referring to FIGs. 14 and 15, the eccentric drive system 1707 (FIGs. 17 and 18) causes the wobble plate 1405 to undulate, which causes sequential operation of the liquid pump diaphragm 1510A and air pump diaphragms 1510B, 1510C. As the liquid pump diaphragm 1510A expands, liquid travels from container 1202, through liquid inlet 1552 and liquid inlet aperture 1509A, and into liquid pump diaphragm 1510A. The liquid pump diaphragm 1510A is in a primed position when it is filled with liquid. As air pump diaphragms 1510B, 1510C expand, air travels through at least one air inlet (not shown), through air inlet apertures 1509B, 1509C, and into respective air pump diaphragms 1510B, 1510C. The air pump diaphragms 1510B, 1510C are in primed positions when they are filled with air. An exemplary operating cycle includes one pump of liquid from liquid pump diaphragm 1510A, followed by one pump of air from air pump diaphragm 1510B, followed by one pump of air from air pump diaphragm 1510C.

[0062] In some embodiments, each pump diaphragm 1510A, 1510B, 1510C has a volume between about 0.1 and 1.0 ml. The pump diaphragms 1510A, 1510B, 1510C pump liquid and air into a mixing chamber (not shown), and the liquid and air mix to form a foamy mixture. The foamy mixture goes through a foaming cartridge 1210 to form a rich foam, and the rich foam exits the refill unit 1200 through nozzle 1212. In some embodiments the liquid pump diaphragm 1510A has a volume of between about 0.1 and 1.0 ml.

[0063] In some embodiments the dose of foam dispensed by the foam dispenser contains between about .3 ml and about 7.0 ml of liquid of liquid. In some embodiments, the dose of foam comprises between about 3 and 10 revolutions per dispense, including between about 3 and 7 revolutions, including between about 5 and 10 revolutions. In some embodiment, the dose of foam is about 0.3 ml for a highly concentrated light duty soap. In some embodiments, the dose of foam is about 7.0 ml of liquid for heavy duty soaps, such as grease cleaning soaps.

[0064] In some embodiments, the dispenser operates at a voltage of between about 3 volts and 10 volts, including between about 3 volts and about 5 volts, including between about 4 and about 6 volts, including between about 4 volts and 8 volts, including between about 6 volts and about 9.5 volts.

[0065] In some embodiments, the pump sequences for between about .3 and 2 seconds to dispense a dose of foam, including between about .5 seconds and 1.5 seconds, including between about .5 and 1 seconds. In some embodiments, such as, for example, dispensing of foam sanitizer having about 1.2 ml of liquid, the dispense time is about .6 sec. In some embodiments, such as, for example, light duty and heavy duty soap having between about 0.3 ml liquid to about 7.0 ml liquid, the dispense time in less than 1.50 sec.

[0066] In some embodiments, the wobble plate drive actuator rotates at between about 120 and about 480 revolutions per minute.

[0067] In some embodiments, there are multiple liquid pump diaphragms, such as for example, two liquid pump diaphragms, three liquid pump diaphragms, four liquid pump diaphragms. In some embodiments there are multiple air pump diaphragms, for example, two air pump diaphragms, three air pump diaphragms, four air pump diaphragms, five air pump diaphragms, six air pump diaphragms, seven air pump diaphragms and eight. air pump

diaphragms. In some embodiments, the number of air pump diaphragms to liquid pump diaphragms is 1:1, 2:1, 3:1, 4:1, 5:1, 6:1, 7:1, and 8:1.

[0068] While the present invention has been illustrated by the description of embodiments thereof and while the embodiments have been described in considerable detail, it is not the intention of the applicants to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications will readily appear to those skilled in the art. Moreover, elements described with one embodiment may be readily adapted for use with other embodiments. Therefore, the invention, in its broader aspects, is not limited to the specific details, the representative apparatus and illustrative examples shown and described. Accordingly, departures may be made from such details without departing from the spirit or scope of the applicants' general inventive concept.

CLAIMS

1. A refill unit for a foam dispenser comprising:

a container for holding foamable liquid;

a foam pump secured to the container wherein the foam pump includes:

a housing;

a liquid pump diaphragm in fluid communication with the container; and

a plurality of air pump diaphragms;

a mixing chamber for mixing foamable liquid from the liquid pump diaphragm with air from the plurality of air pump diaphragms;

a foaming cartridge in fluid communication with the mixing chamber;

an outlet for dispensing foam wherein the outlet is in fluid communication with the foaming cartridge; and

an actuation mechanism to sequentially activate the liquid pump diaphragm and the plurality of air pump diaphragms;

wherein the sequential operation of the liquid pump diaphragm and the air pump diaphragms is such that the liquid pump diaphragm pumps at least a partial dose of liquid into the mixing chamber prior to the air pump diaphragms pumping one or more doses of air into the mixing chamber;

wherein the actuation mechanism is configured to releasably connect to a drive system that is permanently attached to a dispenser; and

wherein the actuation mechanism sequentially activates the liquid pump diaphragm and air pump diaphragm when the refill unit is connected to the dispenser and the drive system is activated to dispense foam.

2. The refill unit of claim 1 wherein the dose of foam dispensed from the outlet has a volume between about 2.1 ml and 70 ml of liquid.

3. The refill unit of claim 1 wherein the at least a partial dose of liquid pumped from the liquid pump diaphragm has a volume between about 0.1 and about 1.0 ml of liquid.

4. The refill unit of claim 1 wherein the actuation mechanism includes a wobble plate and a pin, wherein the pin releasably connects to the drive system that is permanently attached to the dispenser.

5. The refill unit of claim 1 wherein the pump outlet of the foam pump is on a longitudinal axis and the liquid pump diaphragm and the air pump diaphragm are concentric about the longitudinal axis.

6. The refill unit of claim 1 wherein the foamy mixture comprises an air to liquid ratio of between about 7 to 1 and about 10 to 1.

7. The refill unit of claim 1 wherein the foam pump further comprises a plurality of walls for directing the liquid and air into the mixing chamber in opposing directions.

8. The refill unit of claim 7 wherein the plurality of walls are non-linear.

9. A refill unit for a foam dispenser comprising:

a container for holding foamable liquid;

a foam pump connected to the container;

the foam pump having a plurality of diaphragm pumping chambers wherein at least one diaphragm pumping chamber pumps liquid, and at least two diaphragm pumping chambers pump air;

a mixing chamber located downstream of the plurality of diaphragm pumping chambers for mixing liquid and air to form a foamy mixture;

a foaming cartridge located downstream of the mixing chamber; and

an outlet for dispensing foam;

a plate connected to the plurality of diaphragm pumping chambers;

the plate configured to engage with a drive system that is permanently secured to the foam dispenser when the refill unit is installed in the foam dispenser and disengage with the drive system when the refill unit is removed from the foam dispenser;

wherein movement of the plate causes at least a partial dose of liquid to be pumped into the mixing chamber, followed by of a first dose of air being pumped into the mixing chamber, followed by a second dose of air being pumped into the mixing chamber.

10. The refill unit of claim 9 wherein the foam dispensed from the outlet has a volume between about 2.1 ml and 70 ml of liquid

11. The refill unit of claim 9 wherein the at least a partial dose of liquid being pumped into the mixing chamber has a volume between about 0.1 ml and 1 ml of liquid.

12. The refill unit of claim 9 wherein the foam pump further comprises a plurality of walls for directing the liquid and air into the mixing chamber in opposing directions.

13. A refill unit for a foam dispenser comprising:

a container for holding foamable liquid;

a sequentially activated multi-diaphragm foam pump including:

a housing;

a liquid pump portion secured to the housing;

the liquid pump portion having:

a liquid inlet; a liquid inlet valve; a liquid pump diaphragm; a liquid outlet valve; and a liquid outlet;

an air pump portion secured to the housing;

the air pump portion having:

a first air inlet, a first air inlet valve, a first air pump diaphragm and a first air outlet; and

a second air inlet, a second air inlet valve, a second air pump diaphragm and a second air outlet;

a mixing chamber in fluid communication with the liquid outlet, the first air outlet and the second air outlet;

wherein the liquid pump diaphragm pumps a shot of liquid into the mixing chamber;

wherein the first air pump diaphragm pumps a shot of air into the mixing chamber to mix with the liquid to form a liquid air mixture; and

wherein the second air pump diaphragm pumps a shot of air into the mixing chamber to mix with the liquid air mixture to form a foamy mixture; and

a pump outlet for dispensing the foamy mixture;

a plate connected to the liquid pump diaphragm, the first air pump diaphragm, and the second air pump diaphragm;

the plate configured to engage with a drive system that is permanently secured to the foam dispenser when the refill unit is installed in the foam dispenser and disengage with the drive system when the refill unit is removed from the foam dispenser;

wherein movement of the plate causes the shot of liquid to be pumped from the liquid pump diaphragm into the mixing chamber, followed by the shot of air to be pumped from the first air pump diaphragm into the mixing chamber, followed by the shot of air to be pumped from the second air pump diaphragm into the mixing chamber

a foaming cartridge in fluid communication with the pump outlet; and

an outlet for dispensing foam wherein the outlet is in fluid communication with the foaming cartridge.

14. The refill unit of claim 13 wherein the plate engages with the drive system by a pin.

15. The refill unit of claim 13 wherein the plate engages with the drive system by a hook and loop connection.

16. The refill unit of claim 13 wherein the plate engages with the drive system by a magnetic connection.

17. The refill unit of claim 13 wherein the foam dispensed from the outlet has a volume between about 2.1 ml and 70 ml of liquid.

18. The refill unit of claim 13 wherein the shot of liquid pumped from the liquid pump diaphragm has a volume between about 0.1 ml and 1 ml of liquid.

19. The refill unit of claim 13 wherein the pump outlet of the foam pump is on a longitudinal axis and the liquid pump diaphragm and the air pump diaphragm are concentric about the longitudinal axis.

20. The refill unit of claim 13 wherein the sequentially activated multi-diaphragm foam pump further comprises a plurality of walls for directing the liquid and air into the mixing chamber in opposing directions.

