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**Williams et al.**

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(54) **APPARATUS FOR FILTERING AND/OR  
CONDITIONING AND/OR PURIFYING A  
FLUID SUCH AS WATER**

(58) **Field of Classification Search**  
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B01D 35/147; B01D 35/1573;  
(Continued)

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(US)

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patent is extended or adjusted under 35  
U.S.C. 154(b) by 53 days.

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(21) Appl. No.: **15/845,931**

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(57) **ABSTRACT**

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An apparatus for filtering water has a valve head and a  
filtration/purification canister removably mountable thereon.  
Connecting the canister to the valve head automatically  
opens a check valve in the valve head to permit water to flow  
from the valve head into and through the canister, and then  
back to and through the valve head to an outlet port.  
Disconnecting the canister from the valve head automati-  
cally closes the check valve, stopping the flow of water. A  
bypass valve is provided in the valve head to permit a  
sanitizing solution to flow through the valve head and along  
the lines of the water distribution system to sanitize the  
system, while bypassing the canister. The outlet port may be  
directly connected to an appliance that uses water, to elimi-  
nate possible contamination that may occur when water is  
brought indirectly from the outlet port to the appliance  
instead.

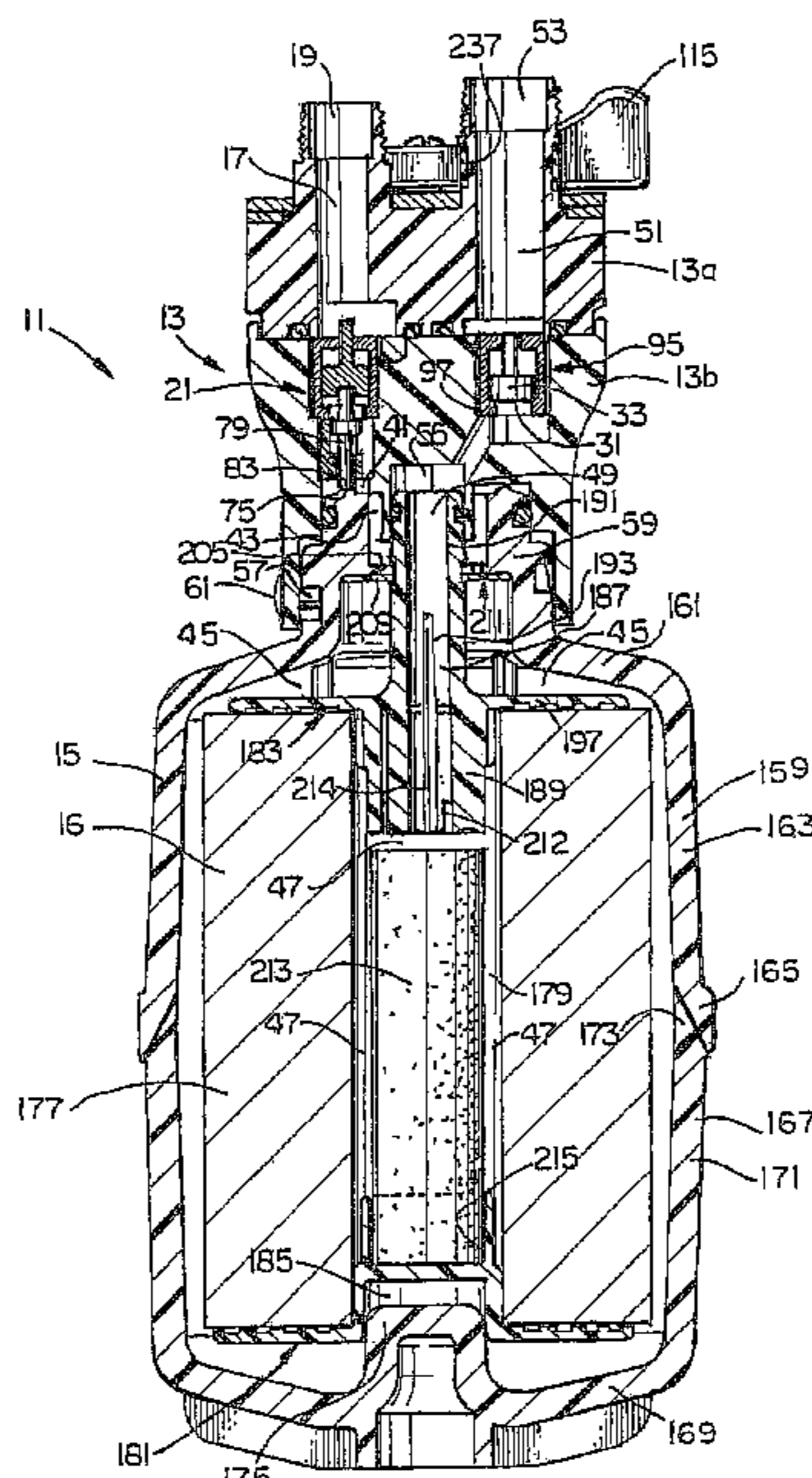
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3, 2009, now Pat. No. 9,845,259.

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**B01D 35/30** (2006.01)  
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(2013.01); **B01D 35/30** (2013.01);  
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**29 Claims, 12 Drawing Sheets**



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*C02F 9/00* (2006.01) 2303/04; C02F 9/005  
*C02F 1/00* (2006.01) See application file for complete search history.  
*C02F 1/44* (2006.01)

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*2201/4015* (2013.01); *C02F 1/008* (2013.01);  
*C02F 1/444* (2013.01); *C02F 2201/001*  
(2013.01); *C02F 2201/006* (2013.01); *C02F*  
*2301/043* (2013.01); *C02F 2303/04* (2013.01);  
*Y10T 137/3084* (2015.04); *Y10T 137/794*  
(2015.04)

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2201/4015; Y10T 137/309; Y10T  
137/3084; Y10T 137/794; C02F 1/008;  
C02F 1/444; C02F 2201/001; C02F

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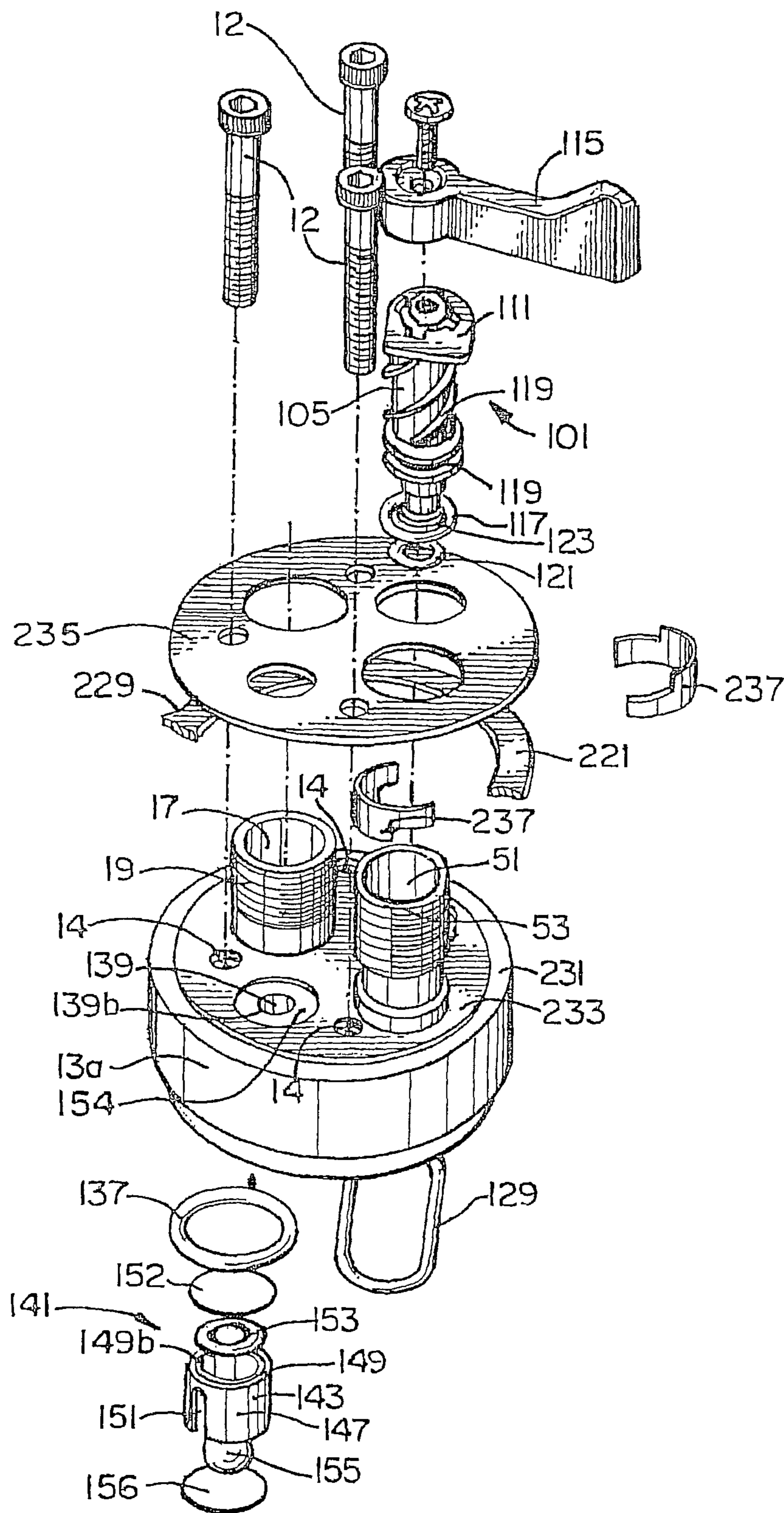


FIG. 1

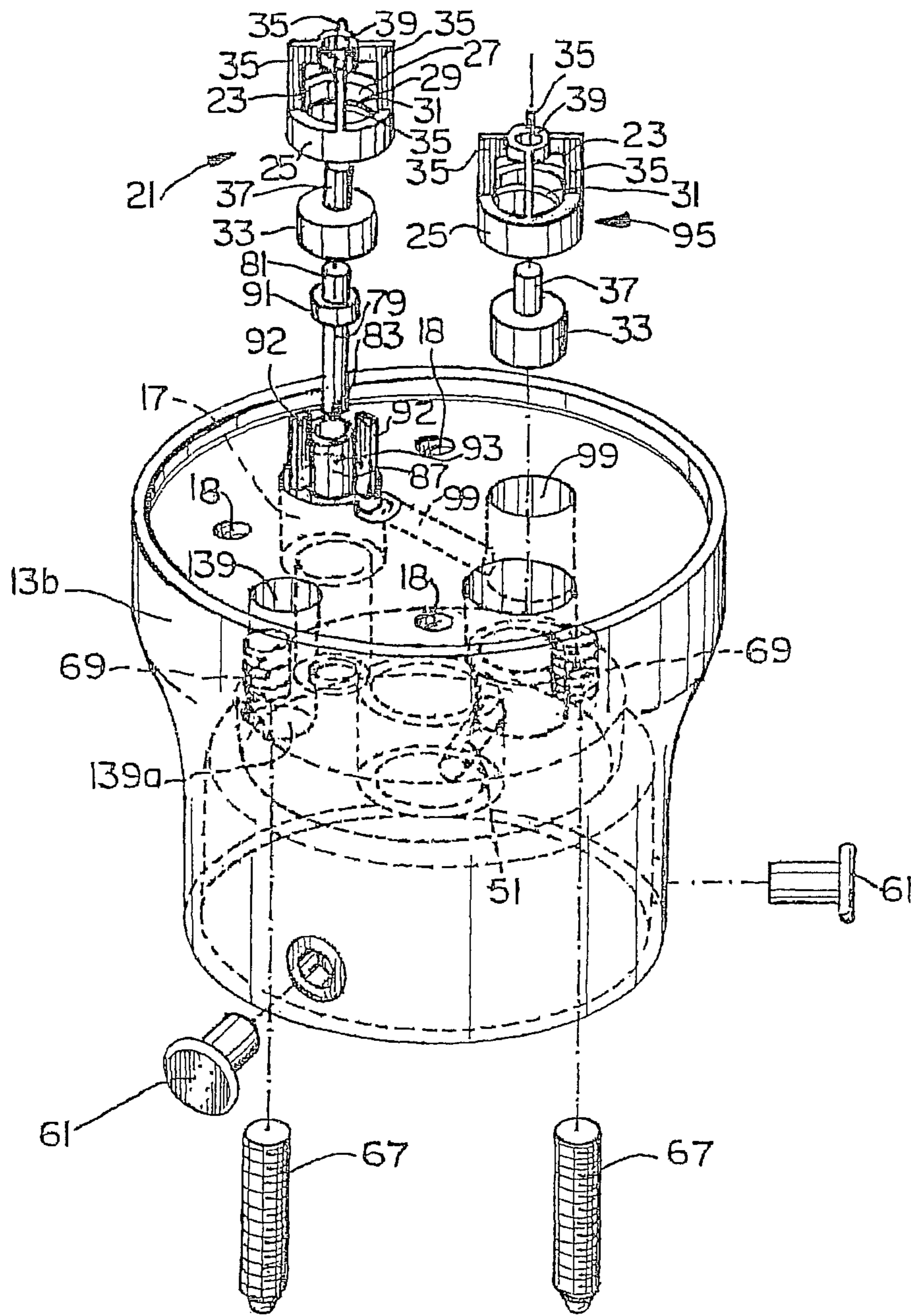


FIG. 2

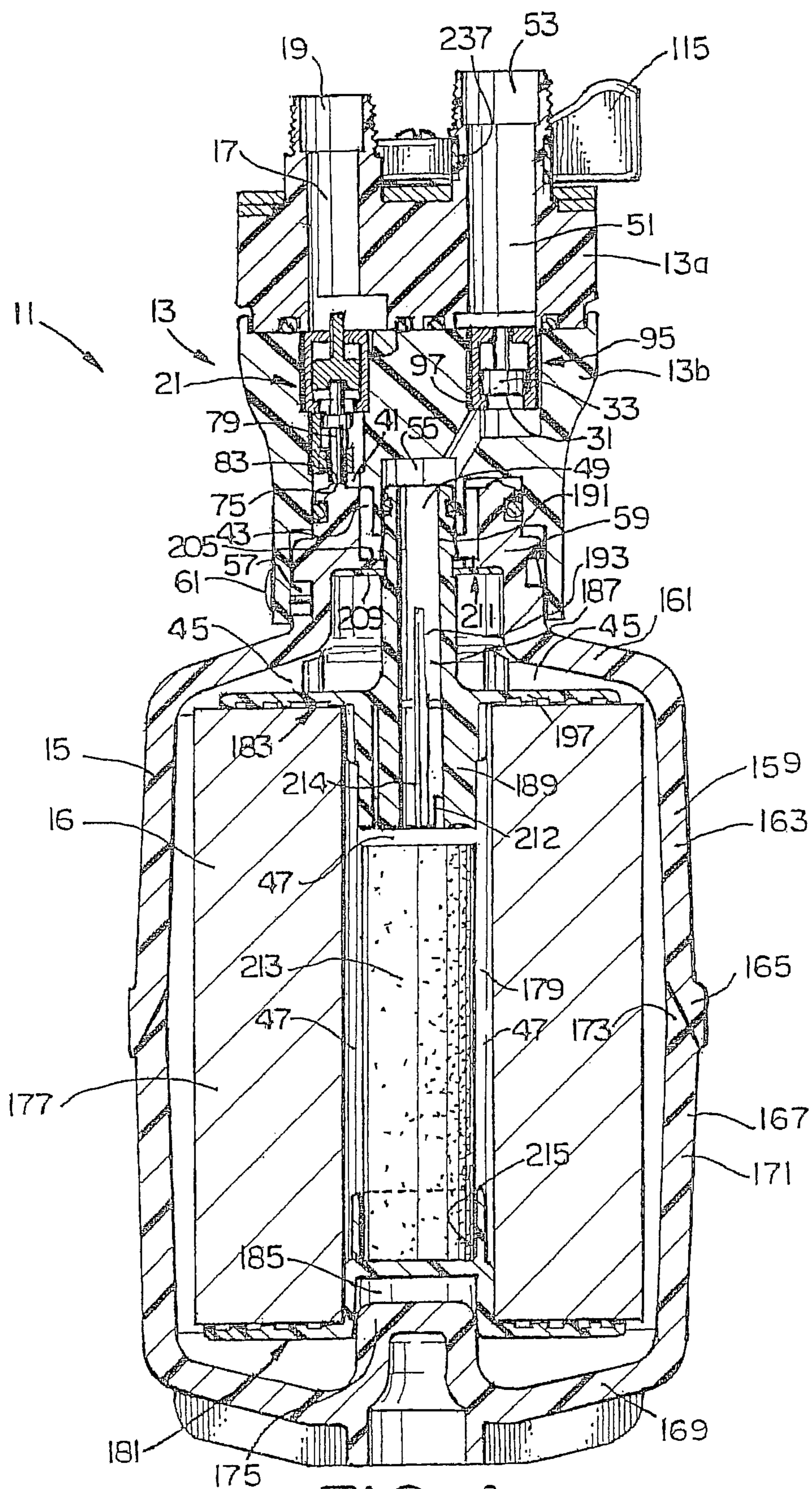


FIG. 4

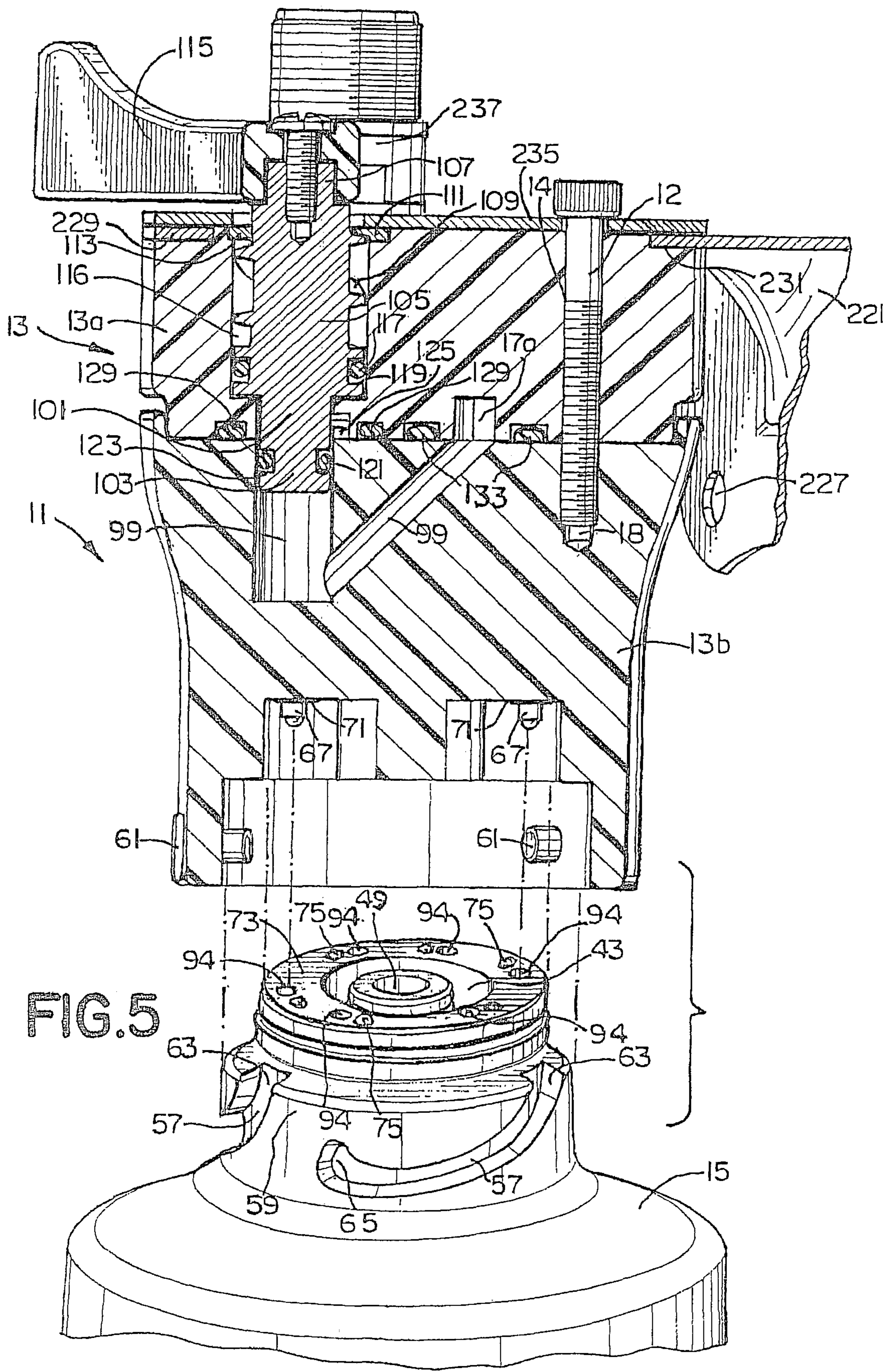
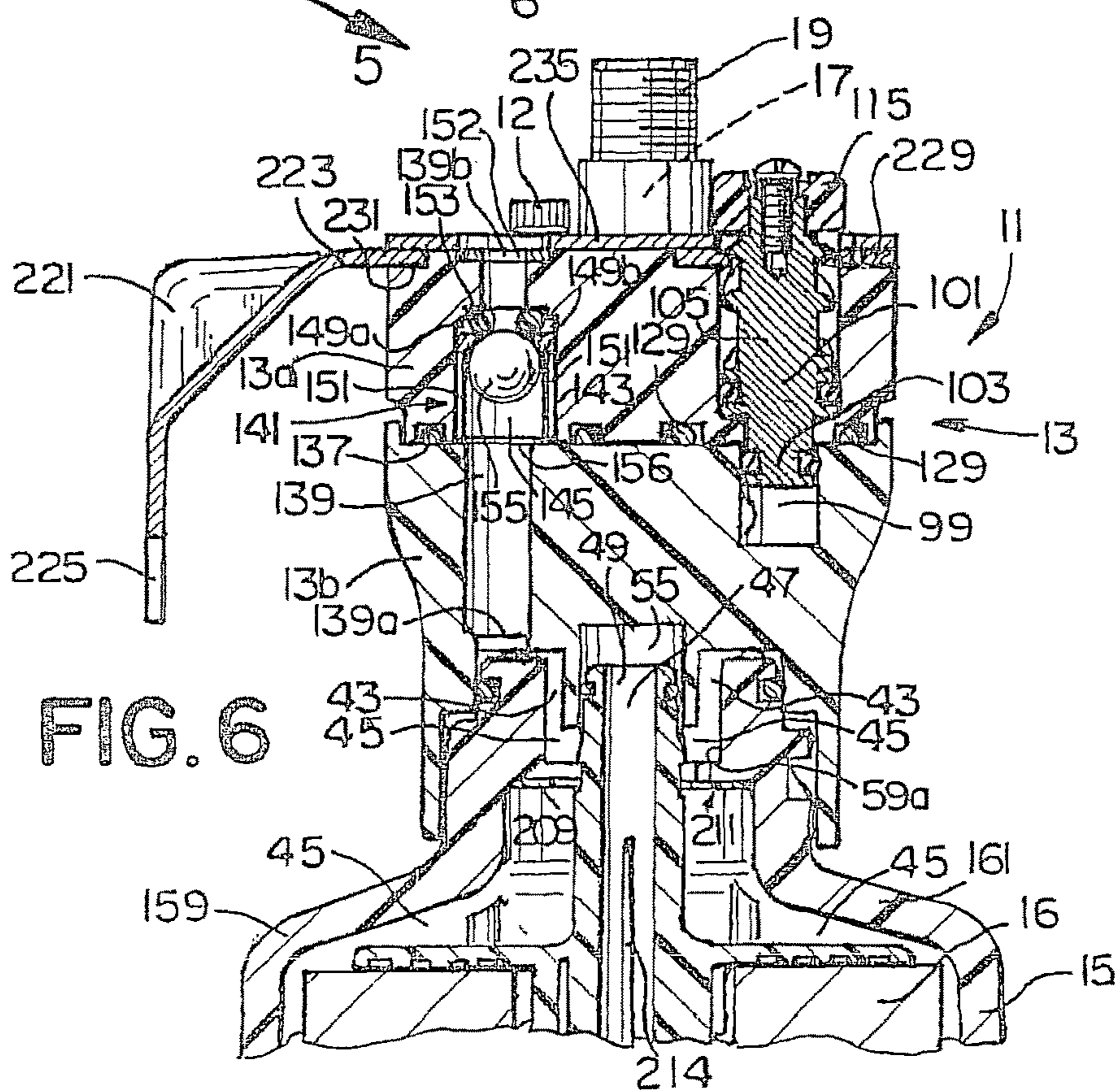
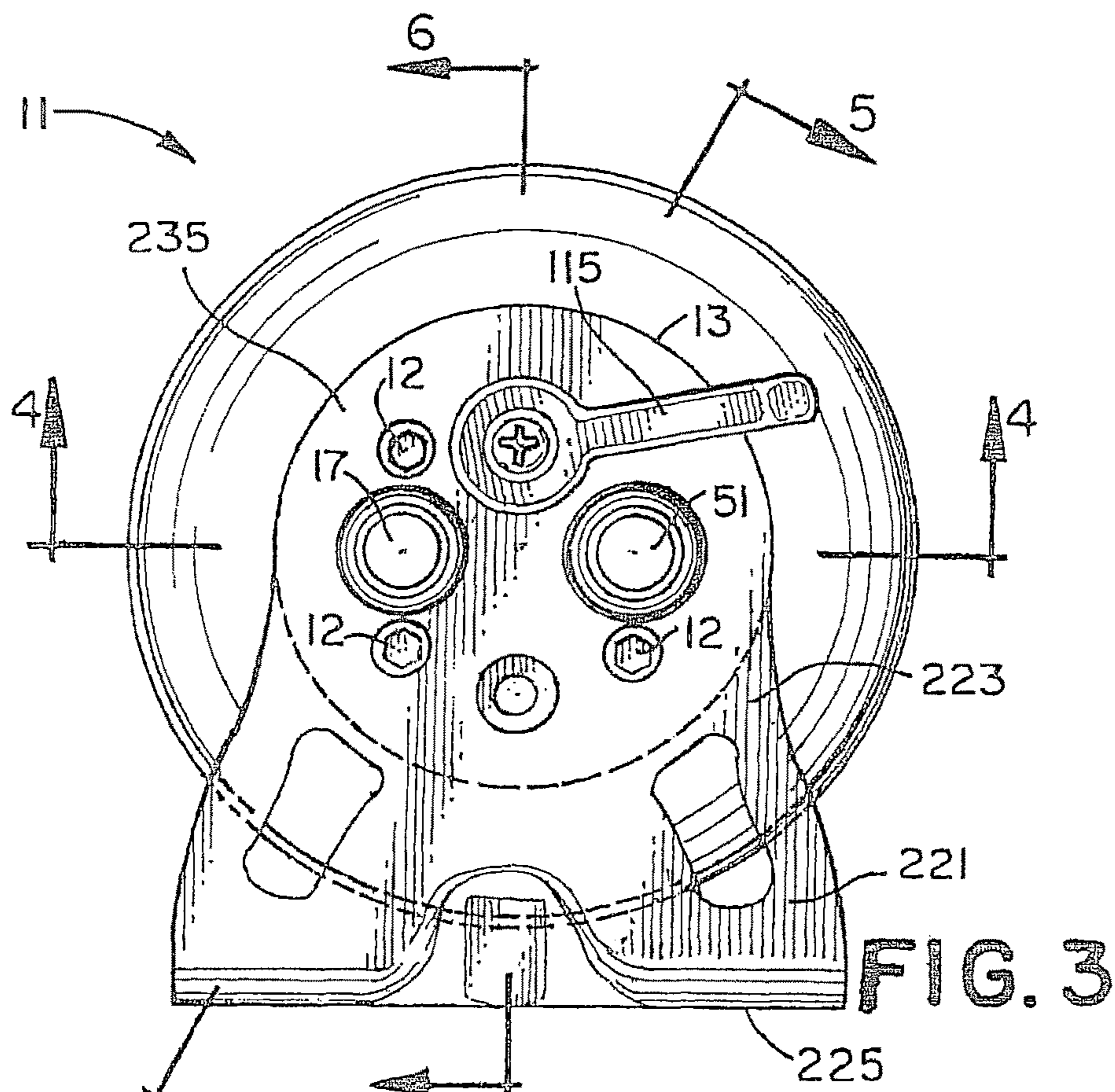