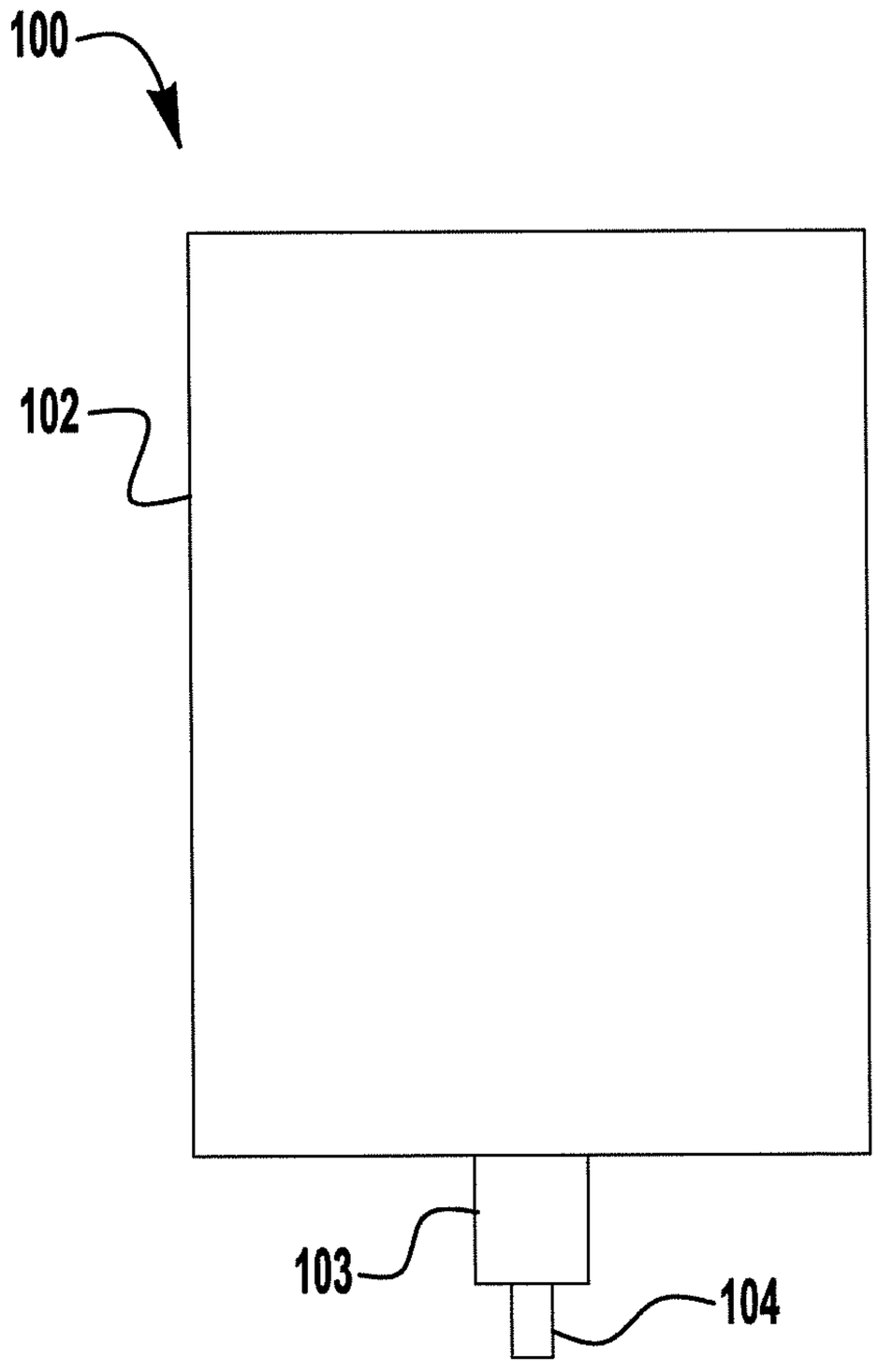


FIG. 1

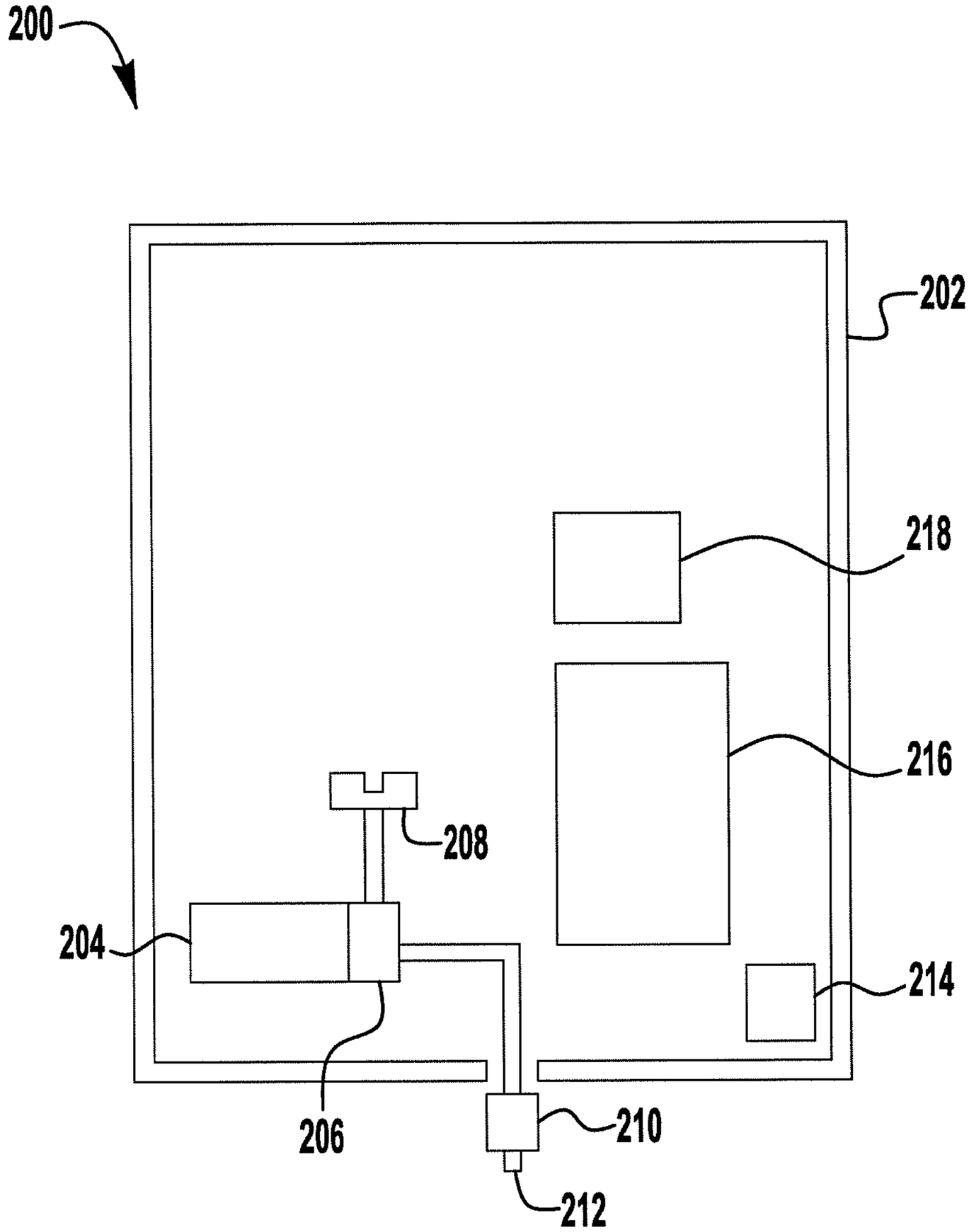


FIG. 2

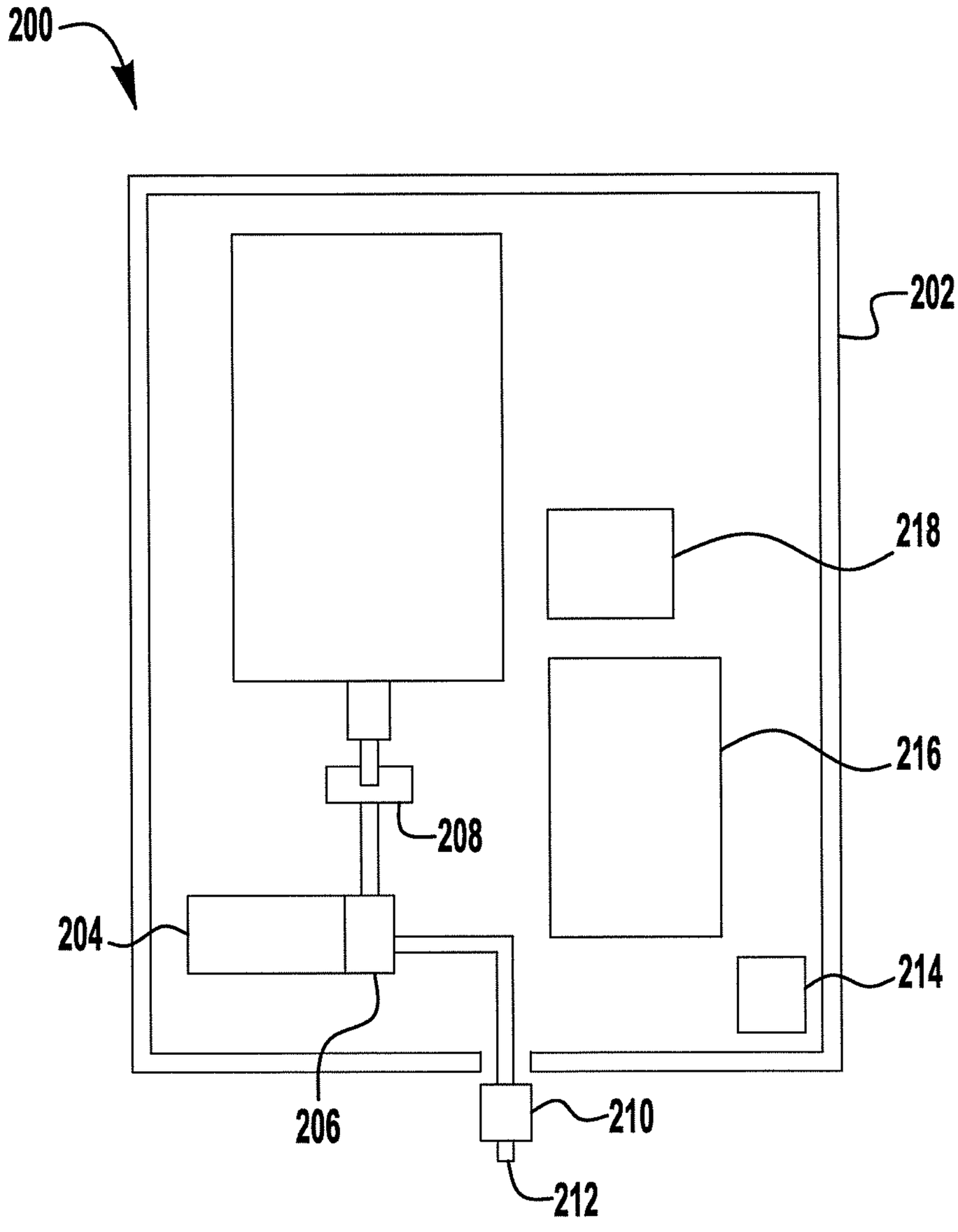
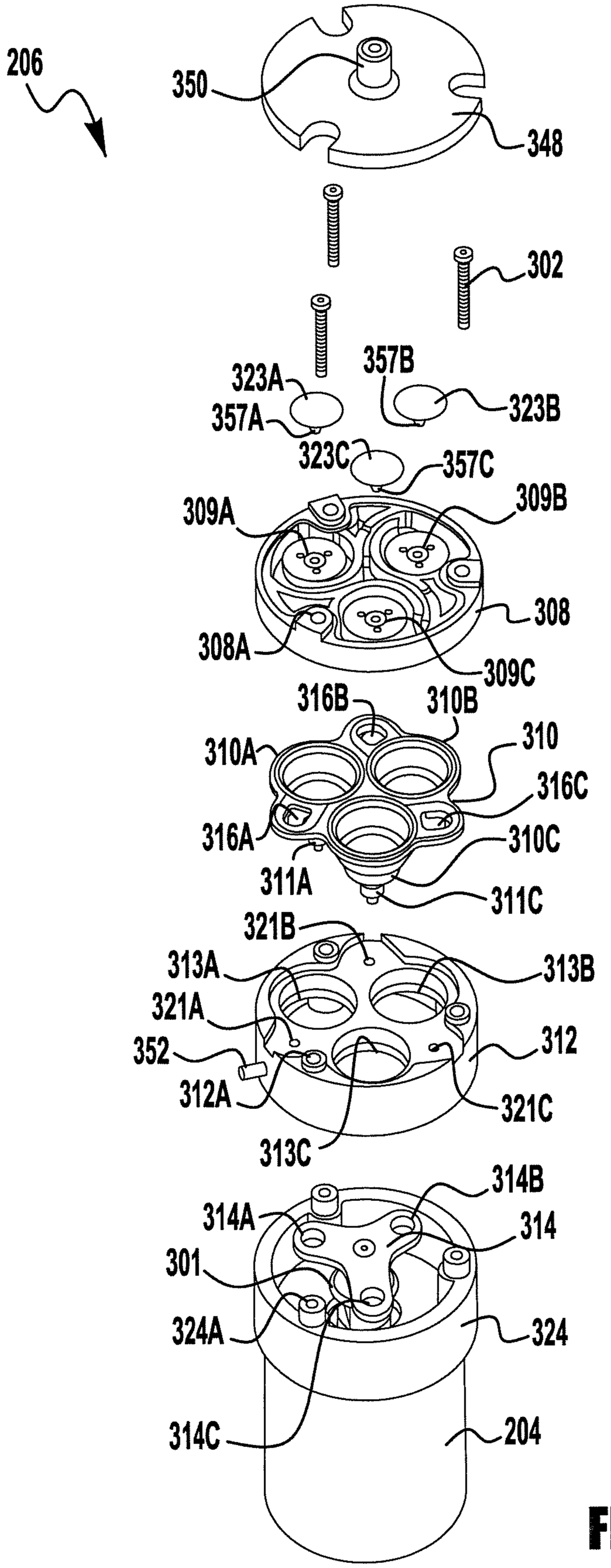