FIG. 5



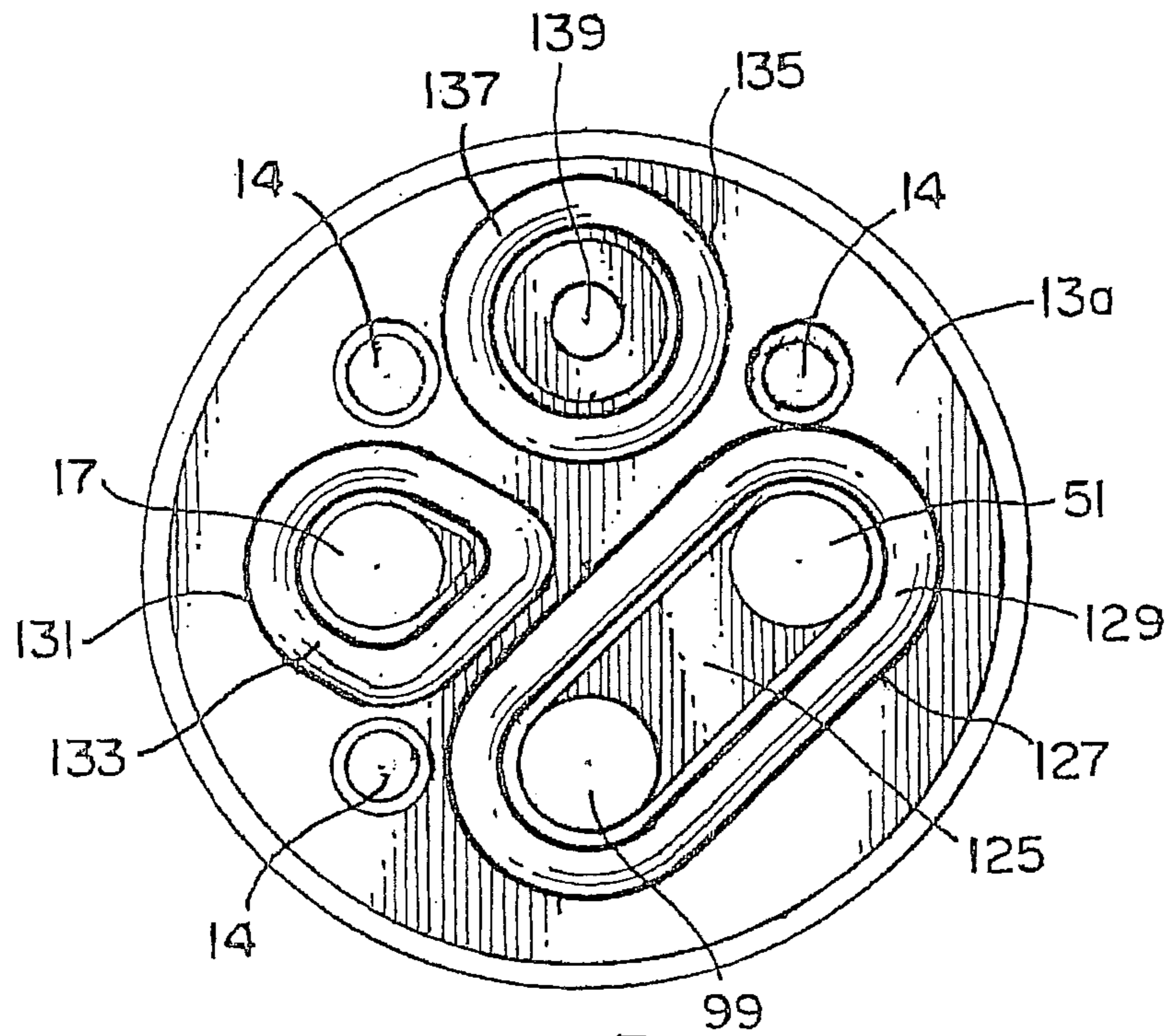


FIG. 7

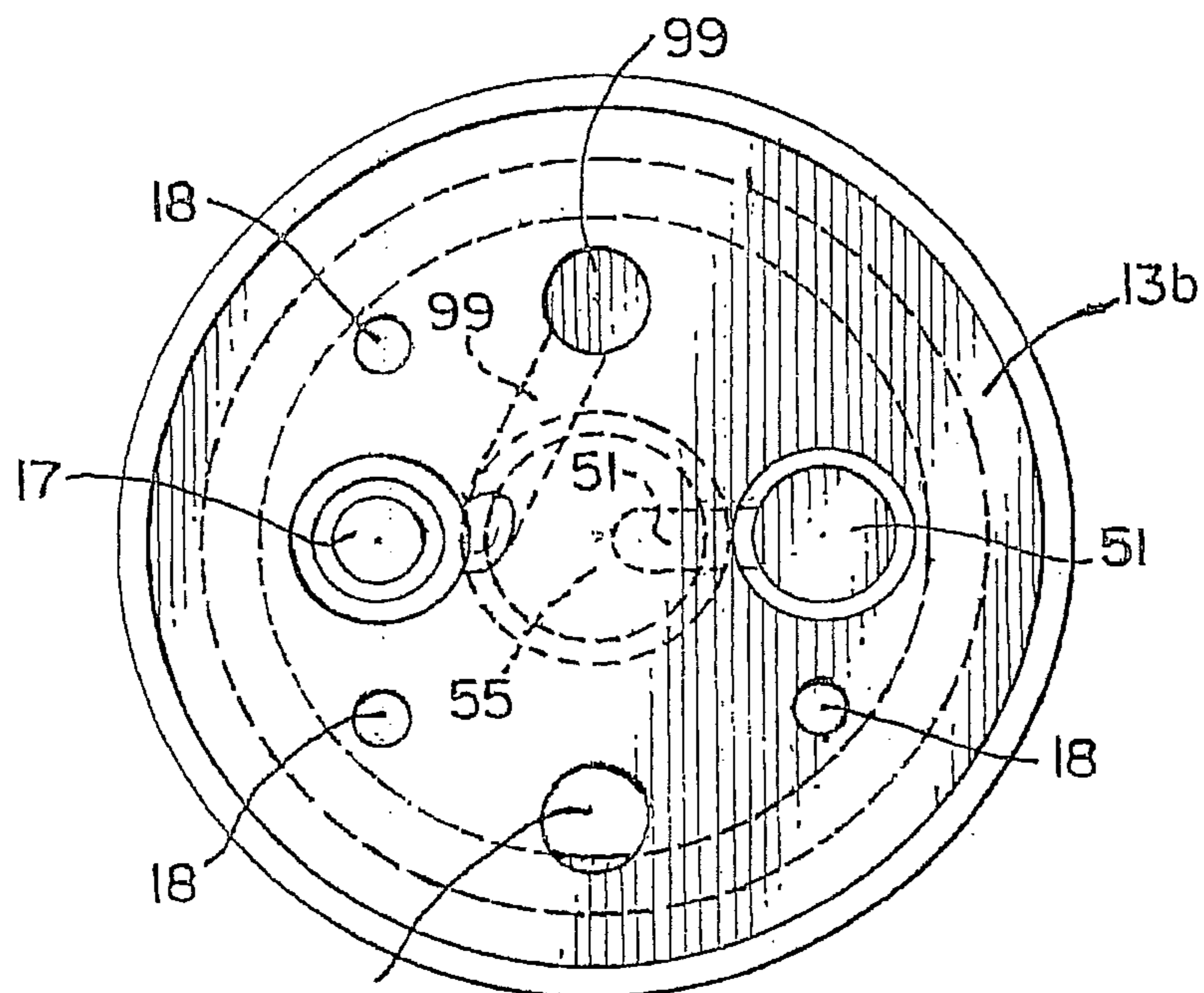


FIG. 8



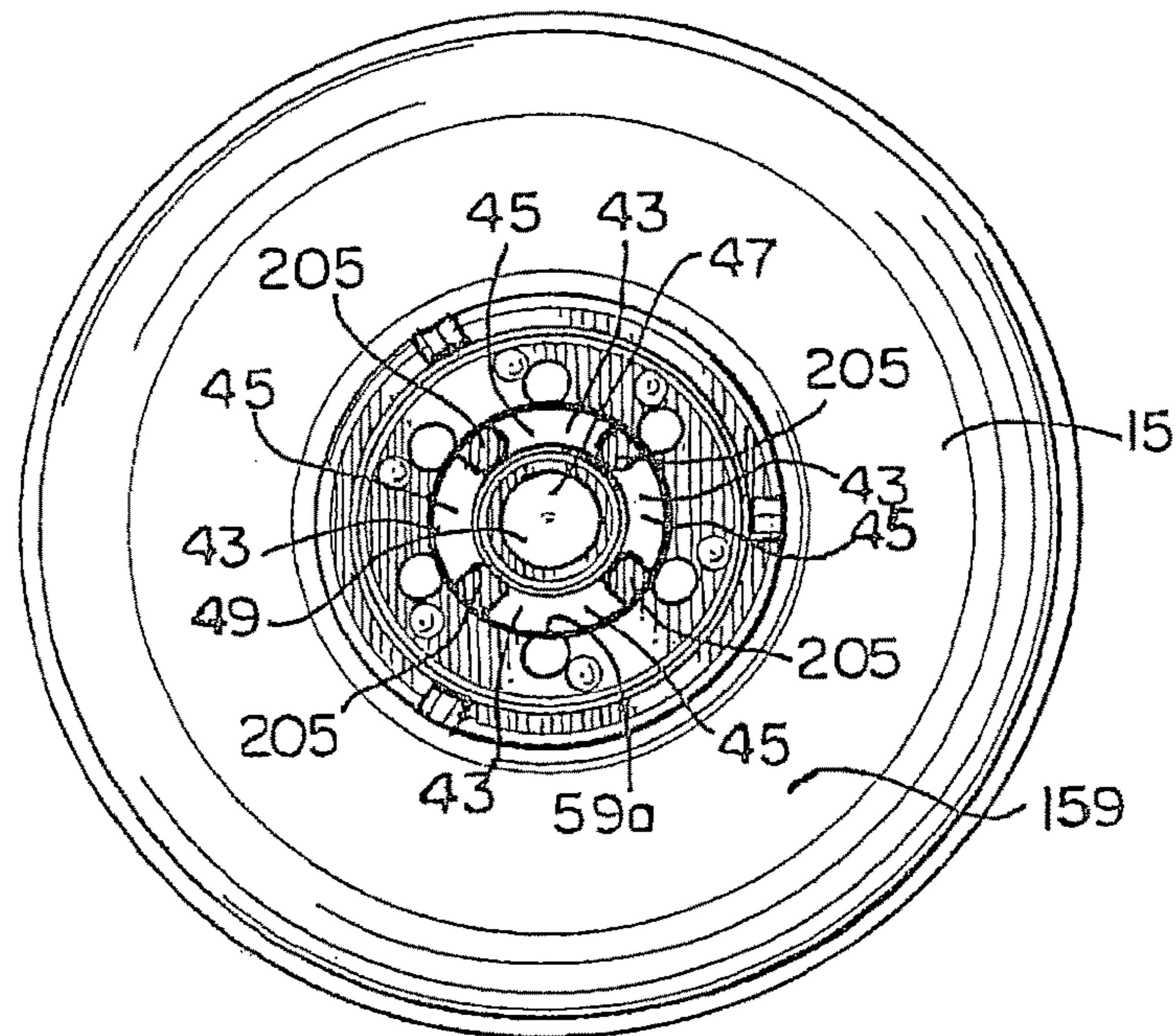


FIG. 9

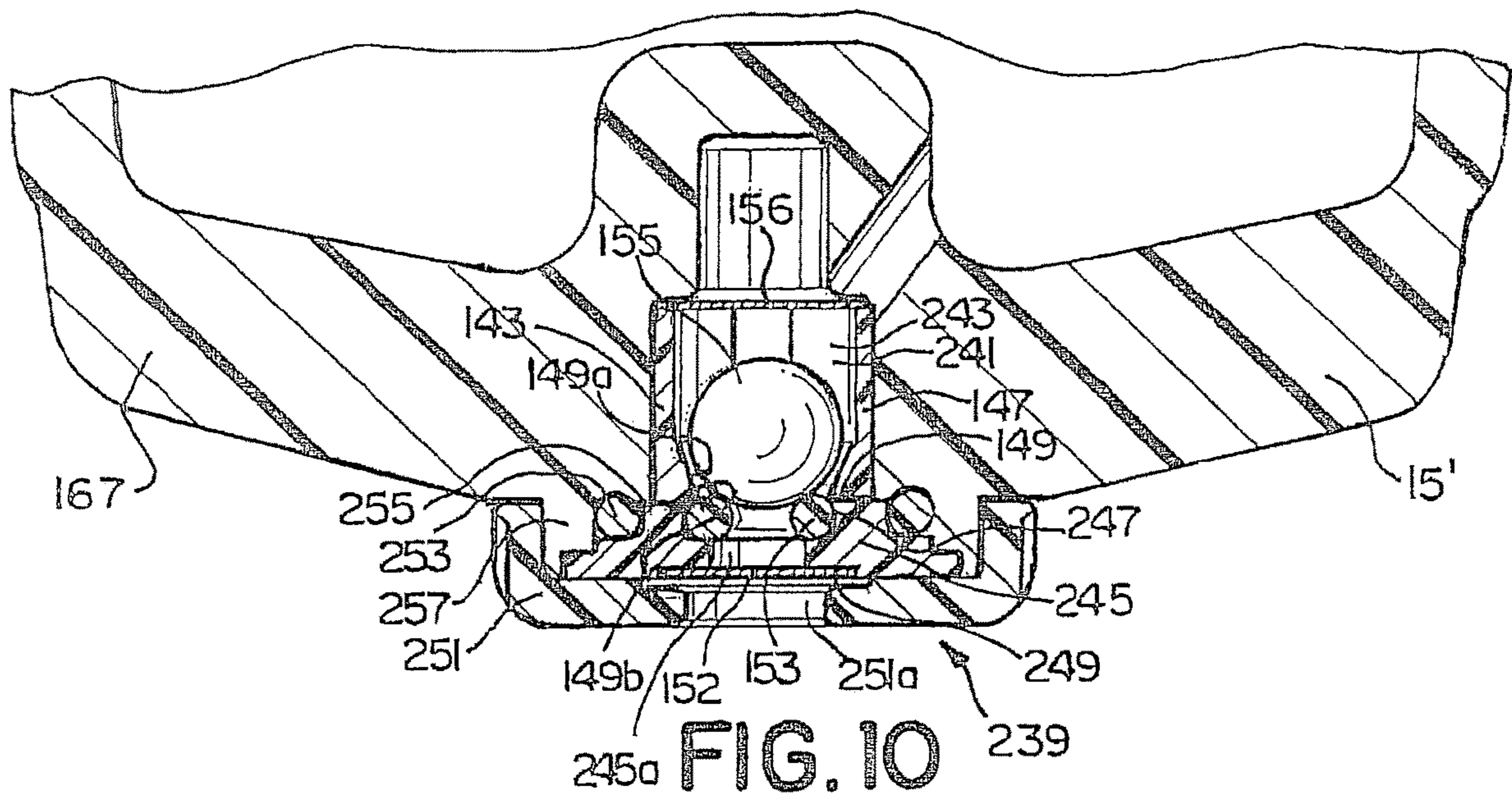


FIG. 10

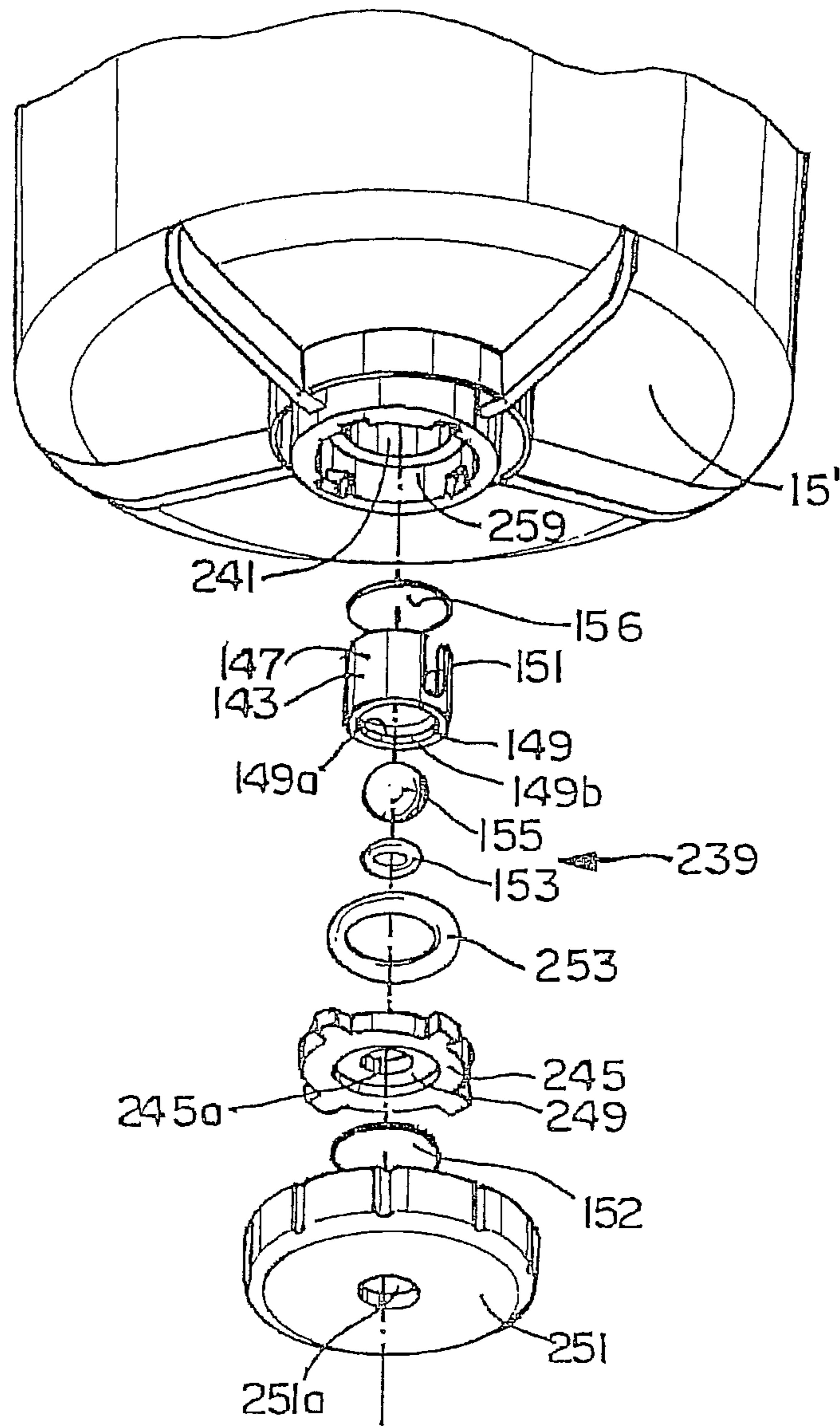
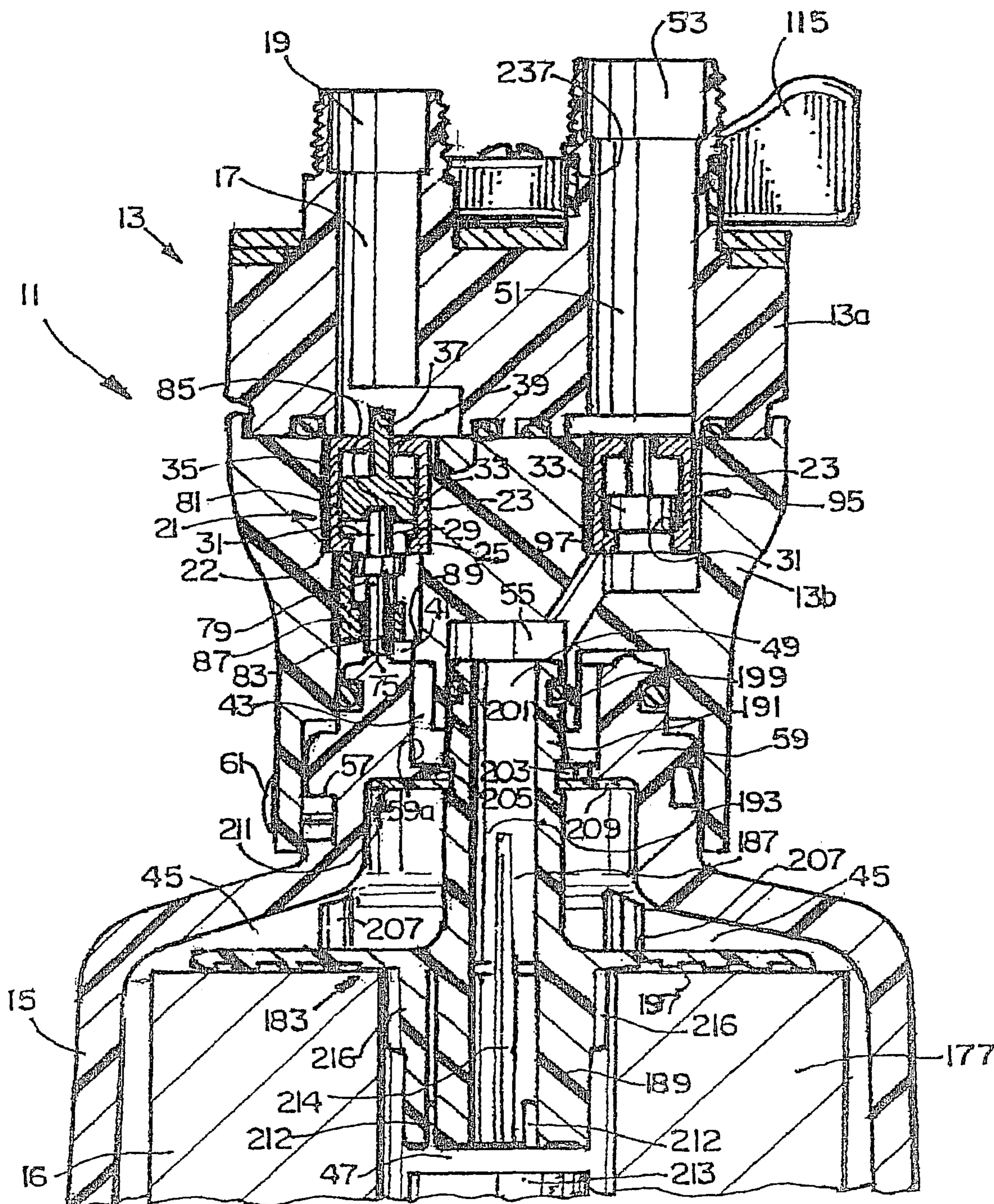


FIG. 11

FIG. 12



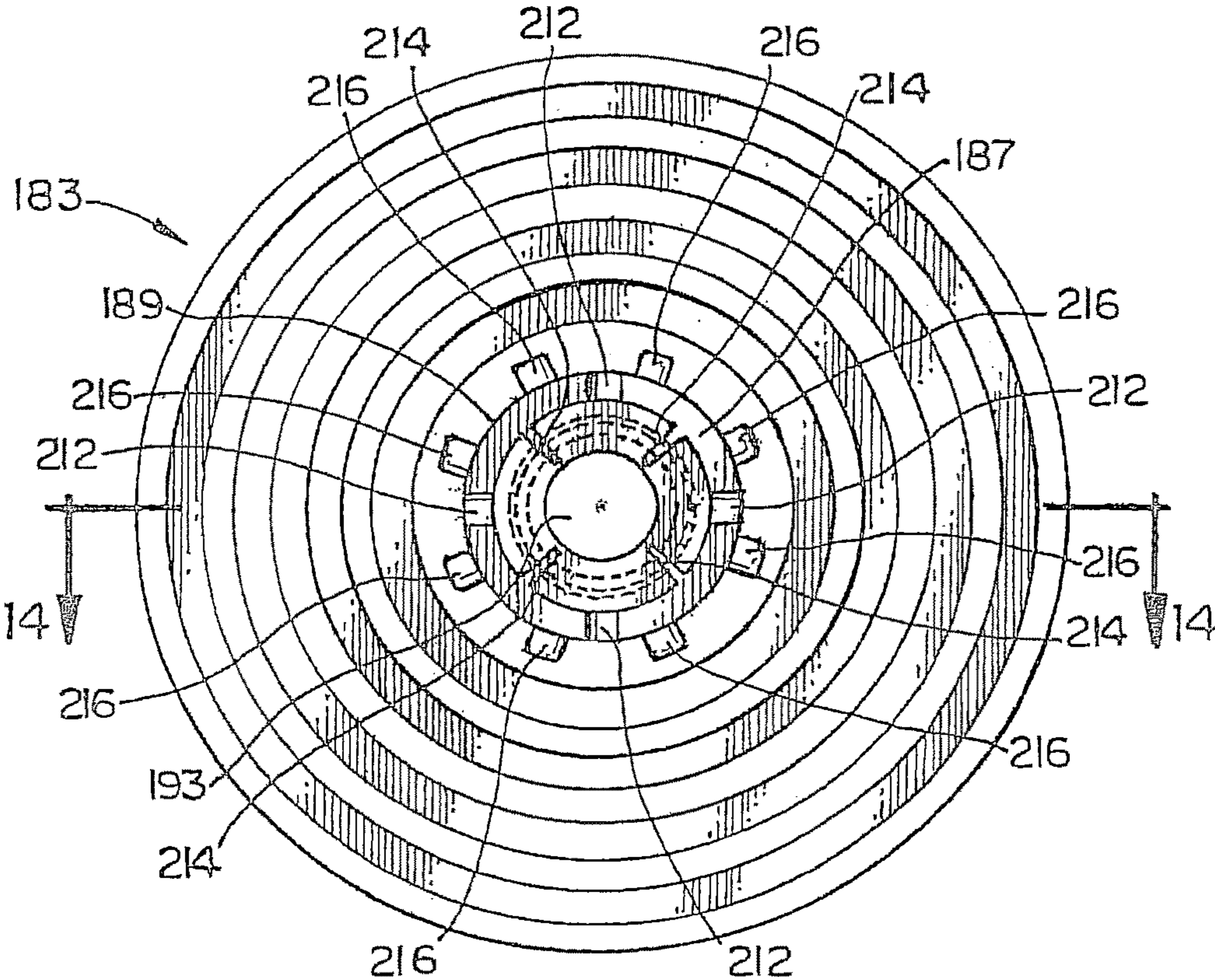


FIG. 13

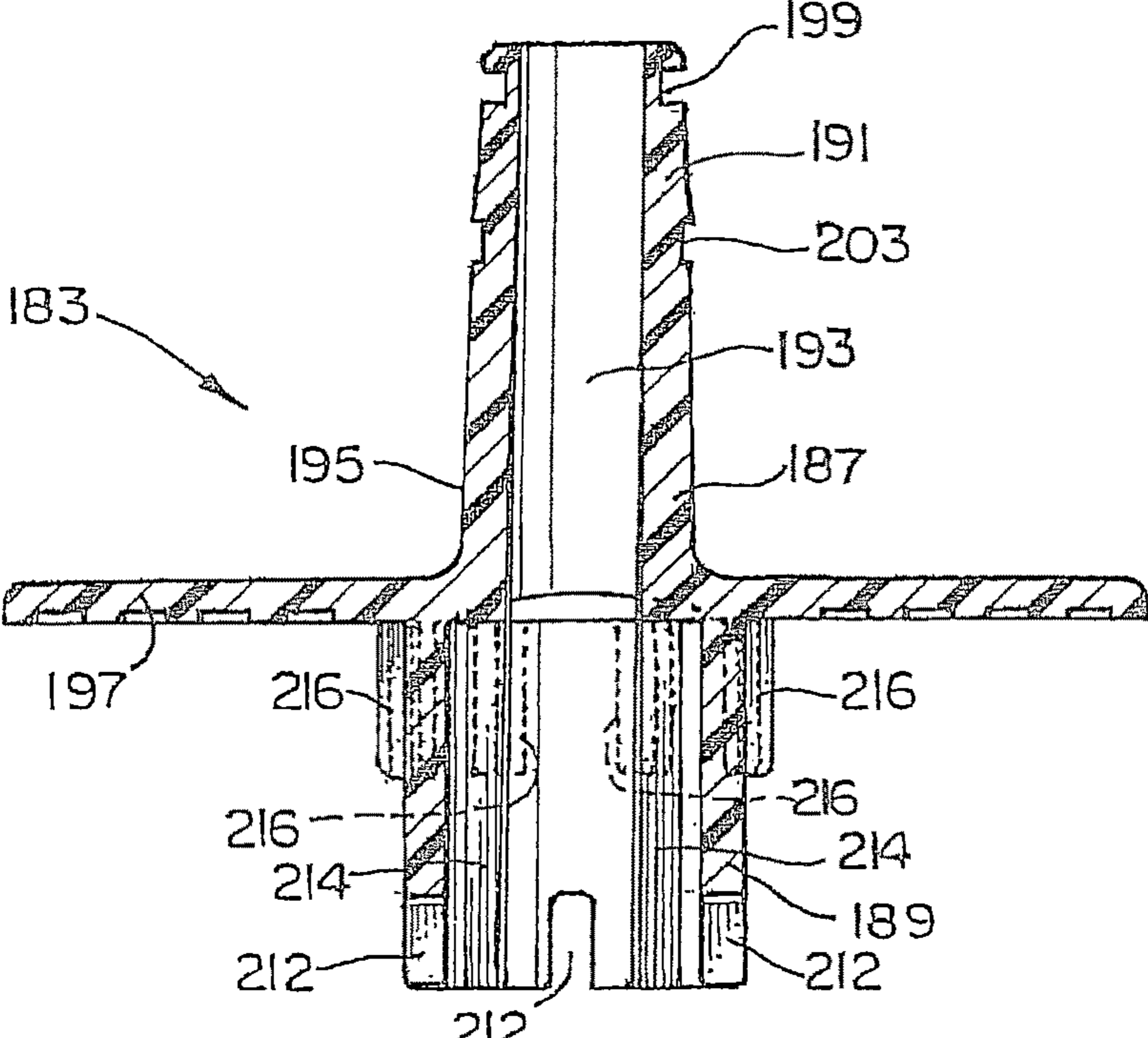


FIG. 14

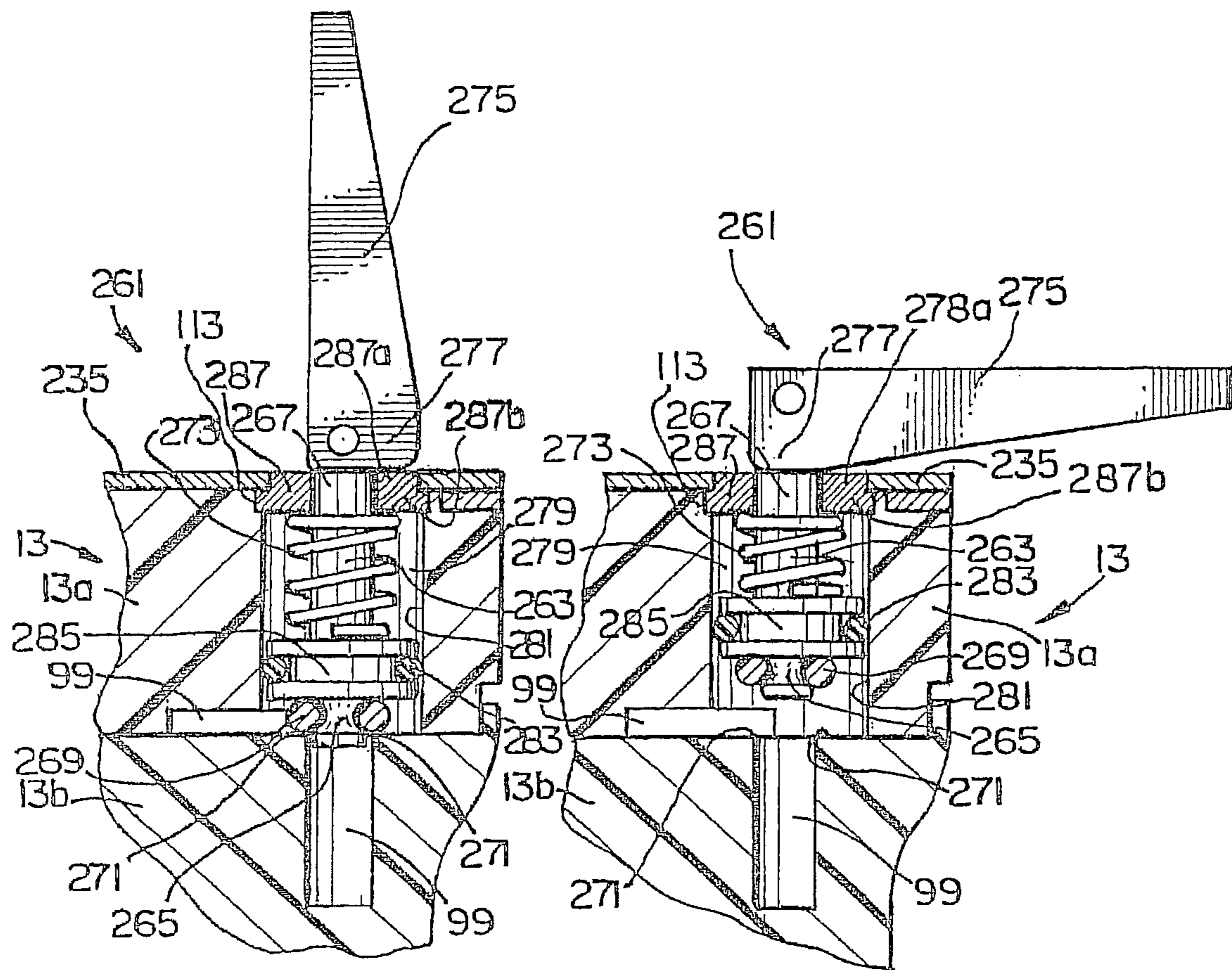


FIG. 15

FIG. 16

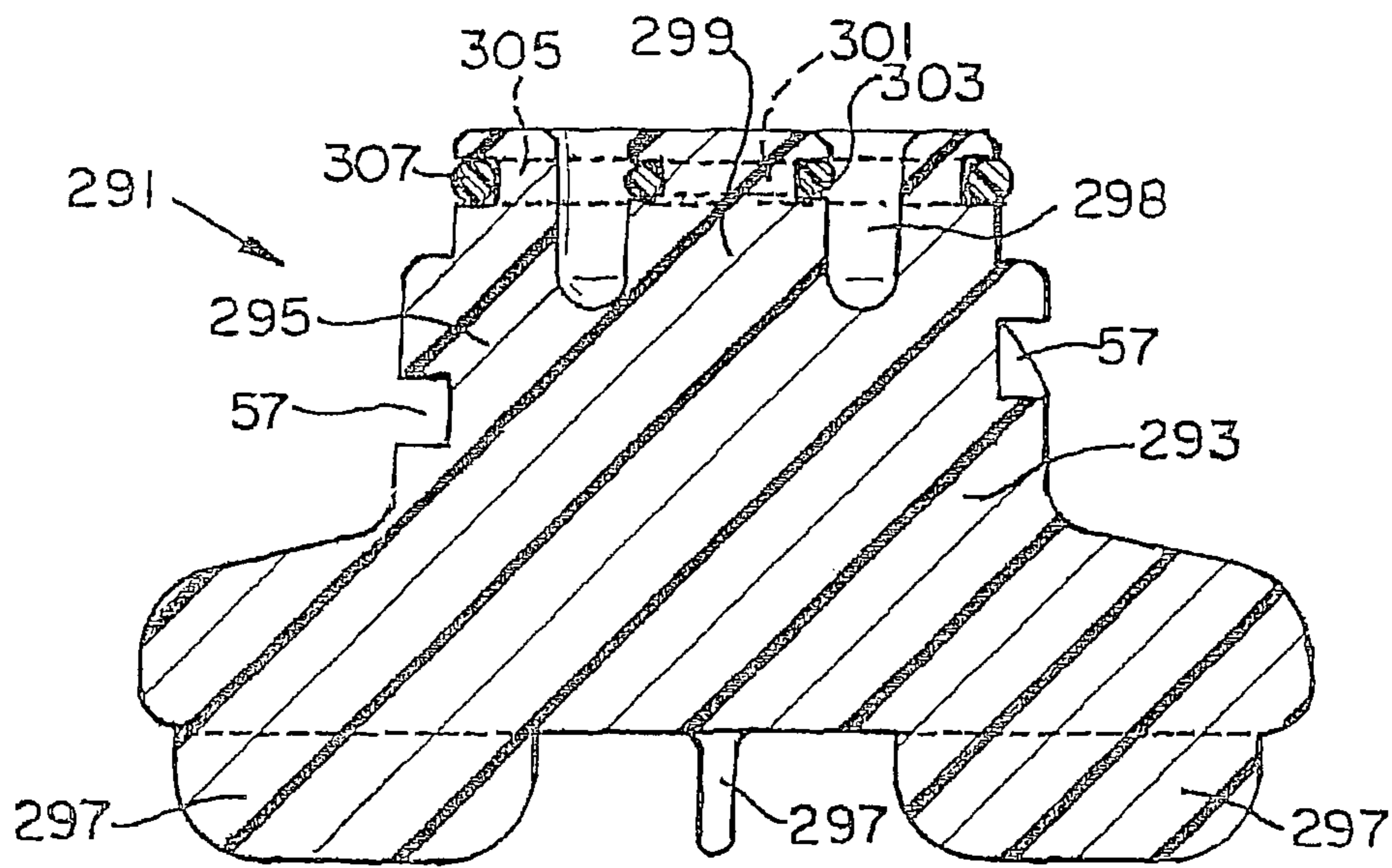


FIG. 17

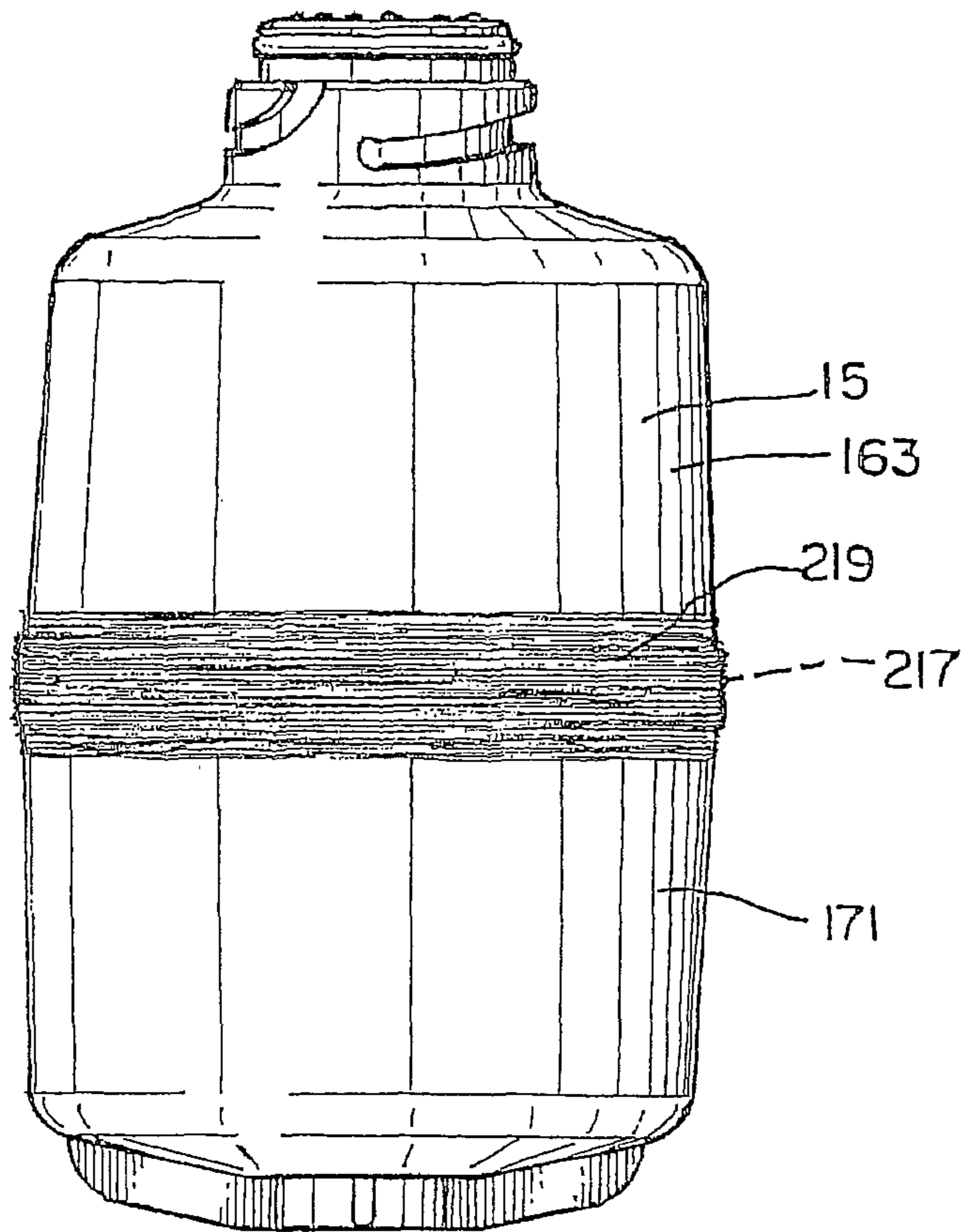


FIG. 18

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**APPARATUS FOR FILTERING AND/OR  
CONDITIONING AND/OR PURIFYING A  
FLUID SUCH AS WATER**

FIELD OF THE INVENTION

This invention relates to apparatuses for filtering and/or conditioning and/or purifying a fluid such as water, and more particularly concerns such apparatuses that use pressure vessels holding a cartridge, loose media, or the like for filtering and/or conditioning and/or purifying a fluid such as water. This invention also relates to various fluid distribution systems, such as potable water distribution systems for aircraft, for example.

BACKGROUND OF THE INVENTION

Aircraft Potable Water Use—Adequate hydration is particularly important for comfortable air travel. Aircraft typically are crowded with thousands of passengers including babies, small children, handicapped and others passing through a commercial passenger aircraft during a single week. Both passengers and crews contribute to microorganism populations aboard aircraft and special precautions must be taken to minimize and avoid the possibility of bacteria and other microorganisms being transferred to others through the water distribution system. A primary sanitation defense mechanism is to maintain an adequate residual of chlorine, preferably free chlorine, within the water storage and distribution system. However, water is supplied to aircraft from many locations and varies widely in taste and sanitary quality. Furthermore, leading causes of water borne disease, worldwide, are relatively large but still invisibly small, parasitic cysts such as *Giardia* and *Crypto* which are not controlled by chlorination. These pathogens can reliably be removed by effective microfiltration.

Aircraft Water Distribution and Management—Typically, a water distribution system on aircraft comprises a water storage tank and a centralized distribution line with various branches or legs extending from the central distribution line to locations throughout the aircraft. Water is distributed from the storage tank throughout the aircraft to galleys, lavatories and other locations as needed for food and beverage preparation, and for personal hygiene during flights. Galleys include coffee makers, water boilers and other drinking water service points. Similarly, lavatories often include drinking water outlets and may be used for face and hand rinsing, cleaning teeth and short term medication.

Water filter/purifier units, each comprising a housing pressure vessel (usually stainless steel) and a filtration/purification cartridge, are installed in or near galleys and lavatories as part of the aircraft water distribution system to improve water quality for consumption and for food and beverage preparation. Space in galley and lavatory compartments is expensive and severely limited. Accordingly, water filter/purifier units usually are installed in “out of the way” locations often behind other more readily accessible equipment and bulkheads.