FIG. 2A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348
302
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357B
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310A
316C
316A
310C
311A
311C
321B
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313B
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321C
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314B
314A
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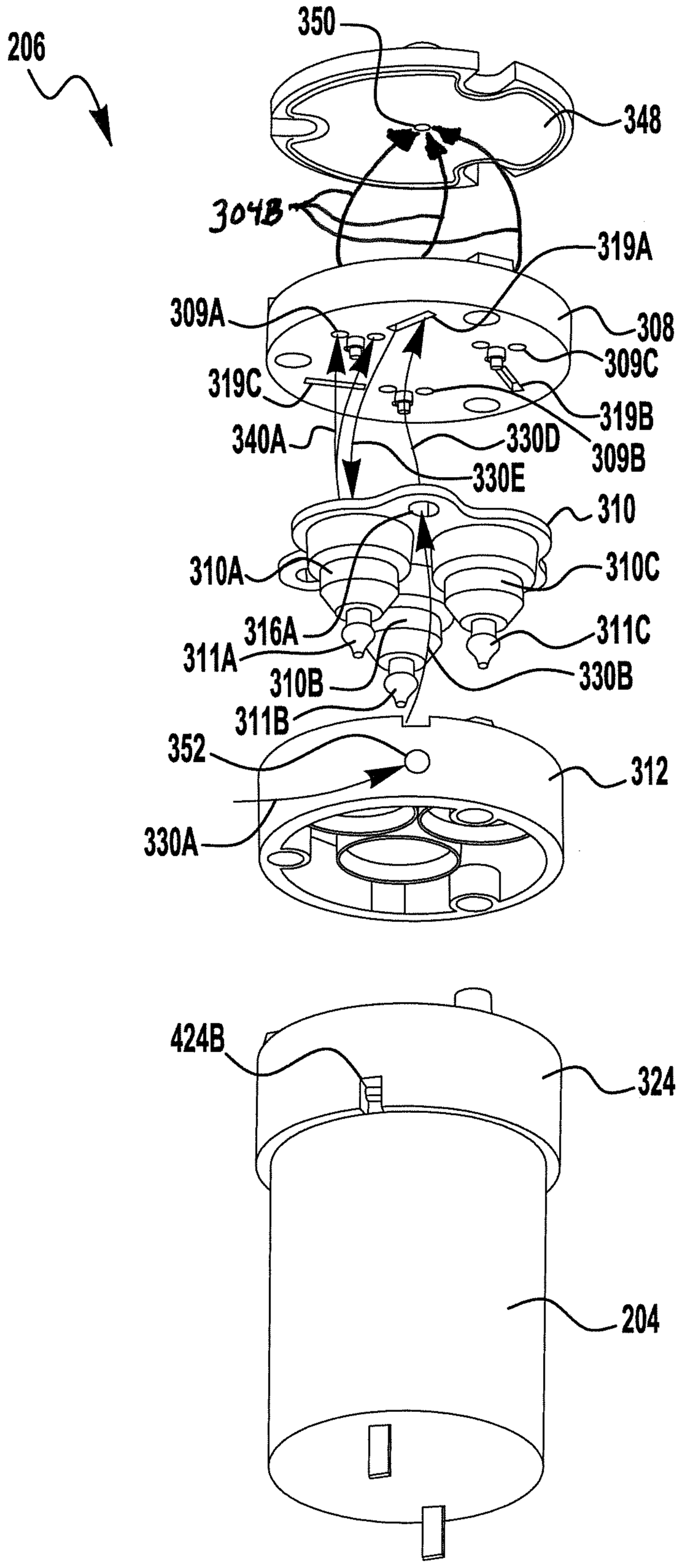
301
324A
324
314C
204

FIG. 3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350
348
304B
319A
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330D
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310A
310C
316A
311C
311A
310B
330B
311B
352
312
330A
424B
324
204

FIG. 4

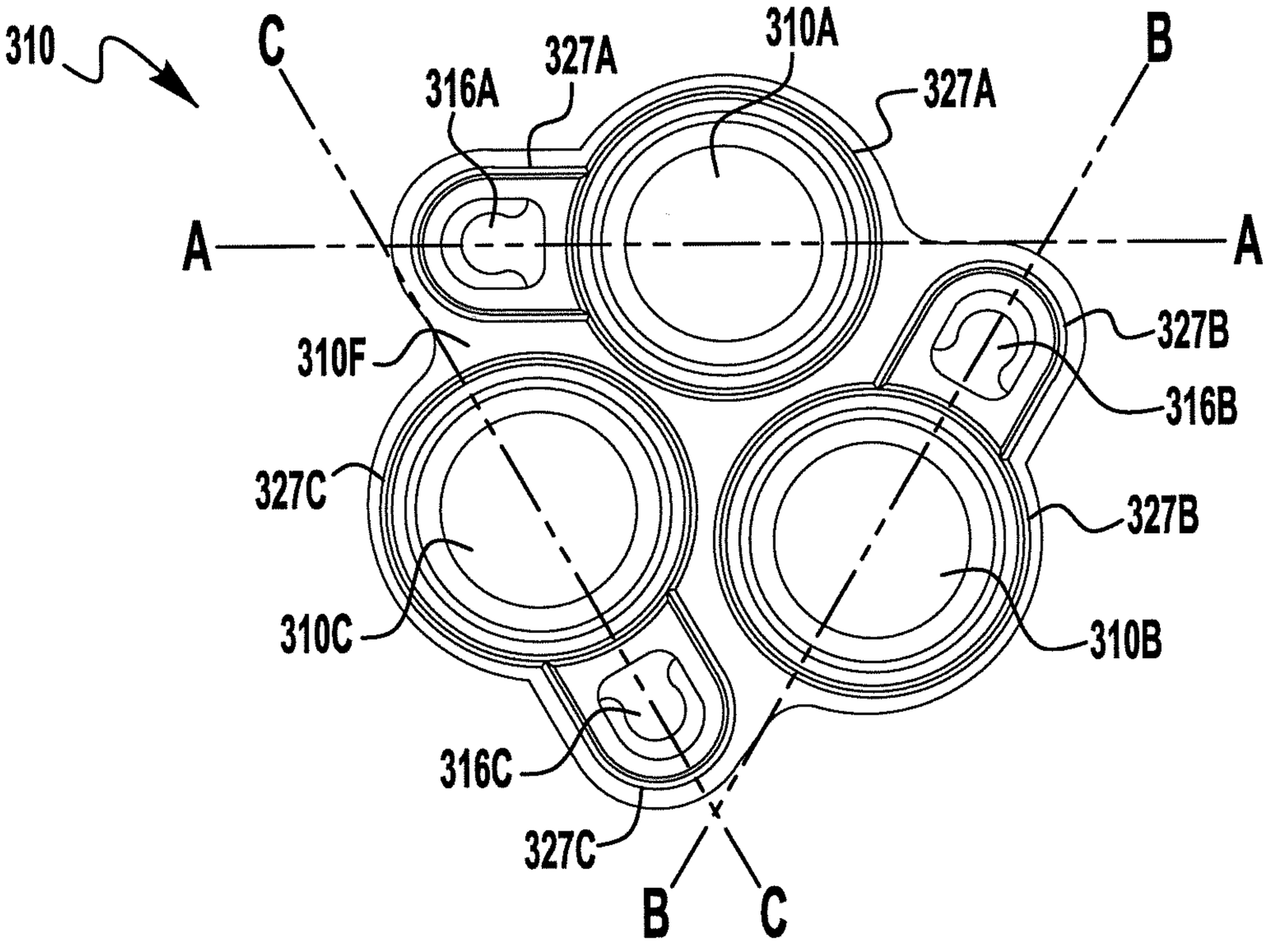
310
C
316A
327A
310A
327A
B
A
A
310F
327B
316B
327C
327B
310C
310B
316C
327C
B
C

FIG. 5

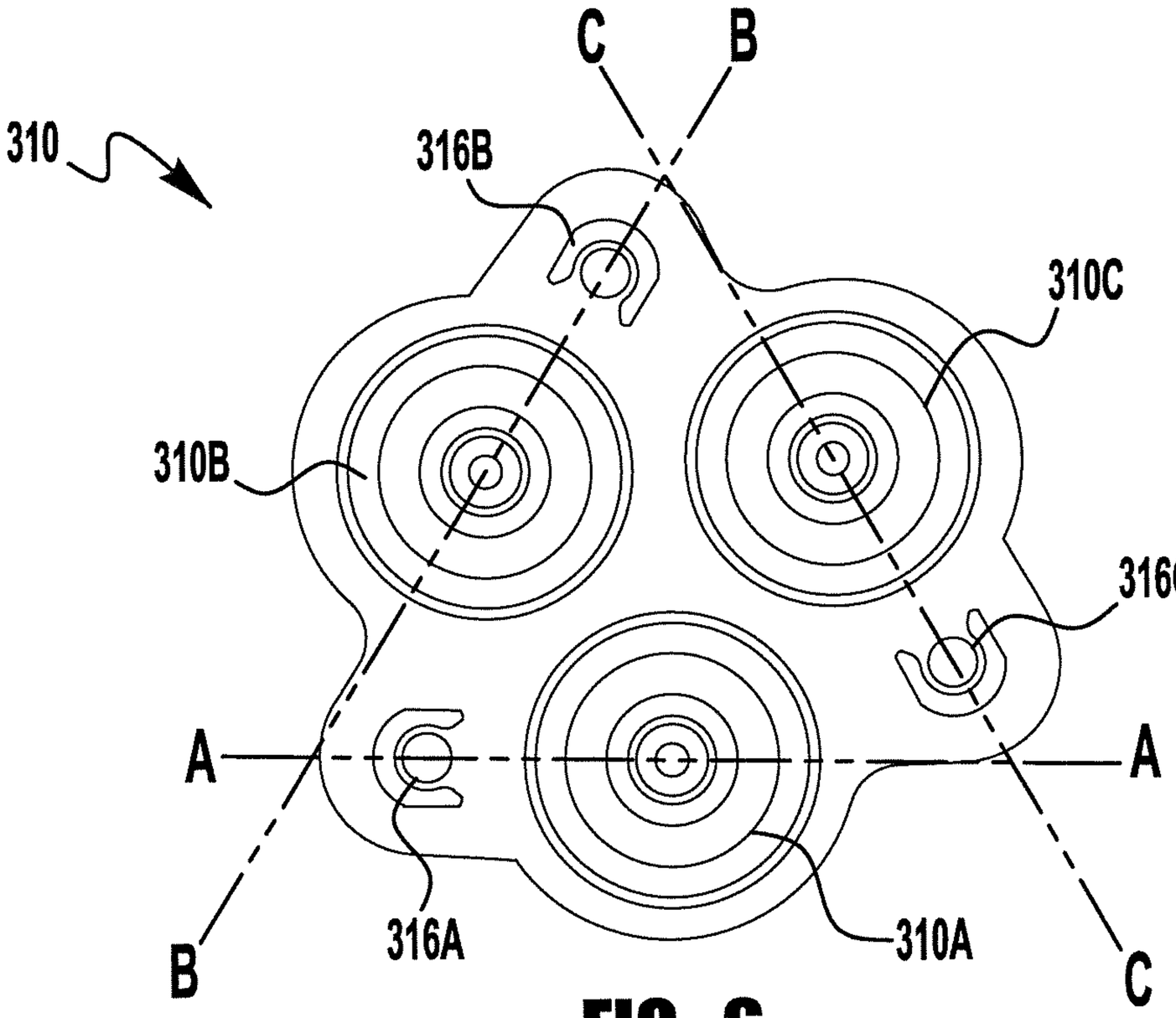
310
C
B
316B
310C
310B
316C
A
A
B
316A
310A
C