Sanitation Practices—To overcome the challenges of virus, bacteria, and larger organism transmission via water systems and colonization within the aircraft potable water distribution systems, airlines, in addition to trying to assure an adequate chlorine residual within the aircraft water supply, periodically sanitize their aircraft water distribution systems with a 2+ hours soak of high concentration (100 ppm) chlorine solutions. The sanitation process is time and labor intensive and, because such high concentrations of

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chlorine is detrimental to the filtration/purification cartridges, requires removing the filtration/purification cartridges from the water filter/purifier units installed in galleys, fountains and lavatories throughout the aircraft prior to the sanitation process. After removal of cartridges, the housings (pressure vessels) must be reassembled to seal against leakage during sanitation. After chlorine flushing and soaking, the housings (pressure vessels) once again must be accessed, opened and the same or new cartridges must be installed. The housings (pressure vessels) frequently are installed in hard to reach locations, resulting in expensive labor costs alone sometimes ranging upwards to hundreds of dollars per unit.

System Draining and Refilling—Water must be drained from aircraft during periods of non-use (such as overnight) in cold climates. Proposed EPA regulations require much more frequent draining and filling of water storage tanks in an effort to improve aircraft drinking water quality and safety. Draining and filling water systems requires “vacuum breaks” at equipment locations to allow water to be properly released and “vents” to allow air to escape in order to assure proper functioning of filters, purifiers, and other equipment. Although the very latest filter/purifier units include automatic vacuum breaks and venting, most aircraft units require manual actuation often resulting in inadequate water draining and filling.

Also, under the proposed EPA regulations, it is likely that accessing and actuating manual vents and vacuum breaks, sometimes previously ignored, may become a significantly higher maintenance cost item due to difficult access to the water filter/purifier units and aircraft “out of service” revenue costs.

Microorganism Growth—Even with periodic sanitization, bacteria may colonize various branches (legs) of water distribution systems. Bacteria multiply rapidly, sometimes doubling in number in approximately 16 minutes. Therefore, a small number of bacteria may quickly reach infectious concentrations in water intended to be consumed, especially downstream of improperly installed/serviced filters/purifiers employed to remove chlorine, foul tastes, and odors. Further, water filter/purifier units installed in semi-remote locations along the water distribution system often require longer than desired distribution lines to specific service points (e.g., locations where the water is discharged from the water distribution system). These distribution lines provide unnecessary opportunities for previously purified water to be recontaminated from inadvertent inoculation, short term bacteria multiplication or biofilm formation/shedding that may have taken place in such distribution lines downstream of the water filter/purifier units.

SUMMARY OF THE INVENTION

It is an object of the invention to provide an apparatus for filtering and/or conditioning and/or purifying a fluid such as water.

It is another object of the invention to enable and introduce a new concept to provide more efficient, more cost effective, improved water quality management aboard passenger aircraft, and for other applications. For example, and more specifically with respect to passenger aircraft applications, the concept is to provide water filter and water purifier systems installed at various aircraft cabin crew readily accessible service locations (service points) within galleys and lavatories of the aircraft, preferably at or near where the water that is filtered and/or conditioned and/or purified for immediate use. This invention provides for various types of

filtering and purifying processes being available in interchangeable self-contained canisters (e.g., pressure vessels **15**, each containing filtration and/or purification media **16**) attached to interfacing “valve heads” integrated into the water distribution system at appropriate cabin crew readily accessible locations. Stored water can then be filtered and/or purified immediately at the time and place of use as it is discharged from the potable water distribution system.

Another object of the invention is to provide an aircraft potable water distribution system having valve heads installed locally at various cabin crew readily accessible service locations or service points within galleys and lavatories of the aircraft, to connect an outlet port of at least one of the valve heads directly to an appliance such as a coffee maker or other water-using equipment located in the galley of the aircraft to reduce possible exposure of the water that has been filtered and/or conditioned and/or purified to contaminants that may be encountered if water were to be indirectly brought from the outlet port of the valve head to the appliance instead.

Still another object of the invention is to provide an apparatus and aircraft potable water distribution system that allows non-technical flight attendants servicing, that is, removal of filtration/purification cartridges, and replacement thereof, on a frequent basis as an extension of normal routines, without requiring professional maintenance crew attendance and support.

These and other objects are provided by our invention, a description of which is set out below.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an exploded view of the first end portion of the valve head **13**, constructed in accordance with the invention.

FIG. **2** is an exploded view of the second end portion of the valve head **13**, constructed in accordance with the invention.

FIG. **3** is a top plan view of the apparatus **11** of the invention.

FIG. **4** is a view in cross section taken along the lines and arrows **4-4** shown in FIG. **3**.

FIG. **5** is a view in partial cross section taken along the lines and arrows **5-5** shown in FIG. **3**, except that the canister or pressure vessel **15** is shown as a partial view in perspective and exploded away from the valve head **13**.

FIG. **6** is a partial view in cross section taken along the lines and arrows **6-6** shown in FIG. **3**.

FIG. **7** is a bottom plan view of the valve head member **13a** of valve head **13**.

FIG. **8** is a top plan view of the valve head member **13b** of valve head **13**.

FIG. **9** is a top plan view of a canister (the pressure vessel **15** containing a cartridge **16**) of the invention.

FIG. **10** is a partial view in cross section showing an automatic venting device **239** formed in the bowl of an alternative embodiment of the pressure vessel, constructed in accordance with the invention.

FIG. **11** is an exploded view of the automatic venting device **239** shown in FIG. **10**.

FIG. **12** is an enlarged view of a portion of the apparatus **11** shown in FIG. **4**.

FIG. **13** is a view in bottom plan of the end cap **183** which has a hollow tube **187** that functions as the outlet port from the canister (the pressure vessel **15** having the cartridge **16** mounted therein).

FIG. **14** is a view in cross section taken along the lines and arrows **14-14** shown in FIG. **13**.

FIG. **15** is a view in partial cross section showing an alternative bypass valve **261**, in which the bypass valve **261** is in a closed position blocking flow through the third passageway **99** formed in the valve head **13**. For purposes of clarity, various details relating to the valve head **13** are not shown in this figure so as to highlight the details relating to the bypass **261**.

FIG. **16** is a view in partial cross section showing an alternative bypass valve **261**, in which the bypass valve **261** is in an opened position to permit flow of fluid through the third passageway **99** formed in the valve head **13**. For purposes of clarity, various details relating to the valve head **13** are not shown in this figure so as to highlight the details relating to the bypass **261**.

FIG. **17** is a view in cross section of an end cap used to cover the second end portion of the valve head **13** when a canister is not connected to the valve head **13** to block dirt and other debris from having easy access to the second end portion **71** of the valve head **13**.

FIG. **18** is a view in front elevation of a pressure vessel **15** that is provided with a reinforcement member **219** secured around the sealed seam portion **217** of the pressure vessel **15**.

#### DETAILED DESCRIPTION

Turning now to the drawings, there is shown the inventive apparatus **11** for filtering and/or conditioning and/or purifying a fluid, such as water. (Purification, per EPA regulations, requires performance meeting the EPA Guide Standard Protocol for Microbiological Purifiers; filtration and conditioning may be almost anything else that is useful, such as taste and odor removal, scale control, etc.)

Referring particularly to FIGS. **1**, **2**, **4**, and **12**, apparatus **11** includes an automatic valving unit **13** for a pressure vessel **15** that holds a cartridge **16**, or loose media, or the like for filtering and/or conditioning and/or purifying a fluid, such as water. The automatic valving unit **13** (also referred to herein as “valve head **13**”), when desired, automatically provides for fluid flow into the pressure vessel **15** when the pressure vessel **15** is in use and, when desired, automatically discontinues fluid flow from the valve head **13** when the pressure vessel **15** is disconnected from the valve head **13**.

The valve head **13**, which preferably is machined from a metal such as stainless steel or aluminum preferably coated and sealed with a hard aluminum oxide coating for scratch resistance and long life, preferably includes a first end member **13a** and a second end member **13b**, which are held together by threaded bolts **12** that extend through bores **14** formed in and extending through the first end member **13a** and into aligned threaded bores **18** formed in the second end member **13b**.

As shown in FIGS. **4** and **12**, the valve head **13** has a first passageway **17** extending through it and adapted to be connected to a fluid transmission line, such as a water supply line of an aircraft potable water distribution system. Preferably, the valve head **13** has a threaded inlet port **19** at the entrance of the first passageway **17** that receives a threaded female fitting of the fluid transmission line.

Referring particularly to FIGS. **12** and **2**, a first check valve **21** is positioned on an annular ledge **22** formed in the first passageway **17** of the valve head **13** for blocking flow of fluid through the first passageway **17** when the valve **21** is closed. Preferably, the first check valve **21** includes a valve housing **23** (preferably made of a suitable polymeric material) having an annular ring-shaped base portion **25** that



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has an annular inner wall surface 27. An annular ledge 29 is formed on the inner wall surface 27 creating a valve seat 31.

A movable valve disc 33 (preferably made of a suitable polymeric material) is contained within the valve housing 23 that closes the valve 21 when the valve disc 33 rests against the valve seat 31 and that permits flow of fluid through the valve 21 when the valve disc 33 is not resting against the valve seat 31. The valve housing 23 also includes a plurality of arms 35 that extend away from the base portion 25 of the valve housing 23 and over the opening in the valve housing 23 formed by the annular ring-shaped base portion 25 to form a cage-like structure that contains the valve disc 33 in the valve housing 23. As shown in FIGS. 2, 4, and 12, the valve disc 33 has a guide pin 37 formed on and extending upstream from its upstream face that is engaged by and slides in a guide pin holder 39 (a small hollow cylinder) formed on the ends of the arms 35 where the arms 35 meet over the opening in the annular ring-shaped base portion 25 to keep motion of the valve disc 33 on a line that permits proper seating of the valve disc 33 on the valve seat 31.

An outlet port 41 is formed at the outlet end portion of the first passageway 17 of the valve head 13.

Referring to FIGS. 4 and 12, the pressure vessel 15 has an inlet port 43 that is in fluid communication with the outlet port 41 formed at the outlet end portion of the first passageway 17 in the valve head 13 when the pressure vessel is connected to the valve head 13. The pressure vessel 15 has a first passageway 45 extending from the inlet port 43 of the pressure vessel 15 to the cartridge 16, or loose media, or the like, through which the fluid passes to filter and/or condition and/or purify the fluid, and a second passageway 47 extending from the cartridge 16, or loose media, or the like to an outlet port 49 of the pressure vessel 15.

The valve head 13 also is provided with a second passageway 51 extending through it and adapted to be connected to a fluid receiving line (such as a water faucet of an aircraft potable water distribution system or an apparatus such as a coffee maker used on an airplane) at an outlet port 53 of the second passageway 51. Preferably, the outlet port 53 has a threaded fitting that is received in a threaded female fitting of the fluid receiving line.

The valve head 13 has an inlet port 55 formed at an inlet portion of the second passageway 51 in the valve head 13 that is in fluid communication with the outlet port 49 of the pressure vessel 15 when the pressure vessel 15 is connected to the valve head 13.

Referring to FIGS. 5, 12, and 2, connecting/disconnecting means is provided for connecting the pressure vessel 15 to the valve head 13, when desired, to permit flow of fluid from the first passageway 17 in the valve head 13 to the inlet port 43 of the pressure vessel 15, and for disconnecting the pressure vessel 15 from the valve head 13, when desired, to stop flow of fluid from the first passageway 17 in the valve head 13. Preferably, the connecting/disconnecting means comprises a bayonet-style mount, including a plurality of grooves 57 (three such grooves 57 being used in the embodiments of the invention shown in the drawings) formed on the neck 59 of the pressure vessel 15, and a corresponding number of pins 61 (three such pins 61 being used in the embodiments of the invention shown in the drawings) mounted on the valve head 13. Each groove 57 has a first end portion 63 where a corresponding pin 61 may be inserted and moved along the groove 57 by turning the pressure vessel 15 around its central axis until the pin 61 reaches a second end portion 65 of the groove 57, thereby securing the pressure vessel 15 to the valve head 13. A plurality of spring-loaded plungers or detents 67 (two such plungers 67

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being used in the embodiments of the invention shown in the drawings) are screwed into threaded bores 69 formed in the second end member 13b of the valve head 13 which push against the first end portion 73 of the neck 59 of the pressure vessel 15 when the pressure vessel 15 is connected to the valve head 13.

Alternatively, instead of grooves 57 and pins 61, the connecting/disconnecting means may comprise threads formed on the outer surface of the neck 59 and matching threads formed on the valve head 13, such as that disclosed in Williams U.S. Pat. No. 5,695,168, which is incorporated herein in its entirety by reference.

Referring again to FIGS. 2, 4, and 12, actuating means is provided for automatically opening the valve 21 when the pressure vessel 15 is connected to the valve head 13. Preferably, the actuating means includes a pin 79 that is positioned in the first passageway 17 of the valve head 13 between the valve disc 33 and the outlet port 41 at the outlet end portion of the first passageway 17 of the valve head 13. The pin 79 has a first end portion 81 and a second end portion 83, the first end portion 81 engaging the valve disc 33 by being received in a bore 85 formed in the downstream face of the valve disc 33, and the second end portion 83 being held by a pin holder 87 (positioned between valve 21 and an annular ledge 89 in the first passageway 17) in which the pin 79 is free to slide back and forth along the center axis of the pin 79. A radially extending ridge 91 is provided on the pin 79 to abut against a portion of the pin holder 87 to prevent the pin 79 from falling completely out of the first passageway 17 through the outlet port 41. The cross-section of the pin 79, even at the ridge 91, is smaller than the cross-section of the first passageway 17 so that fluid may flow through the first passageway 17 where the pin 79 is positioned when the valve 21 is open. Also, when the valve 21 is open, fluid may pass through the first passageway 17 where the pin holder 87 is located by passing between the spacing flanges 92 (three such spacing flanges 92 being used in the embodiments of the invention shown in the drawings), which surround and position a tubular section 93 (which holds the second end portion of the pin 79 in a sliding relationship) in the first passageway 17 in alignment with the valve disc 33.

The length of the pin 79 is such that when the pressure vessel 15 is connected to the valve head 13, the first end portion 73 of the neck 59 of the pressure vessel 15 pushes against the pin 79 causing the first end portion 81 of the pin 79 to push the valve disc 33 off and sufficiently away from the valve seat 31 to open the valve 21 to permit flow of fluid through the valve 21 and passageway 17.

Referring to FIGS. 5, 4, and 12, preferably, the actuating means also includes a cam or bump 75 formed on the first end portion 73 of the neck 59 of the pressure vessel 15, such cam 75 being located on the first end portion 73 of the neck 59 such that when the pressure vessel 15 has been connected to the valve head 13 (that is, when the pressure vessel 15 has been rotated into engagement with the valve head 13 such that the pins 61 have reached the second end portion 65 of the grooves 57), such cam 75 is aligned and in contact with the second end portion 83 of the pin 79 to push against the pin 79 causing the first end portion 81 of the pin 79 to push the valve disc 33 off and sufficiently away from the valve seat 31 to open the valve 21 to permit flow of the fluid through the valve 21 and the first passageway 17. In the embodiment of the invention shown in the drawings and especially in FIG. 5, the first end portion 73 of the neck 59 of the pressure vessel 15 has three such cams or bumps 75 spaced 120° apart from each other in a circle formed by the

first end portion 73 of the neck 59 so that the pressure vessel 15 may be rotated onto the valve head 13 with either the first pin 61 engaging the first groove 57, the second pin 61 engaging the second groove 57, and the third pin 61 engaging the third groove 57, or the first pin 61 engaging the second groove 57, the second pin 61 engaging the third groove 57, and the third pin 61 engaging the first groove 57, or the first pin 61 engaging the third groove 57, the second pin 61 engaging the first groove 57, and the third pin 61 engaging the second groove 57, resulting in one of the three cams or bumps 75 being aligned with and pushing against the second end portion 83 of the pin 79 to cause the first end portion 81 of the pin 79 to push the valve disc 33 off and significantly away from the valve seat 31 to open the valve 21 to permit flow of fluid through the valve 21 and the first passageway 17 when the pressure vessel 15 has been connected to the valve head 13.

In the embodiments of the invention illustrated in the drawings, six indents 94 are formed in the first end portion 73 of the neck 59 spaced 60° apart from each other in a circle formed by the first end portion 73 of the neck 59, with three of the indents 94 being located adjacent to a corresponding bump or cam 75. When the pressure vessel is fully twisted onto the valve head 13 such that one of the bumps or cams 75 is aligned with and pushing against the second end portion 83 of the pin 79, one of the plungers 67 clicks into the indent 94 located adjacent to that bump or cam 75 that is aligned with and pushing against the second end portion 83 of the pin 79, and the other plunger 67 clicks into the indent 94 that is positioned directly across the neck 59 from the indent 94 that is adjacent to the bump or cam 75 that is aligned with and pushing against the second end portion 83 of the pin 79, to provide a tactile sensation or feel to the person twisting the pressure vessel 15 onto the valve head 13 indicating that the pressure vessel 15 has been properly connected to the valve head 13.

A second check valve 95 is positioned on an annular ledge 97 formed in the second passageway 51 of the valve head 13 for blocking backflow of fluid from the second passageway 51 of the valve head 13, especially when the pressure vessel 15 is not connected to the valve head 13. Preferably, the second check valve 95 includes a valve housing 23 which contains a movable valve disc 33, as described above for the first check valve 21. The flow of fluid from the pressure vessel 15 pushes the movable disc 33 of the second check valve 95 off the valve seat 31 of the second check valve 95 and moves it in the downstream direction away from the valve seat 31 of the second valve 95 to permit fluid flowing from the pressure vessel 15 to flow through the second valve 95 and through the second passageway 51 of the valve head 13 to the fluid receiving line connected to the outlet port 53 of the second passageway 51 of the valve head 13. However, backflow of fluid through the second passageway 51 of the valve head 13 is blocked by the second check valve 95 due to any backflow of fluid pushing the moveable disc 33 of the second check valve 95 onto the valve seat 31 of the second check valve 95, thereby causing the second check valve 95 to close.

Preferably, but optionally, the valve head 13 also has a third passageway 99 formed in it that extends from the first passageway 17 at a position upstream of the first check valve 21 to the second passageway 51 downstream of the second check valve 95, and a bypass valve 101 positioned in the valve head 13 that has a portion 103 that when extended into the third passageway 99 blocks flow of fluid through the third passageway 99 and that when withdrawn from the third passageway 99 opens the third passageway 99 to permit

fluid to flow through the third passageway 99. Referring to FIGS. 2, 5, 7, and 8, preferably, the third passageway 99 extends from the first passageway 17 at a position 17a located at the second end portion of the first end member 13a of the valve head 13 into the second end member 13b. The bypass valve 101 preferably includes a shaft 105 having a first end portion 107, a second end portion that fauns the portion 103 of the bypass valve 101, and threading 109 on a portion of the shaft's length. A thread engaging member 111, such as a pin, a nubbin disc, or the like (a nubbin disc being shown in the drawings preferably secured to the valve head 13 in a recess 113 in the first end portion of the first end member 13a) is provided to engage the threading 109 of the shaft 105, and a handle 115 is mounted on the first end portion 107 of the shaft 105 for rotating the shaft 105 in a first direction to move the second end portion 103 of the shaft 105 from the third passageway 99 to permit flow of fluid through the third passageway 99 and for rotating the shaft 105 in a direction opposite to the first direction to move the second end portion 103 of the shaft 105 into the third passageway 99 to block flow of fluid through the third passageway 99. The bypass valve 101 preferably is positioned in a bore 116 that extends through the first end member 13a of the valve head 13 and into engagement with the third passageway 99 formed in the valve head 13. A first o-ring 117, positioned in an annular groove 119 that extends around the shaft 105, is provided to seal between the shaft 105 and the wall that forms the bore 116 to prevent the fluid from escaping from the valve head 13 through the bore 116. A second o-ring 121, positioned in an annular groove 123 that extends around the shaft 105 in its end portion 103, is provided to seal between the shaft 105 and the wall that forms the third passageway 99 when the portion 103 is positioned in the third passageway 99 to prevent fluid from flowing in the third passageway 99 past the portion 103.

The third passageway 99 continues beyond the location of the bypass valve 101 along a groove 125 (FIGS. 5 and 7) formed in the second end portion of the first end member 13a of the valve head 13 that leads to the second passageway 51 in the valve head 13 downstream of the second check valve 95. A groove 127 (FIG. 7) also is formed in the second end portion of the first end member 13a of the valve head 13 that surrounds the groove 125, and an o-ring 129 is received in the groove 127 to seal between the second end portion of the first end member 13a and the first end portion of the second end member 13b around the groove 125 and to seal between the second end portion of the first end member 13a and the first end portion of the second end member 13b around the second passageway 51 along where the groove 125 intersects the passageway 51.

A groove 131 (FIG. 7) also is formed in the second end portion of the first end member 13a of the valve head 13 that receives an o-ring 133 that seals the first passageway 17 between the first end member 13a and the second end member 13b.

Referring to FIGS. 6 and 1, optionally, but preferably, the valve head 13 also has a fourth passageway 139 extending through it, and an automatic venting/vacuum breaking device 141 positioned therein for venting air contained in the apparatus 11 and for breaking any unwanted vacuum formed in the apparatus 11. The fourth passageway 139 has an inlet port 139a and an outlet port 139b. A groove 135 is fanned in the second end portion of the first end member 13a of the valve head 13 that receives an o-ring 137 that seals the fourth passageway 139 between the first end member 13a and the second end member 13b. The automatic venting/vacuum breaking device 141 includes a vent sleeve 143

positioned in a chamber 145 formed along the fourth passageway 139. Vent sleeve 143 has a cylindrical wall 147 having an inwardly extending flange or ledge 149 formed at the downstream end portion of the vent sleeve 143, and a plurality of cutouts 151 (two being used in the embodiments of the invention shown in the drawings) formed in the wall 147 extending from the downstream end portion of the vent sleeve 143 toward the upstream end portion of the vent sleeve 143. The ledge 149 of the vent sleeve 143 has an upstream end portion 149a and a downstream end portion 149b, and each such end portion 149a and 149b preferably is chamfered. An o-ring 153 is positioned immediately downstream of the downstream end portion 149b of the ledge 149 and is blocked by the downstream end portions 149b of the ledge 149 from falling into the chamber 143. A ball 155 preferably having a density slightly greater than the density of the fluid (e.g., if water is the fluid, a preferred specific gravity for the ball 155 is about 1.1) is positioned in the vent sleeve 143 and permits venting of air contained in the apparatus 11 and breaking of any unwanted vacuum in the apparatus 11 until the fluid pushes the ball 155 into engagement with a portion of the o-ring 153 creating a seal between the ball 155 and the o-ring 153 and the o-ring 153 and the wall of the fourth passageway 139, thereby closing the fourth passageway 139. The diameter of the passageway 139 at chamber 145, the diameter of the cylindrical vent sleeve 143, and the diameter of the ball 155 are greater than the diameter of the passageway 139 upstream of the chamber 145.

A screen 152, positioned in a recess 154 formed in the first end portion of the first end member 13a and held therein by the cover plate 235 positioned thereover, and a screen 156, positioned in the chamber 145 upstream of the vent sleeve 143, are provided to reject possible interfering debris or particulates.

Referring to FIG. 4, the pressure vessel 15 includes a cover 159 having a top wall 161 and a side wall 163, which has a lower end portion on which a cover rim 165 is formed. The pressure vessel 15 also includes a bowl 167 having a bottom wall 169 and a side wall 171, which has an upper end portion on which a bowl rim 173 is formed.

In the embodiments of the invention illustrated in the drawings, the means for filtering and/or conditioning and/or purifying a fluid comprises a cartridge 16. As shown in FIG. 4, preferably, the cartridge 16 comprises a cylindrical micro-filtration matrix 177 for filtering and/or conditioning and/or purifying a fluid passing through it. The matrix 177 has a cylindrical channel 179 along its center axis that receives the fluid after it has passed through the matrix 177, the channel 179 comprising part of the second passageway 47 of the pressure vessel 15. An end cap 181 is secured to the bottom end of the matrix 177, and an end cap 183 is secured to the top end of the matrix 177. To secure the cartridge 16 inside the pressure vessel 15, the bowl 167 is provided with a stabilizing stub 175 formed in the bottom wall 169 of the bowl 167 that receives a recess 185 formed in the end cap 181 to prevent the cartridge 16 from swaying back and forth inside the pressure vessel 15 during use.

Referring to FIGS. 4, 12, 13, and 14, the end cap 183 comprises a hollow tube 187 having a first end portion 189, a second end portion 191, and a passageway 193 extending through the tube 187 from the first end portion 189 (where it receives fluid from the channel 179) to the second end portion 191, the passageway 193 also comprising part of the second passageway 47 of the pressure vessel 15. The tube 187 has an exterior surface portion 195 onto which is integrally formed therewith a flange portion 197 that

engages the top end of the matrix 177. The tube 187 has an annular groove 199 formed at its second end portion 191 that receives an o-ring 201 for sealing between the tube 187 and the hollow cylindrical inlet port 55 to the second passageway 51 in the valve head 13 (thereby establishing a sealed connection between the outlet port 49 of the pressure vessel 15 and the inlet port 55 to the second passageway 51 in the valve head 13) when the pressure vessel 15 is connected to the valve head 13. Preferably, the second end portion 191 of the tube 187 is provided with an antimicrobial surface, such as by impregnating the second end portion 191 with antimicrobial materials such as those sold by AgION Technologies, Inc., of Wakefield, Mass.

The tube 187 also has another annular groove 203 formed in the second end portion 191 that receives a plurality of fingers or projections 205 (four fingers 205 being used in the embodiments of the invention shown in the drawings) integrally formed with the neck 59 and extending inwardly from the wall 59a of the neck 59 for positioning the tube 187 so that it extends along the central axis of the neck 59 and secures the cartridge 16 against both horizontal and vertical movement in the pressure vessel 15. Also, projections or lugs 207 are provided in the top wall 161 of the cover 159 which abut against the flange portion 197 of the end cap 183 to secure the cartridge 16 against vertical movement in the pressure vessel 15.

The groove 203 also receives the center portion of a flexible disc 209, that extends outwardly from the tube 187 and engages a portion of the neck 59 formed in the cover 159 to form a flapper valve 211 across the first passageway 45 of the pressure vessel 15. When fluid is flowing from upstream to downstream in the first passageway 45 of the pressure vessel 15, the fluid pushes against the flexible disc 209 causing it to flex in the downstream direction away from the neck wall 59a to open the first passageway 45 to permit fluid to flow into the pressure vessel 15. The flapper valve 211 prevents backflow of fluid from the first passageway 45 of the pressure vessel 15, because any flow of fluid back flowing from downstream to upstream in the first passageway 45 of the pressure vessel 15 pushes against the flexible disc 209 causing it to flex into engagement with the neck wall 59a formed in the cover 159 to close the flapper valve 211, thereby blocking backflow of fluid from the first passageway 45 of the pressure vessel 15.

Preferably, a compressible column 213, such as one made of a polyfoam material and preferably one comprising a polyfoam sealed compressible core column, is mounted in the pressure vessel 15, preferably by bonding the end portion of the column 213 in a receptacle 215 of the end cap 181, and the column 213 extends from the receptacle 215 into the channel 179 such that there is still space for fluid to flow through the channel 179 between the matrix 177 and the compressible column 213. The compressible column 213 provides protection against damage to the pressure vessel 15 and/or the matrix 177 if the fluid to be filtered and/or conditioned and/or purified freezes while in the pressure vessel 15, by providing space for the fluid to expand into if the fluid (for example, water) is the type of fluid that expands during freezing. The compressible column 213 also provides protection for the pressure vessel 15 against possible millisecond and microsecond pressure spikes.

Referring again to FIGS. 4, 12, 13, and 14, the tube 187 also has a plurality of fins or flanges 214 (four such fins 214 being used in the embodiments shown in the drawings) formed on its interior surface portion in the first end portion 189 of the tube 187 that extend inwardly into the passageway 193 towards its central axis. Fluid may flow along the

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passageway 193 past the fins 214. Further, the tube 187 is provided with a plurality of cutouts 212 (four such cutouts 212 being used in the embodiments shown in the drawings) made thereon to permit fluid that has been filtered and/or conditioned and/or purified in the pressure vessel 15 to flow into the tube 187 from the channel 179 through the cutouts 212. If the column 213 ever breaks loose from the receptacle 215 and abuts against the first end portion 189 of the tube 187, the fins 214 block the column 213 from entering the tube 187, and the cutouts 212 permit fluid to continue to flow into the tube 187 even if the column 213 abuts against the first end portion 189 of the tube 187.

The tube 187 also is provided with a plurality of ribs 216 (eight such ribs 216 being used in the embodiments shown in the drawings) formed in its first end portion 189 on the exterior surface portion 195 adjacent to the flange portion 197 for engaging the matrix 177 along a portion of the channel 179 extending therethrough and for centering the tube 187 in the channel 179.

The cover 159 and the bowl 167 preferably are made from a polymeric material, and after the cartridge 16 is positioned on the cover 159 and the bowl 167, the cover 159 and the bowl 167 are joined together along their respective rims 165 and 173, preferably by spin welding, to form a sealed seam portion 217.

Preferably, a reinforcement member 219 (FIG. 18) is secured around the pressure vessel 15, preferably around the side walls 163 and 171 of the pressure vessel 15 at and near the seam portion 217 of the pressure vessel 15 for reinforcing the pressure vessel 15, and preferably the seam portion 217 and the side walls 163 and 171 of the pressure vessel 15 at the seam portion 217. For example, the reinforcement member 219 may comprise fibers, such as carbon fibers or fiberglass or aramid fibers (e.g., Kevlar fibers) wrapped around the pressure vessel 15 and held together with epoxy or polyurethane or other binder. The reinforcement member 219 also may comprise reinforcing metal or other clamping device.

Referring to FIGS. 3, 6, and 1, preferably, a mounting bracket 221 is provided for mounting the valve head 13 in place where it is desired to be used. The mounting bracket 221 preferably has a plate 223 that connects to the valve head 13, and a flange portion 225 extending at a right angle from the end portion of the plate 223 having holes 227 extending therethrough that receive screws, threaded bolts, or the like for mounting the bracket 221 to the place where it is desired to use the valve head 13. In the embodiments of the invention shown in the drawings, the plate 223 has a ring-like portion 229 that sits on an annular ledge 231 formed in the outer periphery of the first end portion 233 of the valve head 13, and a cover plate 235, which has openings through the cover plate 235 to permit the shaft portions of the threaded bolts 12, the inlet port 19, the outlet port 53, and the first end portion 107 of the shaft 105 of the bypass valve 101 to pass through, is positioned over the first end portion 233 of the valve head 13 sandwiching the nubbin disc 111 and the ring-like portion 229 of the bracket 221 between the cover plate 235 and the first end portion 233 of the valve head 13. The cover plate 235 is secured by the threaded bolts 12 to the valve head 13. Because the ring-like portion 229 of the bracket 221 sits on the annular ledge 231 formed in the outer periphery of the first end portion 233 of the valve head 13, the valve head 13 may be rotated around its central axis within the ring-like portion 229 of the bracket 221 to facilitate connecting the inlet port 19 to the fluid transmission line and the outlet port 53 to the fluid receiving line.

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Preferably, in addition to a height difference, a color-coded, snap-on ring 237 (FIGS. 1 and 12) is mounted around the outlet port 53 of the valve head 13 for distinguishing the outlet port 53 from the inlet port 19 of the valve head 13, to facilitate correct identification of the outlet port 53 so that the outlet port 53 is the port that is connected to the fluid receiving line.

In use, the pressure vessel 15 may be connected to the valve head 13 by rotating the pressure vessel 15 into the valve head 13 such that, in accordance with the first embodiment of the invention shown in the drawings, the pins 61 mounted on the valve head 13 move along the sloped grooves 57 formed on the neck 59 of the pressure vessel 15, until the pins 61 reach the second end portions 65 of the grooves 57 where the plungers 67 click into corresponding indents 94 indicating that the pressure vessel 15 has been properly connected to the valve head 13.

When the pressure vessel 15 has been connected to the valve head 13, the cam 75 aligned with the pin 79 pushes against the second end portion 83 of the pin 79 moving the pin 79 upstream in the first passageway 17 in the valve head 13, causing the first end portion 81 of the pin 79 to push the valve disc 33 off and substantially away from the valve seat 31 to open the valve 21 to permit fluid to flow through the valve 21 and the first passageway 17.

After flowing through the first passageway 17, the fluid exits the outlet port 41 of the first passageway 17 of the valve head 13 and enters the first passageway 45 formed in the pressure vessel 15 through the inlet port 43, and then moves along the first passageway 45 to the outside of the matrix 177 and then through the matrix 177 to the channel 179 of the second passageway 47 formed in the pressure vessel 15. Next, the fluid flows from the channel 179 into and through the passageway 193 formed in the tube 187, and exits the pressure vessel 15 from the outlet port 49 formed at the end of the tube 187 and enters into the second passageway 51 formed in the valve head 13 through the inlet port 55. Then, the fluid pushes the movable disc 33 of the second check valve 95 off the valve seat 31 of the second check valve 95 and moves it in a downstream direction away from the valve seat 31 of the second valve 95 to permit fluid to flow through the second valve 95 and through the second passageway 51 of the valve head 13 to a fluid receiving line connected to the outlet port 53.

Twisting the pressure vessel 15 off the valve head 13 discontinues flow of fluid through the first passageway 17 since the pin 79 is no longer being pushed by the pressure vessel 15 to lift the valve disc 33 of the valve 21 off the valve seat 31 of the valve 21 and the fluid flowing into the first passageway 17 pushes the valve disc 33 of the valve 21 back onto the valve seat 31 of the valve 21 to close valve 21.

Backflow of fluid from the second passageway 47 of the pressure vessel 13 is blocked by the check valve 95 since such backflow pushes the valve disc 33 of the valve 95 against the valve seat 31 of the valve 95 to close the valve 95.

Air contained in the apparatus 11 may escape through the automatic venting device 141. Such air may move into the fourth passageway 139 from outlet port 41, which may contain air when the pressure vessel 15 is being placed in service, and which may receive air from the passageway 17 of the valve head 13 and from the inlet port 43 of the pressure vessel 15 including air moving into the inlet port 43 from the pressure vessel 15. As fluid begins to flow through apparatus 11, the fluid pushes the air through the fourth passageway 139, around the ball 155 as the air is pushed through the automatic venting device 141, and out the outlet

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port 139b. As air is moved into the chamber 145, a portion of the air moves past the ball 155 by traveling along the cutouts 151. When the air that travels along the cutouts 151 reaches the end of the cutouts 151 and moves inwardly into the vent sleeve 143, the air hits the inwardly extending ledge 149 of the vent sleeve 143, rebounding off the ledge 149 back toward the ball 155 from downstream of the ball 155 to prevent the ball 155 from prematurely abutting against the o-ring 153 to close the fourth passageway 139 until most, if not all, of the air has been vented through the outlet port 139b. Although the preferred density of the ball 155 is slightly greater than the density of the fluid being filtered and/or conditioned and/or purified, the force/pressure of the fluid pushing against the ball 155 causes the ball 155 to be pressed into engagement with the o-ring 153 to close the outlet port 139b after the air has been vented through the outlet port 139b.

When it is desired to sanitize the fluid distribution system (e.g., an aircraft potable water distribution system) that the valve head 13 is connected to, the bypass valve 101 may be opened to permit any sanitizing fluid used to sanitize the fluid distribution system to flow from the fluid distribution system via the fluid transmission line to the valve head 13, through the valve head 13, and then back to the fluid distribution system via the fluid receiving line. The handle 115 of the bypass valve 101 may be turned to cause the second end portion 103 of the shaft 105 to move from the third passageway 99 to permit the sanitizing fluid entering the first passageway 17 to flow from the first passageway 17 into and through the third passageway 99, and then into the second passageway 51 downstream of the second check valve 95, and then back to the fluid distribution system via the fluid receiving line from outlet port 53. The check valve 95 prevents backflow of the sanitizing fluid into the second passageway 51 upstream of the check valve 95.