FIG. 6

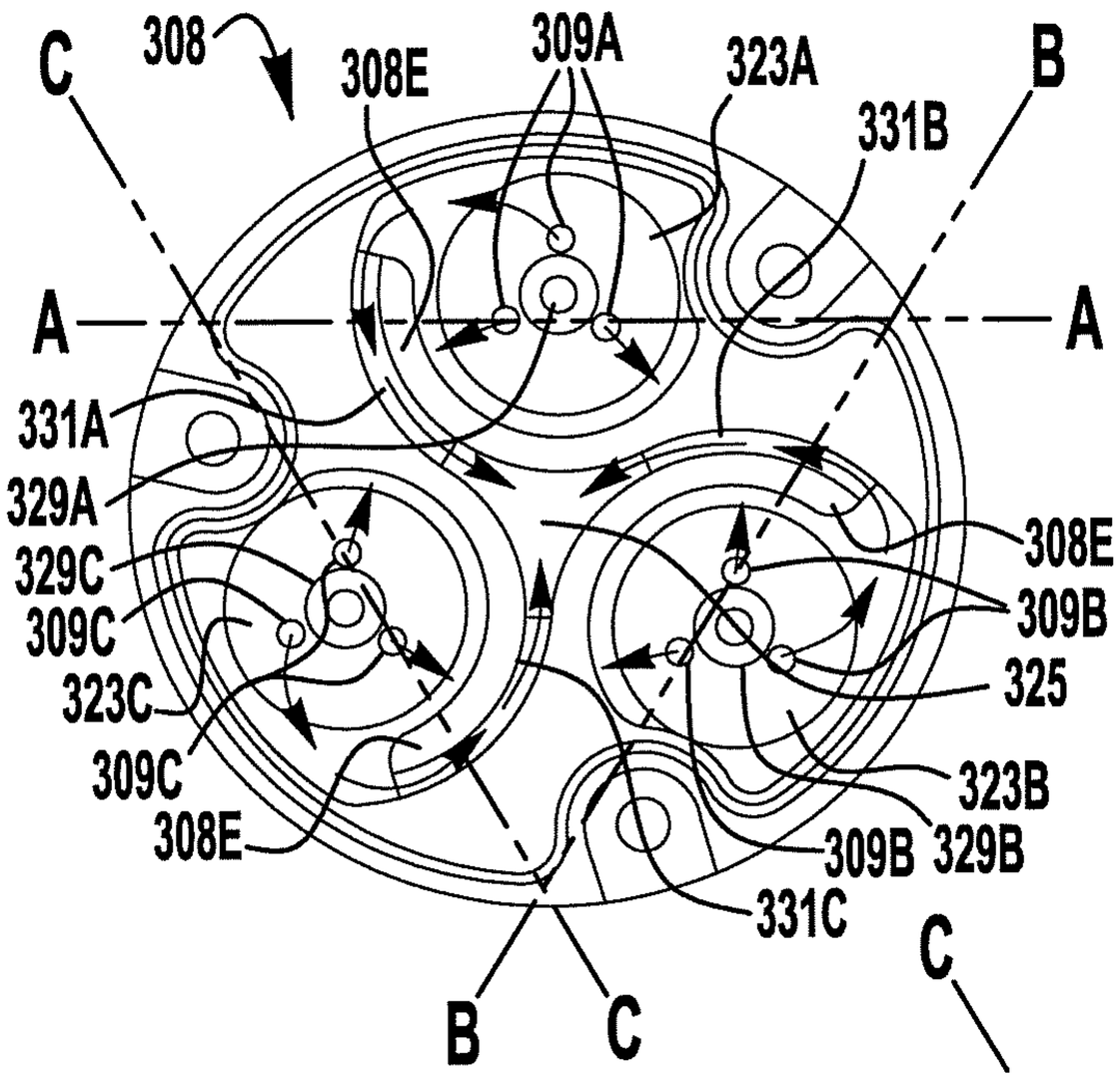

FIG. 7

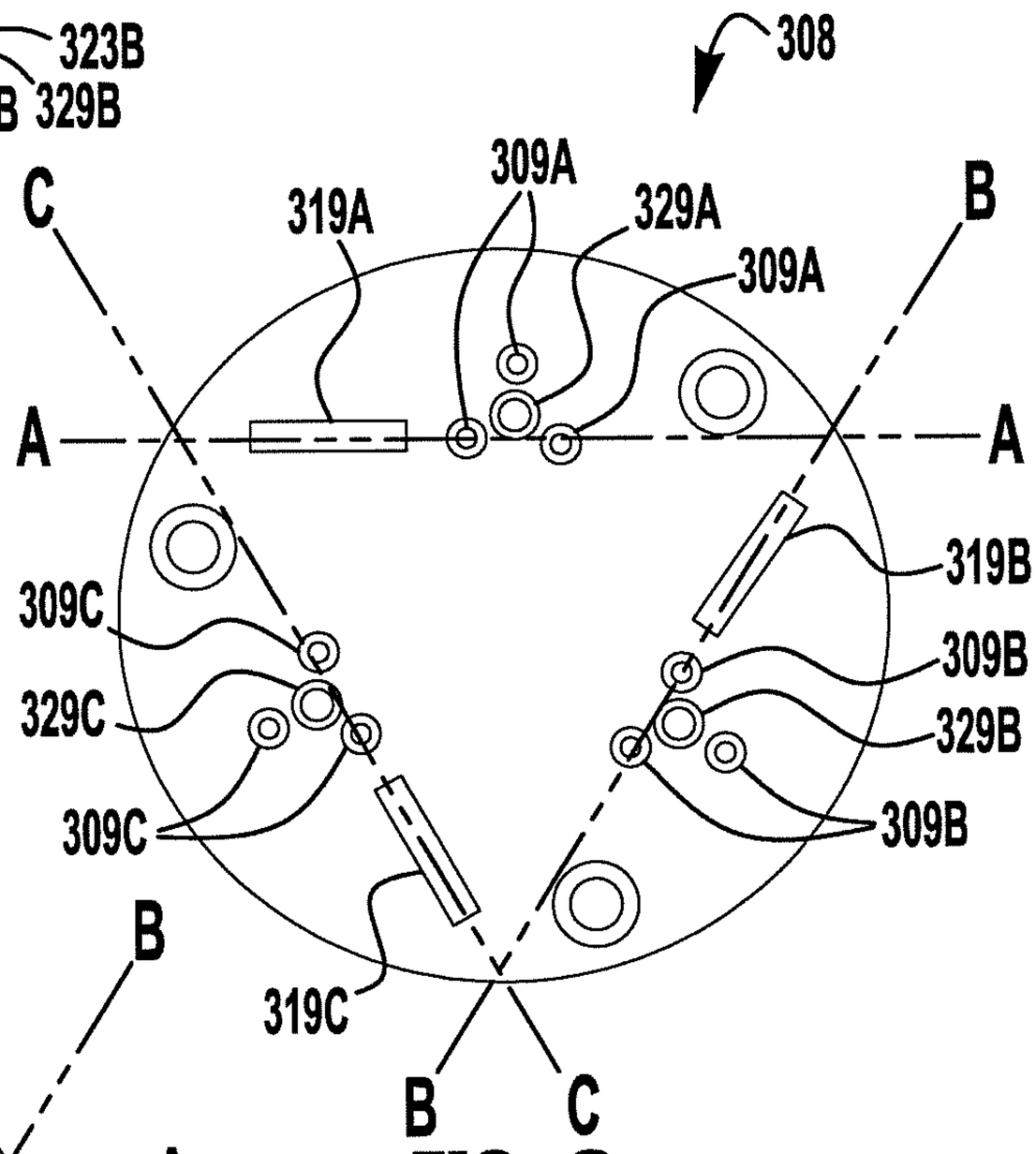

FIG. 8

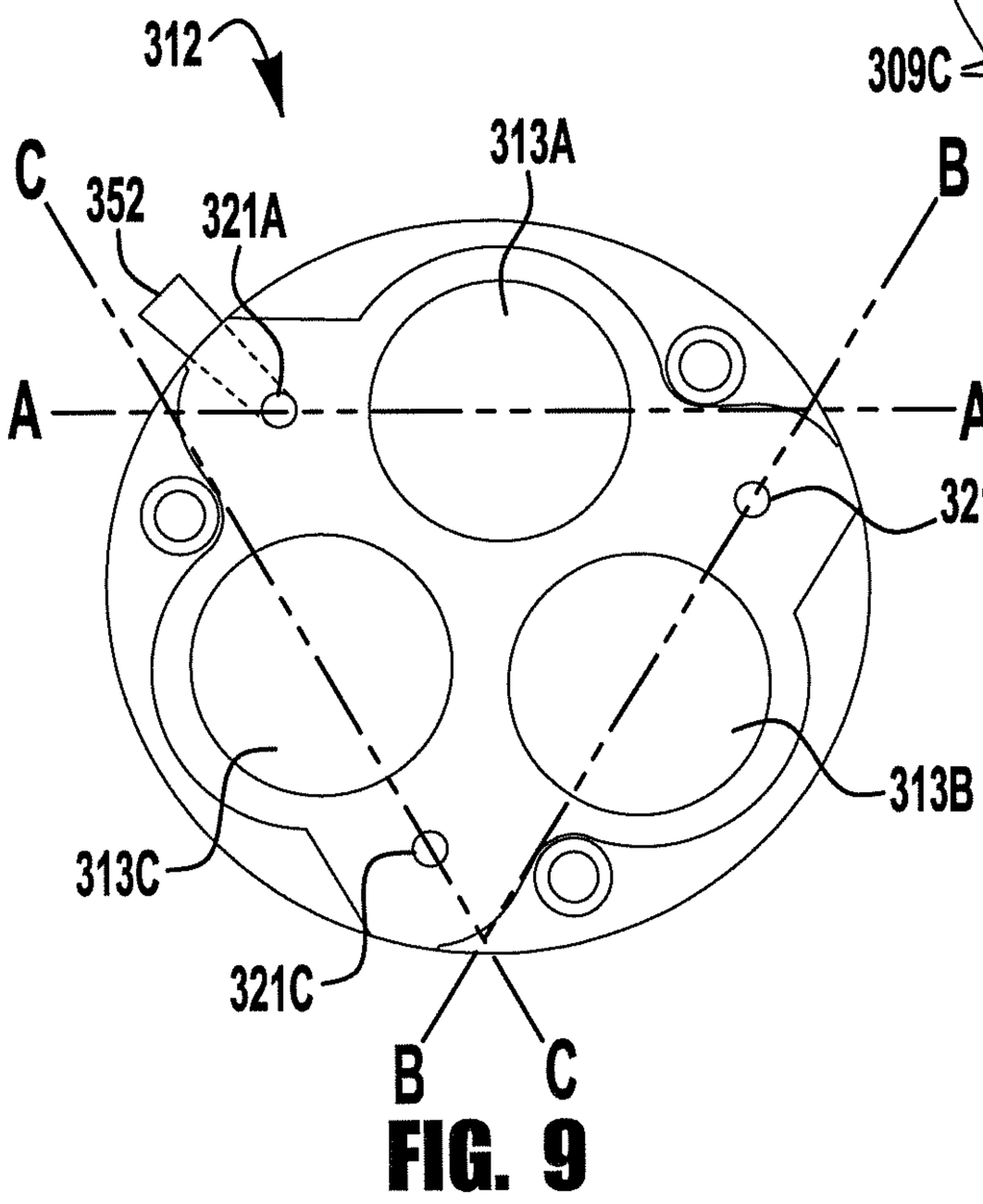

FIG. 9

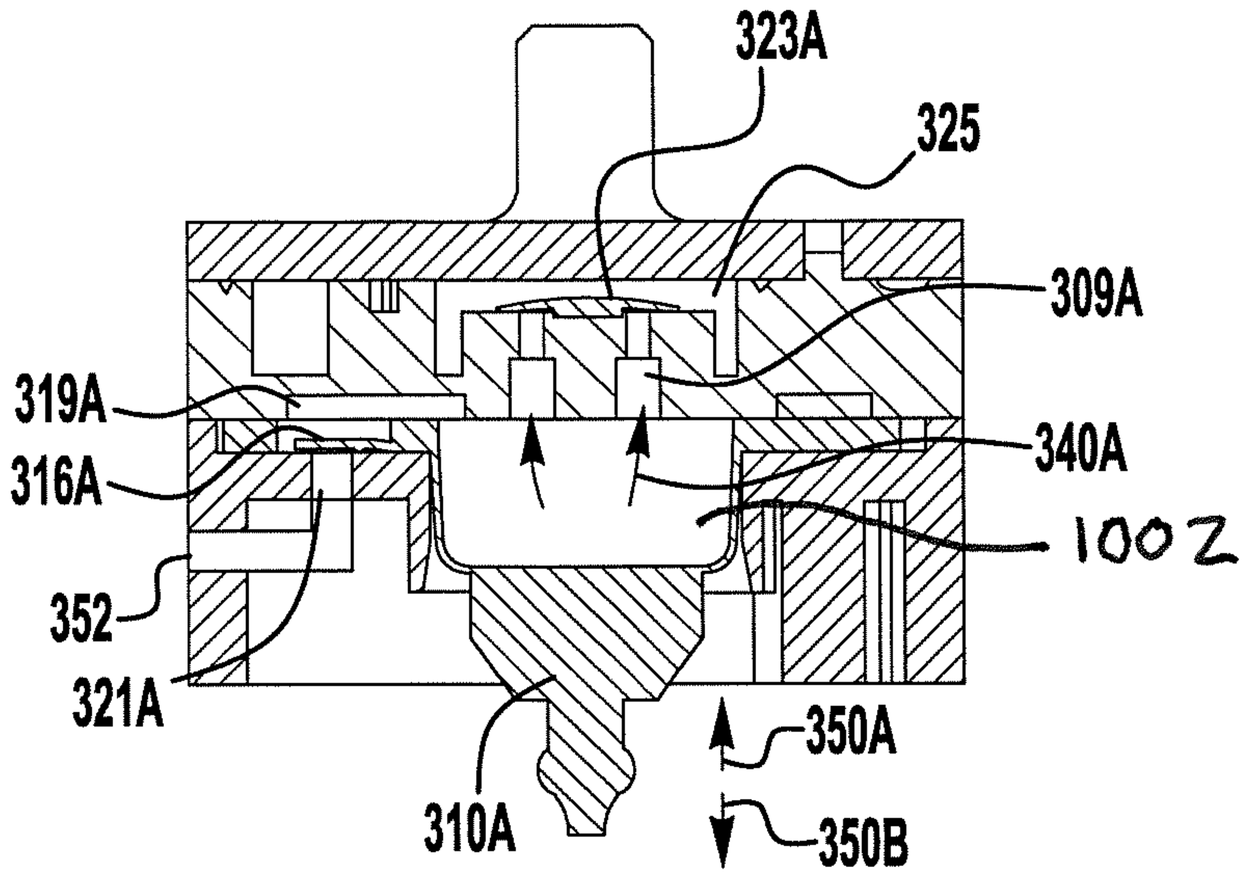

FIG. 10A

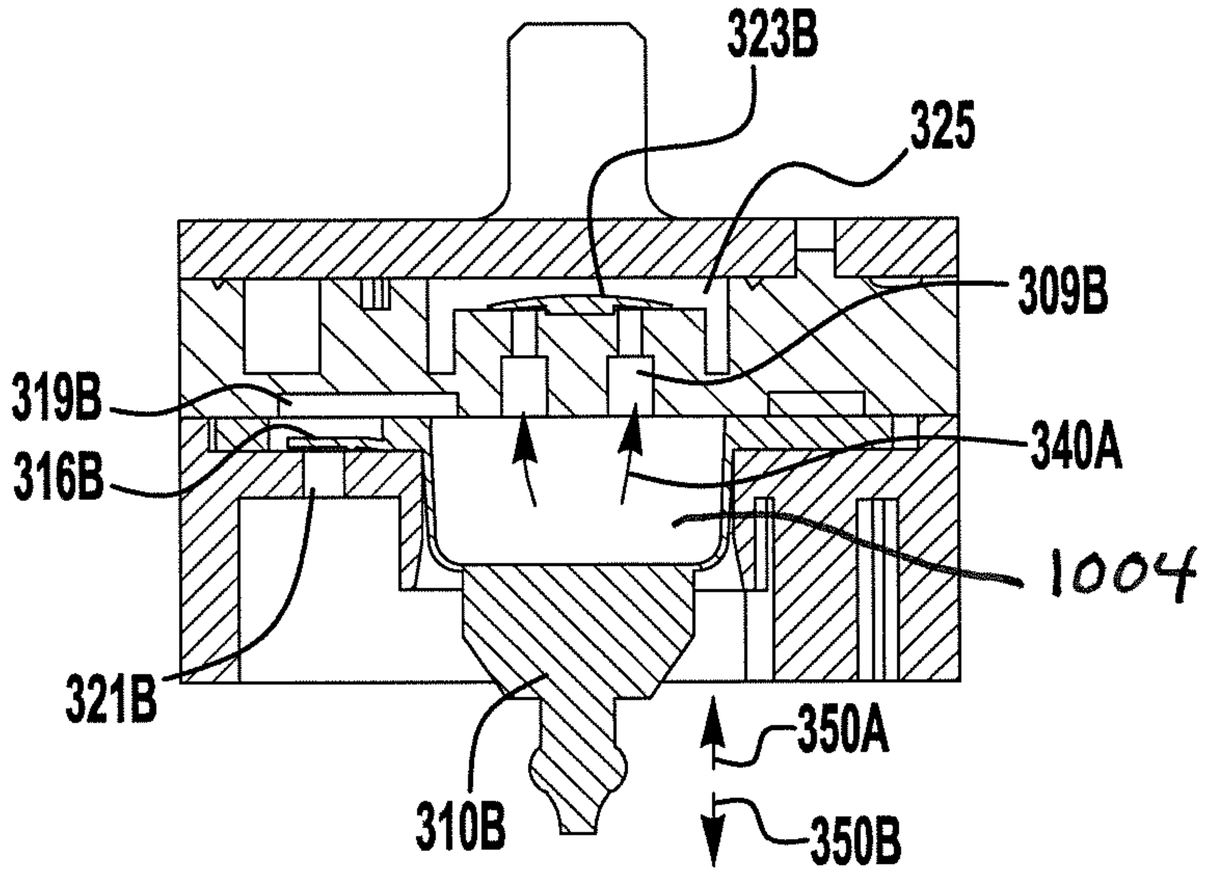