Preferably, when sanitizing fluid used to sanitize the fluid distribution system is being directed through valve head 13 by opening the bypass valve 101, the pressure vessel 15 is not connected to the valve head 13. With the pressure vessel 15 not connected to the valve head 13, the first check valve 21 is pushed closed by the sanitizing fluid entering the first passageway 17, and the sanitizing fluid flows through the valve head 13 as described above when the second end portion 103 has been removed from the third passageway 99, and then back into the fluid distribution system. However, even if the pressure vessel 15 is connected to the valve head 13 (thereby opening the first check valve 21) when sanitizing fluid is being directed through the valve head 13 by opening the bypass valve 101, a majority of the sanitizing fluid moves through the valve head 13 via the third passageway 99 as described above, rather than past the first check valve 21 to and through pressure vessel 15, and then from the pressure vessel 15 to and through the second passageway 51 of the valve head 13, because there is a substantially greater resistance to flow through the pressure vessel 15 due to the matrix 177 than there is for flow through an opened third passageway 99.

In a preferred embodiment of the invention relating to providing filtered and/or conditioned and/or purified water, especially purified water, from a potable water distribution system of, for example, an aircraft, valve heads 13 are installed locally at various cabin crew readily accessible service locations (service points) within galleys and lavatories of the aircraft, and the potable water distribution system is connected to each of the valve heads 13. Preferably, the valve heads 13 are positioned at or near where the water that is filtered and/or conditioned and/or purified in the pressure

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vessels 15 attached to the valve heads 13 is discharged from the potable water distribution system. With this arrangement, the valve head 13 may be easily accessed to install filtration/purification canisters (e.g., pressure vessels 15 each containing filtration/conditioning/purification means such as a cartridge 16, loose media, or the like) onto the valve heads 13, and to remove filtration/purification canisters (e.g., pressure vessels 15 each containing filtration/conditioning/purification means such as a cartridge 16, loose media, or the like) that have been used and install fresh canisters (e.g., pressure vessels 15 each containing filtration/conditioning/purification means such as a cartridge 16, loose media, or the like) in their place. Also, in contrast to prior art aircraft potable water distribution systems where water is passed through a cluster of more remote or centralized filters/purifiers to remove chlorine, foul tastes, and odors, and then sent along branches or legs of the potable water distribution system to be discharged from the branches or legs for use, possibly becoming contaminated from bacteria growing in the branches or legs, under this preferred embodiment of our invention, the water is filtered and/or conditioned and/or purified at or very near the point where it is discharged from the valve head 13 and actual used, thereby reducing the chances of contamination of the water after it has been filtered and/or conditioned and/or purified due to bacteria growing in the branches or legs or other possible contamination between the remote or centralized filters/purifiers and the point of discharge from the potable water distribution system. Further, when the valve heads 13 dispense water directly into an appliance, such as a coffee maker or hot water generating device for heating water for tea, access that contaminants have to the water after it has been filtered and/or conditioned and/or purified is even further limited.

Turning now to FIGS. 10 and 11, there is shown an alternative embodiment of the invention. In this embodiment of the invention, the valve head 13 described above is mounted in an inverted position to that shown in the first embodiment of the invention to allow fluid to be directed downwardly such that the pressure vessel 15' connected to the valve head 13 extends above rather than below the valve head 13. Pressure vessel 15' is substantially the same as pressure vessel 15 described above, except pressure vessel 15' is oriented neck-side down when connected to the valve head 13 and the pressure vessel 15' is provided with an automatic venting device 239 for venting air and breaking any unwanted vacuum.

The pressure vessel 15' is provided with a third passageway 241 extending through the bottom wall 169 of its bowl 167, and the automatic venting device 239 is positioned in the passageway 241. The automatic venting device 239 has substantially the same structure and operates the same way as the automatic venting device 141 described above. Like the automatic venting device 141, the automatic venting device 239 includes a vent sleeve 143 positioned in a chamber 243 formed along the third passageway 241. The vent sleeve 143 of the automatic venting device 239 has a cylindrical wall 147 having an inwardly extending ledge 149 formed at the downstream end portion of the vent sleeve 143, and a plurality of cutouts 151 (two being used in the vent sleeve 143 illustrated in FIGS. 10 and 11) formed in the wall 147 extending from the downstream end portion of the vent sleeve 143 toward the upstream end portion of the vent sleeve 143. The ledge 149 of the vent sleeve 143 has an upstream end portion 149a and a downstream end portion 149b, and each such end portion 149a and 149b preferably is chamfered. An o-ring 153 is positioned immediately

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downstream of the downstream end portion **149b** of the ledge **149** and is blocked by the downstream end portion **149b** of the ledge **149** from falling upstream into the chamber **243**. A vent seal **245** sits over and against the o-ring **153**, the vent seal **245** having a recess **247** that receives the downstream portion of the o-ring **153** and a central opening **245a** extending through the vent seal **245** through which air from the third passageway **241** vents. The vent seal **245** preferably is provided with tabs **246** which are received by recesses **248** formed in the annular ridge **257** formed in the bowl **167** of the pressure vessel **15'**. A ball **155** preferably having a density slightly greater than the density of the fluid (e.g., if water is the fluid, a preferred specific gravity for the ball **155** is about 1.1) is positioned in the vent sleeve **143** and permits venting of air and breaking of any unwanted vacuum until the fluid pushes the ball **155** into engagement with the o-ring **153** creating a seal between the ball **155** and the o-ring **153** and the o-ring **153** and the vent seal **245**, thereby closing the third passageway **241**.

The diameter of the third passageway **241** at the chamber **243** and the diameters of the cylindrical vent sleeve **143** and the ball **155** of the automatic venting device **239** are greater than the diameter of the third passageway **241** upstream of the chamber **243**.

A screen **156**, positioned in the chamber **243** upstream of the vent sleeve **143** of the automatic venting device **239**, and a screen **152**, positioned in a recess **249** formed in the downstream side end portion of the vent seal **245** and held therein by a vent cap **251** positioned thereover, are provided to reject possible interfering debris or particulates.

An o-ring **253** sits around an annular ridge **255** formed in the downstream side of the vent seal **245** to seal between the vent seal **245** and the annular ridge **257** formed in the bowl **167** of the pressure vessel **15'** that defines the outlet port **259** of the third passageway **241**.

The vent cap **251**, which has a central opening **251a** extending there through through which air from the third passageway **241** vents, is secured over the annular ridge **257** securing the screen **152** in the recess **249** of the vent seal **245**, as well as securing the automatic venting device **239** in place in the third passageway **241**.

The second embodiment of the invention facilitates providing fluid that has been filtered and/or conditioned and/or purified directly to a device in which the fluid is to be used, rather than providing the fluid to an intermediate location before it is subsequently transferred to the device in which the fluid is to be used. For example, if the fluid that is being filtered and/or conditioned and/or purified is water, rather than connecting the outlet port **53** of the valve head **13** to a water receiving line that leads to a water faucet in the galley of an airplane, drawing water from the faucet into a container, and pouring the water from the container into an apparatus, such as a coffee maker, that uses the water, the outlet port **53** may be connected directly down onto the coffee maker. Accordingly, with this setup, there is less of a chance that the water, which has been filtered and/or conditioned and/or purified by moving through the matrix **177**, becomes contaminated from coming into contact with contaminants like bacteria after leaving the outlet port **53**.

Turning now to FIGS. **15** and **16**, there is shown an alternative embodiment of the bypass valve of the invention. Rather than using bypass valve **101** described above, a bypass valve **261** may be used. Like the bypass valve **101**, the bypass valve **261** is positioned in the valve head **13** along the third passageway **99**. The bypass valve **261** has a shaft **263** having a first end portion **265** and a second end portion **267**. A sealing member **269**, preferably an o-ring, is mounted

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on the first end portion **265** of the shaft **263** for sealing between the shaft **263** and a portion of the wall **271** of the third passageway **99** to sealing close the third passageway **99** when the first end portion **265** of the shaft **263** is positioned in the third passageway **99** such that the sealing member **269** is in sealing engagement with the third passageway wall **271**. The bypass valve **261** has a biasing member **273**, which preferably comprises a spring mounted around the shaft **263**, for pushing the shaft **263** into the position shown in FIG. **15** that closes the third passageway **99**. A handle **275** is pivotally mounted on the second end portion **267** of the shaft **263** and has a cam **277** formed thereon. When the handle **275** is positioned in a first position shown in FIG. **15**, the biasing member **273** pushes the shaft **263** into a position that closes the third passageway. When the handle **275** is positioned in a second position, as shown in FIG. **16**, by pivoting the handle **275** on its cam **277**, the first end portion **265** of the shaft **263** is pulled into a position that opens the third passageway **99** by withdrawing the first end portion **265** of the shaft **263** from a blocking position in the third passageway **99**, thereby permitting fluid to flow through the passageway **99**.

The bypass valve **261** preferably is positioned in a bore **279** that extends through the first end member **13a** of the valve head **13** and into engagement with the third passageway **99** formed in the valve head **13**. An o-ring **283** is provided in an annular groove **285** that extends around the shaft **263** to seal between the shaft **263** and the wall **281** that forms the bore **279** to prevent fluid from escaping from the valve head **13** through the bore **279**. To retain the bypass valve **261** within the bore **279**, a plate **287**, which has a first end portion **287a**, a second end portion **287b**, and an opening extending therethrough which the second end portion **267** of the shaft **263** extends, is positioned in the recess **113**, and cover plate **235** is secured over the peripheral edge portion of the second end portion **287b** of the plate **287**. The first end portion **287a** of the plate **287** projects into the opening in the cover plate **235** to provide a surface against which the handle **275** may be rotated on its cam **277**.

Preferably, an end cap **291** is provided, to be secured onto the valve head **13** when a pressure vessel **15** is not secured to the valve head **13** to maintain a sanitary condition inside the valve head by blocking dirt, debris, or other contaminants from having easy access to the second end portion **71** of the valve head **13**, including the outlet port **41** from the first passageway **17** of the valve head **13** and the inlet port **55** to the second passageway **51** of the valve head **13**. As shown in FIG. **17**, preferably, the end cap **291** has a solid body **293** having a neck portion **295** formed on its first end portion for connecting the cap **291** onto the valve head **13** and four flanges **297** formed on its second end portion to facilitate gripping of the end cap **291** when rotating the end cap **291** into position on the valve head **13** and when rotating end cap **291** off of the valve head **13**. Like the neck **59** of the pressure vessel **15**, the neck portion **295** has three grooves **57** that receive the pins **61** of the valve head **13** when the end cap **291** is screwed onto the valve head **13**. Alternatively, these grooves **57** and pins **61** may be replaced with threads formed on the outer surface of the neck portion **295** and matching threads formed on the valve head **13**. The neck portion **295** also is provided with an annular recess **298** that defines a cylindrical column **299** that is received in the inlet port **55** of the second passageway **51** when the end cap **291** is secured onto the valve head **13**. The cylindrical column **299** is provided with an annular groove **301** that extends around the column **299**, and an o-ring **303** is positioned in the groove **301** for sealing between the column **299** and the

inlet port **55** when the end cap **291** is secured onto the valve head **13**. Also, an annular groove **305** is provided around the neck portion **295**, and an o-ring **307** sits in the annular groove **305** for sealing between the neck portion **295** and the second end portion of the valve head **13**. A further application of the end cap **291** is to block the flow of fluid from the first passageway **17** in the valve head **13** if it is desired to do so, such as in the event that the first check valve **21** is damaged or otherwise malfunctioning and does not close when the pressure vessel **15** is removed from the valve head **13**.

Under the invention, water may be filtered and/or conditioned and/or purified at the point of use of the filtered and/or conditioned and/or purified water and at the time of use of the filtered and/or conditioned and/or purified water, significantly reducing chances of the filtered and/or conditioned and/or purified water becoming contaminated before it is used.

In addition to its applicability to aircraft potable water distribution systems, the invention may be applied in drinking water systems of recreational boats and yachts, commercial boats, recreational vehicles/caravans, residential homes, and water vending, cooling, warming and dispensing machines (such as those used in hospitals, schools, homes and factories). The invention also maybe applied to water systems in dental offices and laboratories.

The invention provides exceptional effectiveness (regarding water treatment results and cost effectiveness) and flexibility, and often weight reduction for aircraft and other uses with respect to providing filtered and/or conditioned and/or purified water. The apparatus **11** of the invention is easy to operate, requires little maintenance, and is dependable.

The apparatus **11** is very compact, light weight, long lasting, easily refurbished for extra-long service and embodies a slim-line design.

The filtration/purification canister (e.g., pressure vessel **15** containing filtration/conditioning/purification means such as a cartridge **16**, loose media, or the like) may be provided with a light-weight composite construction. Due to its size/structure, the filtration/purification canister holds approximately 50% less unusable "transition water" (water retained in the canister necessary for the canister to function optimally) than prior art filters/purifiers, thereby making more of the water in the water distribution system available for use.

The invention provides point of use and time of use advantages. For instance, in an aircraft, the invention provides a potable water distribution system having valve heads **13** installed locally at various cabin crew readily accessible service locations or service points within galleys and lavatories of the aircraft, preferably at or near where water that is filtered and/or conditioned and/or purified is discharged from the potable water distribution system. Further, the invention provides for directly connecting the outlet port **53** of the valve head **13** to an appliance such as a coffee maker used in the aircraft galley, which reduces possible exposure of the filtered and/or conditioned and/or purified water to contaminants that may be encountered if such water were to be indirectly brought from the outlet port **53** of the valve head **13** to the appliance instead.

The invention provides for positioning the apparatus **11** of the invention in convenient, easily accessible locations. For instance, with respect to an aircraft water distribution system, in contrast to the prior art, the apparatuses are provided at various cabin crew readily accessible service locations in the galleys and lavatories of the aircraft at or near where

water that is to be filtered and/or conditioned and/or purified is to be discharged from the potable water distribution system.

The cartridge **16** may be obtained from General Ecology, Inc., of Exton, Pa., and may be configured to provide what the user desires for optimum service related to the application. For instance, the cartridge **16** may be configured to provide microbiological purification as independently certified to now current EPA Protocol for Microbiological Purifiers, or to provide scale control and taste and odor removal, or to provide taste and odor removal along with larger pathogen removal, etc.

In accordance with the invention, antimicrobial surfaces may be provided to various components of the apparatus **11**, such as to the tube **187**, to assist in preventing backwards directed growth of bacteria, mildew and fungus into the canister, especially during short term periods of open non-use.

Backflow prevention provided in the valve head **13** prevents spillage from the valve head **13** when the canister is removed from the valve head **13**. Further, this backflow prevention prevents reverse water flow into the purified/filtered water side of the canister.

The valve **211**, which preferably is made from a flexible elastomeric material, helps prevent backflow from the canister, thereby limiting spillage when the canister is removed from the valve head **13**.

Due to the two-piece construction of the body (first end member **13a** and second end member **13b**) of the valve head **13** and the simple means of holding the valve head **13** together, the valve head **13** may be easily disassembled and inexpensively refurbished for exceptionally long life using readily available hand tools, if necessary, with common replacement components to replace items such as o-rings, check valves, etc. Accordingly, the valve head **13** of the invention is long lasting.

The apparatus **11** of the invention is provided with an automatically venting feature for venting air and breaking vacuum in the apparatus **11**.

In addition to being capable of being mounted such that the canister is positioned on the valve head **13** below the valve head **13**, the valve head **13** may be mounted in an inverted position such that the outlet port **53** of the valve head **13** points downwardly to facilitate direct feed into appliances, such as coffee makers.

The apparatus **11** of the invention provides for exceptionally quick and easy one-handed canister changes by non-technical, untrained personnel.

Canisters (e.g., pressure vessels **15** each containing filtration/conditioning/purification means such as a cartridge **16**, loose media, or the like) are disposable and can be completely incinerated. The pressure vessel **15** of the canister provides a barrier against contact with the internal, contaminated section of a used canister when it is being removed from the valve head and discarded.

The apparatus **11** is provided with an automatic valving features, which discontinues flow from the outlet port **41** of the valve head **13** when the canister is disconnected from the valve head **13**, and that activates flow of fluid (e.g., water) through the valve head **13** into the canister when the canister is connected to the valve head **13**.

A simple quarter turn of the manual bypass valve of the invention facilitates periodic overall sanitizing processes of the distribution system without removing canisters. The invention permits manual bypass with or without a canister in place on the valve head **13**. Also, an individual apparatus **11** of a series of apparatuses **11** may be bypassed, if desired

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(such as when the individual apparatus **11** leads to a fluid receiving line that is leaking), by simply activating the bypass valve allowing continuing operation of the remainder of the water distribution system.

The canisters are protected from breaking if freezing occurs by the compressible column **213**. Accordingly, draining of the canisters is not necessary if freezing temperatures exist. Further, the canisters function normally after thawing.

The canisters are heat resistant up to a survival temperature of 185° F. for two hours.

The bayonet-style canister mount with its “capture” positions provides tactile feedback via the spring plungers **67** that engage indents **94** formed in the neck **59** of the canister when the canister is properly seated on the valve head **13**. The first check valves **21** is not activated (pushed into an open position) until the canister in proper position on the valve head **13**.

Canisters (e.g., pressure vessels **15** each containing filtration/conditioning/purification means such as a cartridge **16**, loose media, or the like) of the invention are ready to use immediately after being installed with normally minimal purge of water to expel air and small amounts of residual manufacturing materials.

The end cap **291**, an optional feature, is available to protect the water distribution system from contaminants and debris when a canister is not installed on a valve head **13**. The end cap **291** also provides a means to shut down a particular valve head **13** that it is connected to, while allowing uninterrupted use of the remainder of the water distribution system. It is NOT necessary to use the end cap **291** for disinfecting the system—the bypass valve is sufficient to avoid damaging the canister.

The valve head **13** may be rotated throughout 360° to accommodate installation constraints, and the valve head **13** may be installed with the valve head **13** being positioned above or below the canister.