FIG. 10B

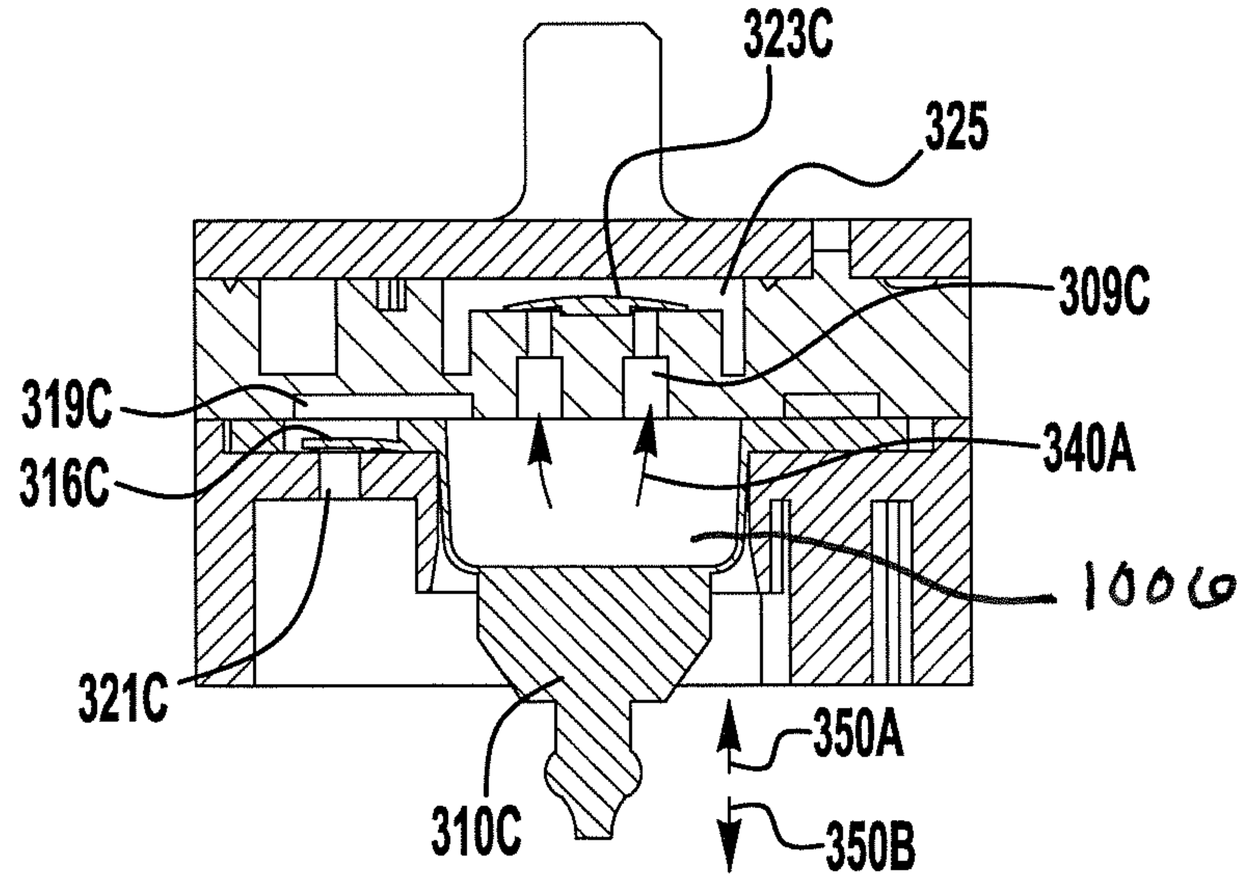

FIG. 10C

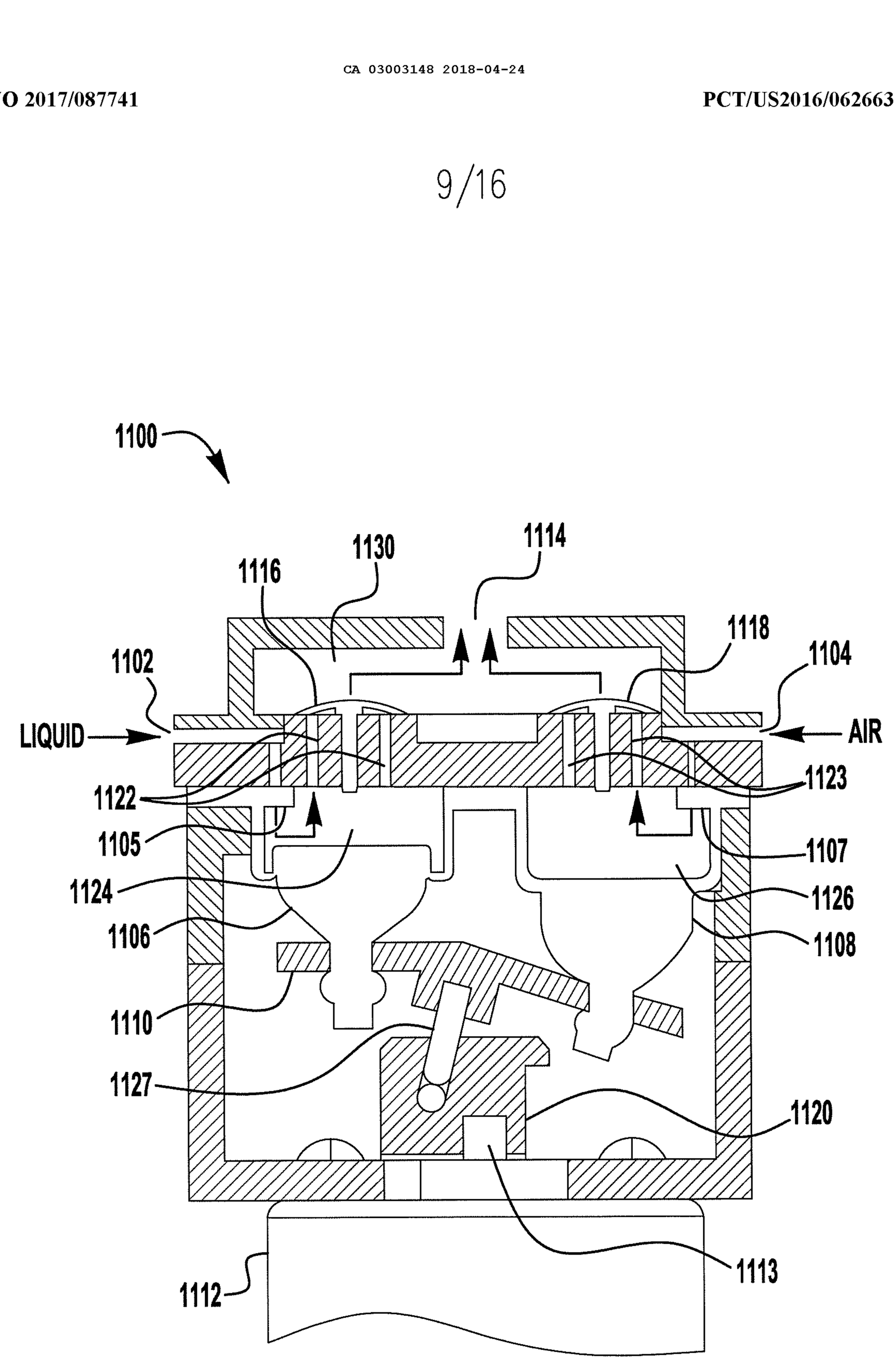
1100
1130
1114
1116
1118
1102
1104
LIQUID
AIR
1122
1123
1105
1107
1124
1126
1106
1108
1110
1127
1120
1112
1113

FIG. 11

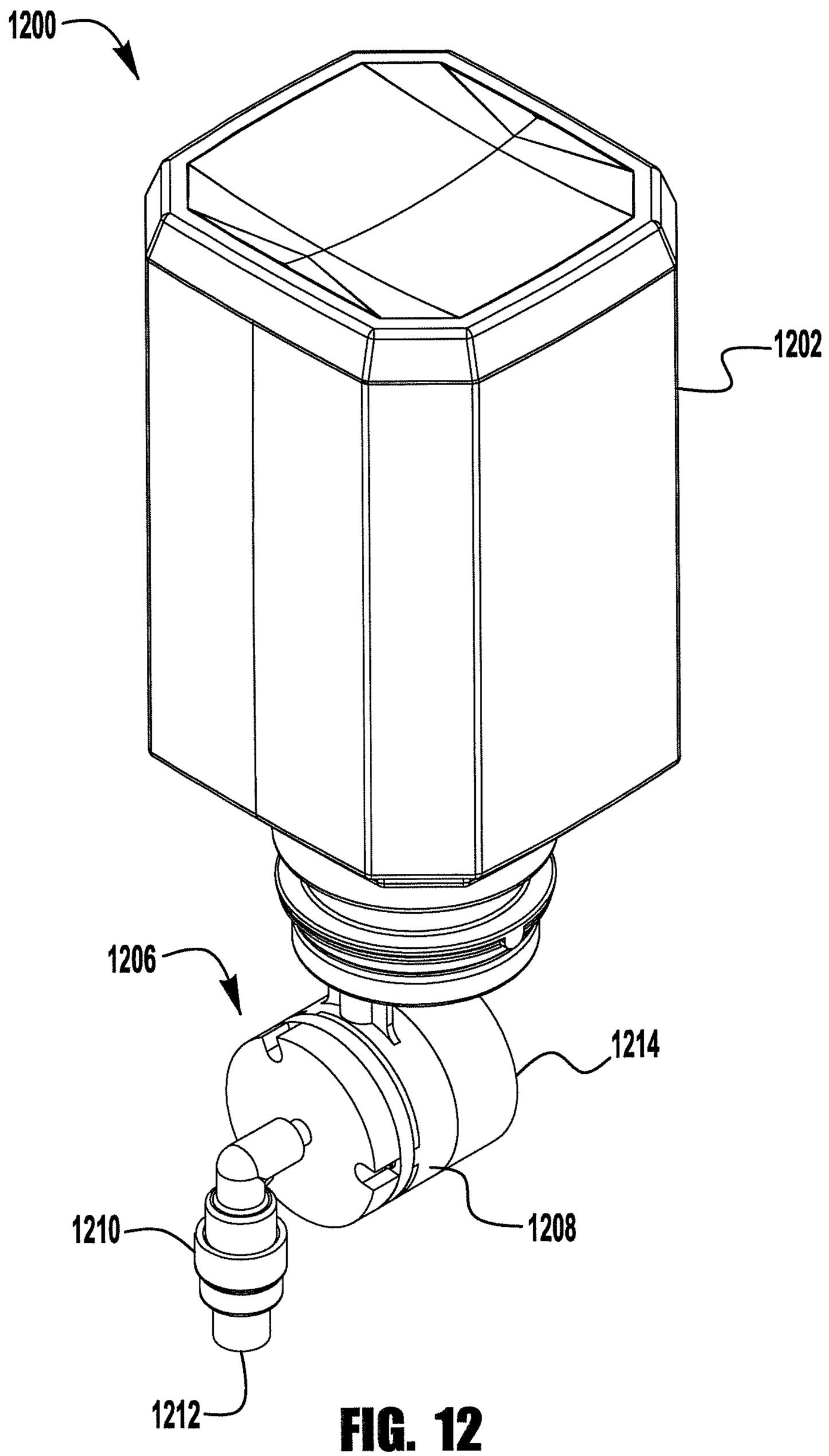

FIG. 12

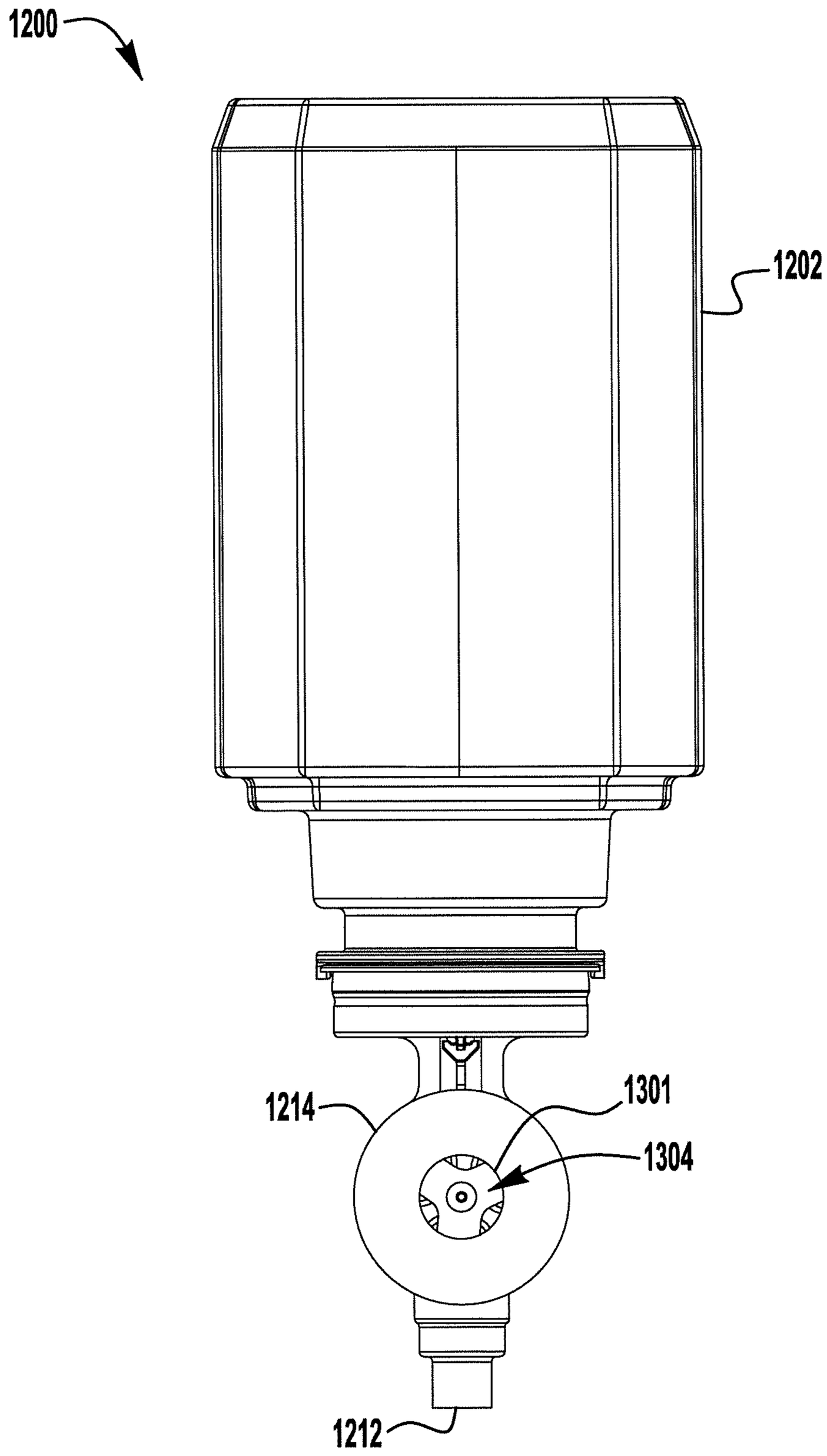

FIG. 13

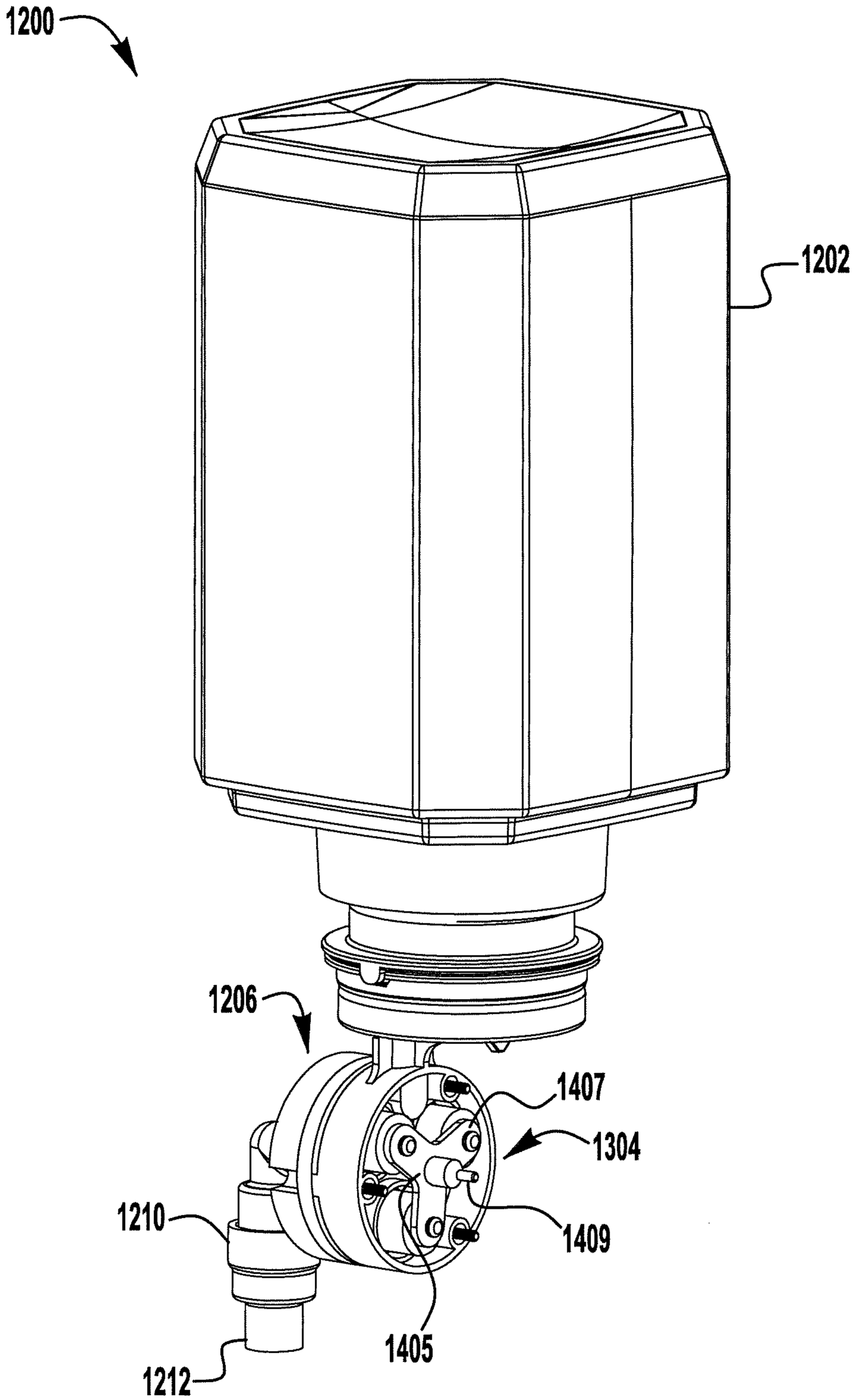

FIG. 14

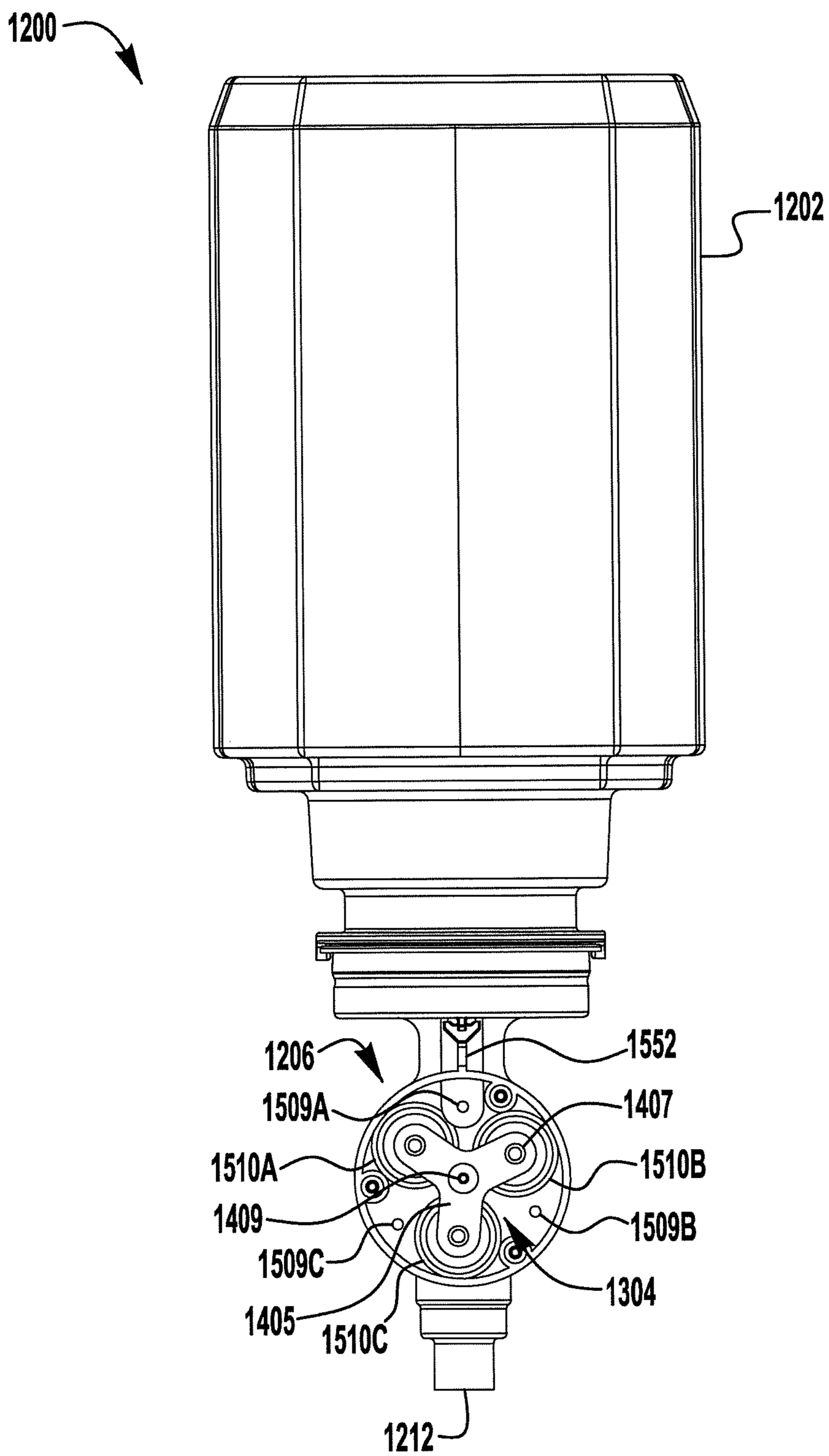
1200
1202
1206
1552
1509A
1407
1510A
1510B
1409
1509B
1509C
1304
1405
1510C
1212

FIG. 15

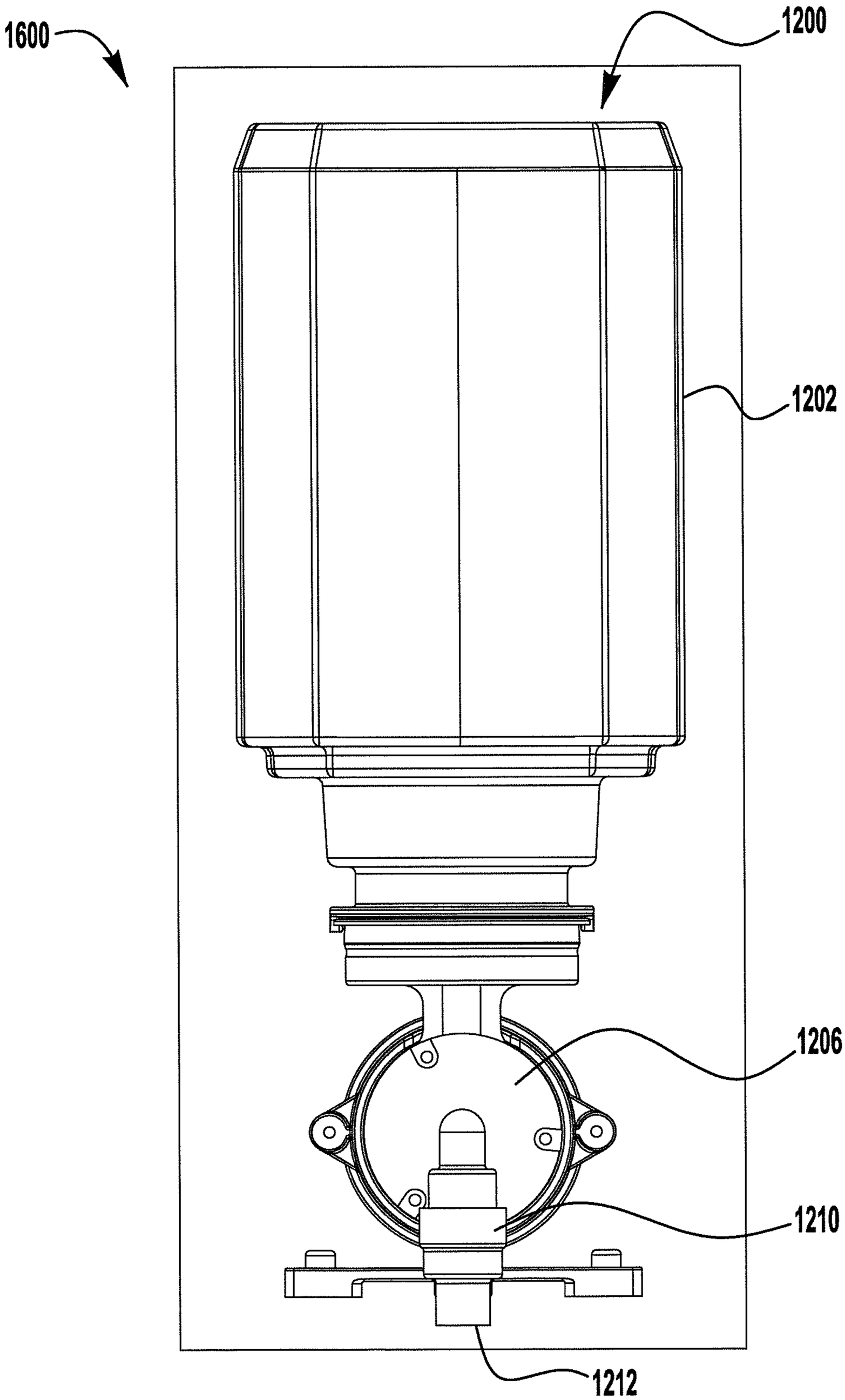

FIG. 16

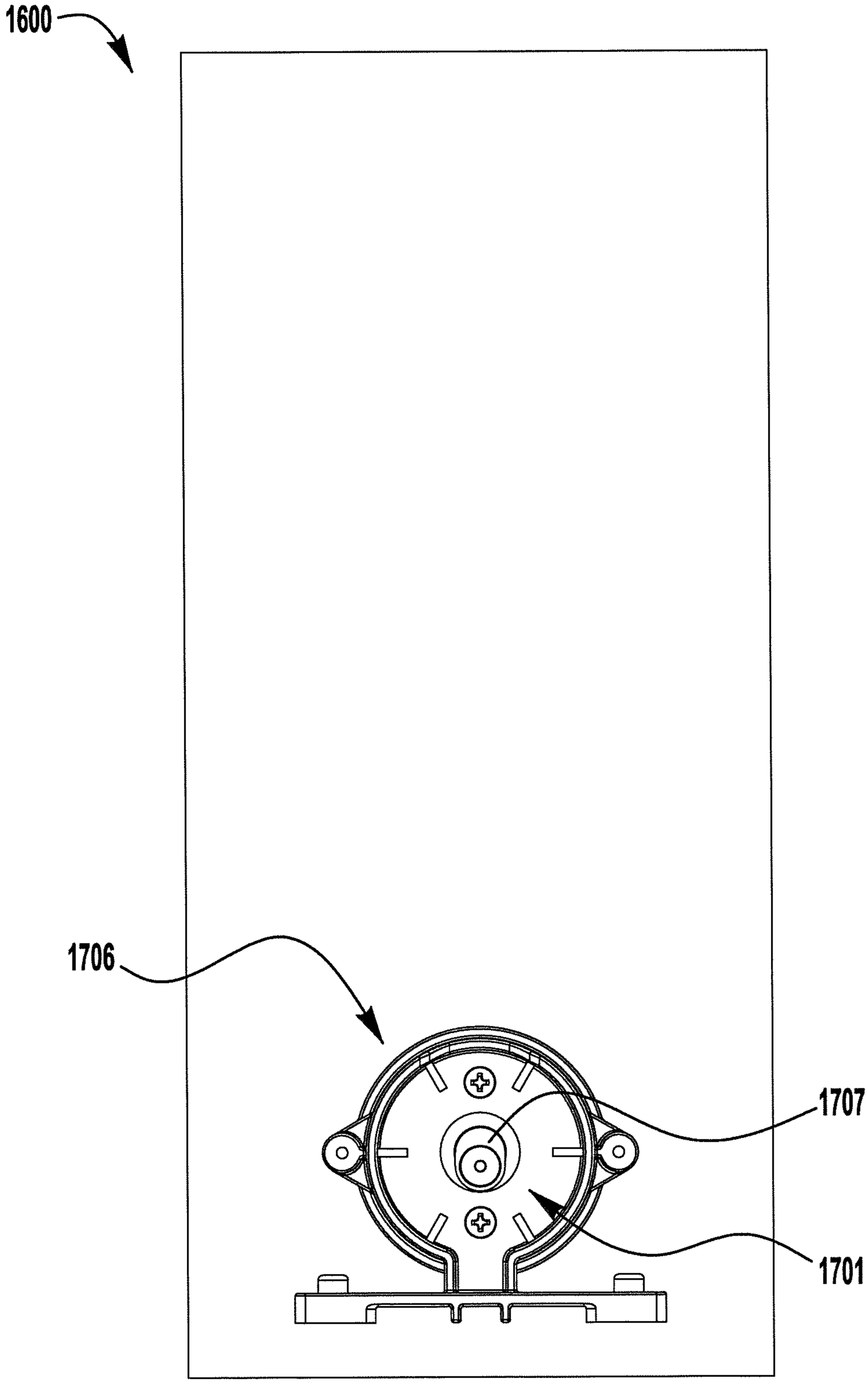

FIG. 17

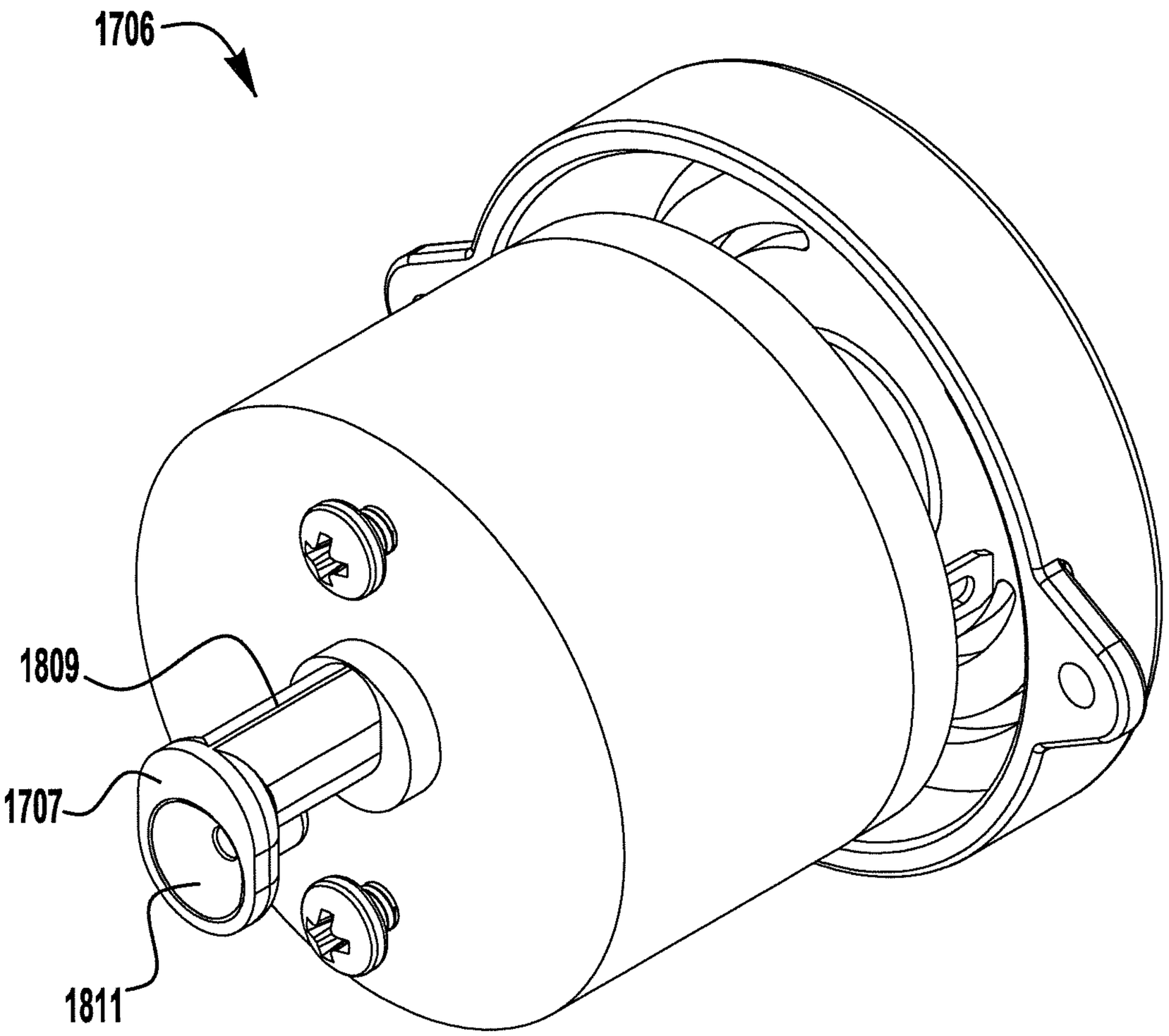

FIG. 18

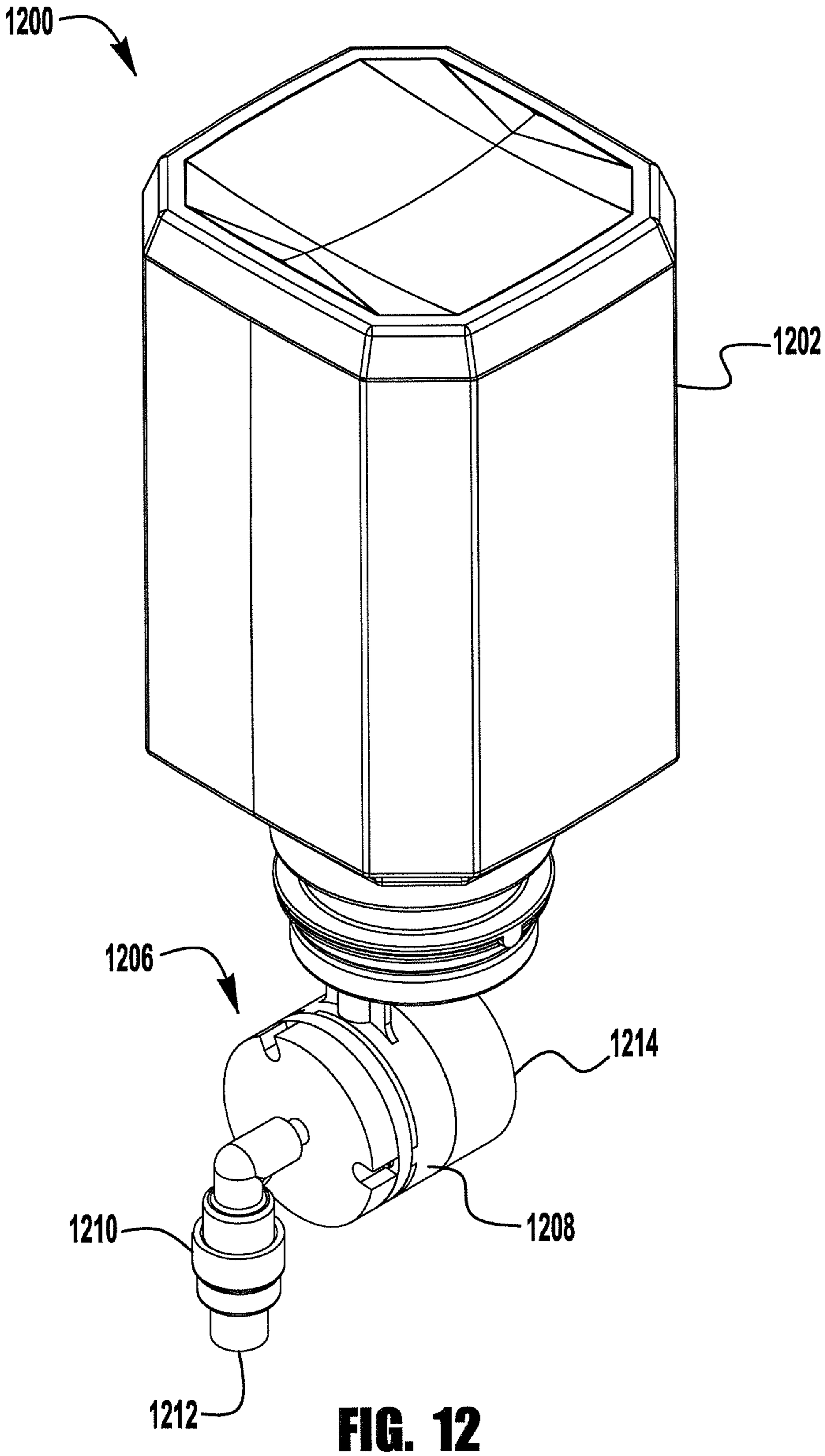

FIG. 12