Because the invention provides for easy, quick, and cost effective replacement of the filtration/purification canisters (pressure vessels **15** each containing a cartridge **16**) onto the valve heads **13**, preferably, the filtration/purification canisters (pressure vessels **15** each containing a cartridge **16**) may be removed from the valve heads **13** and replaced with new filtration/purification canisters (pressure vessels **15** each containing a cartridge **16**) before each flight of the aircraft or before the first flight of the day for the aircraft, to avoid using a contaminated or spent filtration/purification canisters (pressure vessels **15** each containing a cartridge **16**). In contrast, due to the cost and difficulty of changing filtration/purification canisters in prior art systems, changes of filtration/purification canisters in prior art systems are not typically done more often than every 90 days or so by a maintenance crew.

The invention claimed is:

1. A pressure vessel for filtering and/or conditioning and/or purifying a fluid, comprising
  - a housing,
  - means positioned in the pressure vessel for filtering and/or conditioning and/or purifying the fluid,
  - the pressure vessel including an inlet port for passage of fluid into the pressure vessel,
  - the pressure vessel including a first passageway of the pressure vessel extending from the inlet port to the means for filtering and/or conditioning and/or purifying the fluid,
  - the pressure vessel including an outlet port for passage of fluid from the pressure vessel,

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the pressure vessel including a second passageway of the pressure vessel extending from the means for filtering and/or conditioning and/or purifying the fluid to the outlet port, and

the pressure vessel including a compressible member mounted in the pressure vessel and positioned within a bore located within and substantially surrounded by the means for filtering and/or conditioning and/or purifying the fluid for accommodating possible expansion of the fluid,

the bore having a center axis,

the compressible member protecting against damage to the pressure vessel and/or the means for filtering and/or conditioning and/or purifying the fluid caused by freezing if the fluid freezes and expands in the pressure vessel and for mitigating possible millisecond and/or microsecond pressure spikes by providing space for fluid to expand into, the fluid expanding into and compressing the compressible member as the fluid freezes,

the compressible member having an outer surface facing radially outwardly away from the center axis of the bore toward the means for filtering and/or conditioning and/or purifying the fluid surrounding it, and

the entire outer surface of the compressible member that faces radially outwardly away from the center axis of the bore toward the means for filtering and/or conditioning and/or purifying the fluid being spaced out of contact with the means for filtering and/or conditioning and/or purifying the fluid when the compressible member is mounted in the pressure vessel, and

the outlet port of the pressure vessel including a tube having a first end portion, a second end portion, and a passageway extending through the tube from the first end portion of the tube to the second end portion of the tube through which fluid that has been filtered and/or conditioned and/or purified moves to exit the pressure vessel,

the tube having an interior surface portion,

the tube having a plurality of fins formed in the interior surface portion of the tube at the first end portion of the tube, the fins extending inwardly into the passageway of the tube and being oriented to extend parallel to a center axis of the tube for blocking the compressible member from entering the tube and plugging the passageway extending therethrough if the compressible member inadvertently breaks loose from where it is mounted in the pressure vessel, and

the tube at its first end portion having a plurality of cutouts made therein to permit flow of fluid that has been filtered and/or conditioned and/or purified in the pressure vessel to continue to enter the tube if the compressible member breaks loose from where it is mounted in the pressure vessel and abuts against the first end of the tube.

2. The pressure vessel of claim 1,

the tube of the outlet port of the pressure vessel being stationarily fixed in place within the pressure vessel, the tube having an exterior surface portion, and the exterior surface portion having an annular groove formed therein,

the pressure vessel further including

a flapper valve for reducing possible backflow of fluid from the inlet port of the pressure vessel,

the flapper valve comprising a flexible disc mounted on the tube in the annular groove formed on the tube, the



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flexible disc having a central opening formed therein through which the tube extends,  
the flapper valve having means for mounting the flexible disc at its central opening to the tube in the annular groove formed on the tube to stationarily fix the disc at its central opening in place on the tube and prevent the disc at its central opening from changing its position in the pressure vessel,  
the flexible disc extending radially outwardly from the tube across the first passageway of the pressure vessel, the flexible disc throughout being at substantially an equal height of that of the annular groove in which the flexible disc is mounted,  
the flexible disc flexing in a first direction to open the first passageway of the pressure vessel when pushed by inbound fluid entering the pressure vessel to permit inbound flow of fluid to pass it as inbound fluid flows through the first passageway of the pressure vessel, and the flexible disc flexing in a second direction to abut against a portion of an interior wall of the pressure vessel along the first passageway of the pressure vessel to close the first passageway of the pressure vessel when pushed by a back flow of fluid from the pressure vessel along the first passageway of the pressure vessel.

3. The pressure vessel of claim 1,  
the compressible member being a polyfoam material.

4. A pressure vessel for filtering and/or conditioning and/or purifying a fluid, comprising  
a housing,  
means positioned in the pressure vessel for filtering and/or conditioning and/or purifying the fluid,  
the pressure vessel including an inlet port for passage of fluid into the pressure vessel,  
the pressure vessel including a first passageway of the pressure vessel extending from the inlet port to the means for filtering and/or conditioning and/or purifying the fluid,  
the pressure vessel including an outlet port for passage of fluid from the pressure vessel,  
the pressure vessel including a second passageway of the pressure vessel extending from the means for filtering and/or conditioning and/or purifying the fluid to the outlet port,  
the housing comprising a cover and a bowl,  
the cover having a top wall, a side wall extending downwardly from the top wall, the side wall of the cover having a lower end portion, and a cover rim formed on the lower end portion of the side wall of the cover,  
the bowl having a bottom wall, a side wall extending upwardly from the bottom wall, the side wall of the bowl having an upper end portion, and a bowl rim formed on the upper end portion of the side wall of the bowl, and  
the cover rim and the bowl rim being joined together to form a sealed seam portion of the pressure vessel, and further including  
a reinforcement member secured around the side wall of the cover and the side wall of the bowl at and near the seam portion of the pressure vessel for reinforcing the pressure vessel,  
the reinforcement member comprising carbon fibers or fiberglass fibers or aramid fibers wrapped around the pressure vessel and held together with a binder.

5. The pressure vessel of claim 4,  
the binder being epoxy or polyurethane.

6. A pressure vessel for filtering and/or conditioning and/or purifying a fluid, comprising

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a cover having a top wall, a side wall extending downwardly from the top wall, the side wall of the cover having a lower end portion, and a cover rim formed on the lower end portion of the side wall of the cover,  
a bowl having a bottom wall, a side wall extending upwardly from the bottom wall, the side wall of the bowl having an upper end portion, and a bowl rim formed on the upper end portion of the side wall of the bowl,  
the cover rim and the bowl rim being joined together to form a sealed seam portion of the pressure vessel,  
means positioned in the pressure vessel for filtering and/or conditioning and/or purifying the fluid,  
a compressible column mounted in the pressure vessel, the compressible column protecting against damage to the pressure vessel and/or the means for filtering and/or conditioning and/or purifying the fluid caused by freezing if the fluid freezes and expands in the pressure vessel and for mitigating possible millisecond and/or microsecond pressure spikes by providing space, for fluid to expand into,  
the bottom wall of the bowl having a passageway extending therethrough for venting purposes, the passageway being defined by a wall, and  
an automatic venting/vacuum breaking device positioned in the passageway for automatically venting air and for breaking any unwanted vacuum,  
the automatic venting/vacuum breaking device including a vent sleeve positioned in a chamber formed in the passageway, the vent sleeve having a downstream end portion and an upstream end portion, the vent sleeve having a cylindrical wall having an annular inwardly extending ledge formed at the downstream end portion of the vent sleeve, the vent sleeve having a plurality of cutouts in its cylindrical wall extending from the upstream end portion of the vent sleeve toward the downstream end portion of the vent sleeve, the ledge having an upstream side and a downstream side,  
means positioned downstream of the ledge for creating a valve seat and means positioned downstream of the ledge for sealing between the valve seat and the wall of the passageway, and  
a ball having a density slightly greater than the density of the fluid being filtered and/or conditioned and/or purified, the ball being positioned in the vent sleeve,  
the venting/vacuum breaking device remaining in an open position until the ball is pushed by the fluid into engagement with the valve seat to close the passageway.

7. A pressure vessel for filtering and/or conditioning and/or purifying a fluid, comprising  
a cover having a top wall, a side wall extending downwardly from the top wall, the side wall of the cover having a lower end portion, and a cover rim formed on the lower end portion of the side wall of the cover,  
a bowl having a bottom wall, a side wall extending upwardly from the bottom wall, the side wall of the bowl having an upper end portion, and a bowl rim formed on the upper end portion of the side wall of the bowl,  
the cover rim and the bowl rim being joined together to form a sealed seam portion of the pressure vessel,  
means positioned in the pressure vessel for filtering and/or conditioning and/or purifying the fluid, and  
the bottom wall of the bowl having a passageway extending therethrough for venting purposes, the passageway being defined by a wall,

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an automatic venting/vacuum breaking device positioned in the passageway for automatically venting air and for breaking any unwanted vacuum,

the automatic venting/vacuum breaking device including a vent sleeve positioned in a chamber formed in the passageway, the vent sleeve having a downstream end portion and an upstream end portion, the vent sleeve having a cylindrical wall having an annular inwardly extending ledge formed at the downstream end portion of the vent sleeve, the vent sleeve having a plurality of cutouts in its cylindrical wall extending from the upstream end portion of the vent sleeve toward the downstream end portion of the vent sleeve, the ledge having an upstream side and a downstream side, means positioned downstream of the ledge for creating a valve seat and means positioned downstream of the ledge for sealing between the valve seat and the wall of the passageway, and

a ball having a density slightly greater than the density of the fluid being filtered and/or conditioned and/or purified, the ball being positioned in the vent sleeve, the venting device/vacuum breaking device remaining in an open position until the ball is pushed by the fluid into engagement with the valve seat to close the passageway.

8. The pressure vessel of claim 7, further including air directing means formed in the vent sleeve for directing air being vented past the ball and then back toward the ball to prevent the ball from prematurely abutting against the valve seat until most, if not all, of the air has been vented.

9. The pressure vessel of claim 8, the air directing means including a plurality of cutouts formed in the vent sleeve and extending from the upstream end portion of the vent sleeve toward the downstream end portion of the vent sleeve which direct air to move along past the ball, and an annular inwardly extending ledge formed on the downstream end portion of the vent sleeve which directs air that has moved past the ball to rebound off back toward the ball.

10. A pressure vessel for filtering and/or conditioning and/or purifying a fluid, comprising

a housing,

means positioned in the pressure vessel for filtering and/or conditioning and/or purifying the fluid,

the pressure vessel including an inlet port for passage of fluid into the pressure vessel,

the pressure vessel including a first passageway of the pressure vessel extending from the inlet port to the means for filtering and/or conditioning and/or purifying the fluid,

the pressure vessel including an outlet port for passage of fluid from the pressure vessel,

the pressure vessel including a second passageway of the pressure vessel extending from the means for filtering and/or conditioning and/or purifying the fluid to the outlet port, and

the pressure vessel including a compressible member mounted in the pressure vessel and positioned within a bore located within and substantially surrounded by the means for filtering and/or conditioning and/or purifying the fluid for accommodating possible expansion of the fluid,

the bore having a center axis,

the compressible member protecting against damage to the pressure vessel and/or the means for filtering and/or

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conditioning and/or purifying the fluid caused by freezing if the fluid freezes and expands in the pressure vessel and for mitigating possible millisecond and/or microsecond pressure spikes by providing space for fluid to expand into, the fluid expanding into and compressing the compressible member as the fluid freezes,

the compressible member having an outer surface facing outwardly away from the center axis of the bore toward the means for filtering and/or conditioning and/or purifying the fluid surrounding it, and

a majority of the outer surface of the compressible member that faces radially outwardly away from the center axis of the bore toward the means for filtering and/or conditioning and/or purifying the fluid being spaced out of contact with the means for filtering and/or conditioning and/or purifying the fluid when the compressible member is mounted in the pressure vessel,

the outlet port of the pressure vessel including a tube having a first end portion, a second end portion, and a passageway extending through the tube from a first end of the tube to a second end of the tube through which fluid that has been filtered and/or conditioned and/or purified in the pressure vessel moves to exit the pressure vessel,

the tube having an interior surface portion and an exterior surface portion,

the tube having a plurality of fins formed in the interior surface portion of the tube at the first end portion of the tube, the fins extending inwardly into the passageway of the tube and being oriented to extend parallel to a center axis of the tube for blocking the compressible member from entering the tube and plugging the passageway extending therethrough if the compressible member inadvertently breaks loose from where it is positioned in the pressure vessel, and

the tube at its first end portion having a plurality of cutouts made therein to permit flow of fluid that has been filtered and/or conditioned and/or purified in the pressure vessel to continue to enter the tube if the compressible member breaks loose from where it is positioned in the pressure vessel and abuts against the first end of the tube.

11. The pressure vessel of claim 10, the compressible member being a polyform material.

12. The pressure vessel of claim 10, all of the outer surface of the compressible member that faces radially outwardly away from the center axis of the bore toward the means for filtering and/or conditioning and/or purifying the fluid being spaced out of contact with the means for filtering and/or conditioning and/or purifying the fluid when the compressible member is mounted in the pressure vessel.

13. A pressure vessel for filtering and/or conditioning and/or purifying a fluid, comprising

a housing,

means positioned in the pressure vessel for filtering and/or conditioning and/or purifying the fluid,

the pressure vessel including an inlet port for passage of fluid into the pressure vessel,

the pressure vessel including a first passageway of the pressure vessel extending from the inlet port to the means for filtering and/or conditioning and/or purifying the fluid,

the pressure vessel including an outlet port for passage of fluid from the pressure vessel,

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the pressure vessel including a second passageway of the pressure vessel extending from the means for filtering and/or conditioning and/or purifying the fluid to the outlet port, and

the pressure vessel including a compressible member 5 mounted in the pressure vessel and positioned within a bore located within and substantially surrounded by the means for filtering and/or conditioning and/or purifying the fluid for accommodating possible expansion of the fluid, 10

the bore having a center axis,

the compressible member protecting against damage to the pressure vessel and/or the means for filtering and/or conditioning and/or purifying the fluid caused by freezing if the fluid freezes and expands in the pressure 15 vessel and for mitigating possible millisecond and/or microsecond pressure spikes by providing space for fluid to expand into, the fluid expanding into and compressing the compressible member as the fluid freezes, 20

the compressible member having an outer surface facing radially outwardly away from the center axis of the bore toward the means for filtering and/or conditioning and/or purifying the fluid surrounding it, and

a majority of the outer surface of the compressible mem- 25 ber that faces radially outwardly away from the center axis of the bore toward the means for filtering and/or conditioning and/or purifying the fluid being spaced out of contact with the means for filtering and/or conditioning and/or purifying the fluid when the com- 30 pressible member is mounted in the pressure vessel, the outlet port of the pressure vessel including a tube having a first end portion, a second end portion, and a passageway extending through the tube from the first end portion of the tube to the second end portion 35 of the tube through which fluid that has been filtered and/or conditioned and/or purified moves to exit the pressure vessel,

the tube having an exterior surface portion, and

the exterior surface portion having an annular groove 40 formed therein,

the pressure vessel further including

a flapper valve for reducing possible backflow of fluid from the inlet port of the pressure vessel,

the flapper valve comprising a flexible disc mounted on 45 the tube in the annular groove formed on the tube, the flexible disc having a central opening formed therein through which the tube extends,

the flexible disc extending radially outwardly from the tube across the first passageway of the pressure 50 vessel, the flexible disc throughout being at substantially an equal height of that of the annular groove in which the flexible disc is mounted,

the flexible disc flexing in a first direction to open the first passageway of the pressure vessel when pushed 55 by inbound fluid entering the pressure vessel to permit inbound flow of fluid to pass it as inbound fluid flows through the first passageway of the pressure vessel, and

the flexible disc flexing in a second direction to abut 60 against a portion of an interior wall of the pressure vessel along the first passageway of the pressure vessel to close the first passageway of the pressure vessel when pushed by a back flow of fluid from the pressure vessel along the first passageway of the 65 pressure vessel,

the compressible member being a polyform material,

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the tube having an interior surface portion,

the tube having a plurality of fins formed in the interior surface portion of the tube at the first end portion of the tube, the fins extending inwardly into the passageway of the tube and being oriented to extend parallel to a center axis of the tube for blocking the compressible member from entering the tube and plugging the passageway extending therethrough if the compressible member inadvertently breaks loose from where it is positioned in the pressure vessel, and

the tube at its first end portion having a plurality of cutouts made therein to permit flow of fluid that has been filtered and/or conditioned and/or purified in the pressure vessel to continue to enter the tube if the compressible member breaks loose from where it is positioned in the pressure vessel and abuts against the first end of the tube.

**14.** The pressure vessel of claim 13, all of the outer surface of the compressible member that faces radially outwardly away from the center axis of the bore toward the means for filtering and/or conditioning and/or purifying the fluid being spaced out of contact with the means for filtering and/or conditioning and/or purifying the fluid.

**15.** A pressure vessel for filtering and/or conditioning and/or purifying a fluid, comprising

a housing,

means positioned in the pressure vessel for filtering and/or conditioning and/or purifying the fluid,

the pressure vessel including an inlet port for passage of fluid into the pressure vessel,

the pressure vessel including a first passageway of the pressure vessel extending from the inlet port to the means for filtering and/or conditioning and/or purifying the fluid,

the pressure vessel including an outlet port for passage of fluid from the pressure vessel,

the pressure vessel including a second passageway of the pressure vessel extending from the means for filtering and/or conditioning and/or purifying the fluid to the outlet port, and

the pressure vessel including a compressible member mounted in the pressure vessel and positioned within a bore located within and substantially surrounded by the means for filtering and/or conditioning and/or purifying the fluid for accommodating possible expansion of the fluid,

the bore having a center axis,

the compressible member protecting against damage to the pressure vessel and/or the means for filtering and/or conditioning and/or purifying the fluid caused by freezing if the fluid freezes and expands in the pressure vessel and for mitigating possible millisecond and/or microsecond pressure spikes by providing space for fluid to expand into, the fluid expanding into and compressing the compressible member as the fluid freezes,

the compressible member having an outer surface facing radially outwardly away from the center axis of the bore toward the means for filtering and/or conditioning and/or purifying the fluid surrounding it, and

a majority of the outer surface of the compressible member that faces radially outwardly away from the center axis of the bore toward the means for filtering and/or conditioning and/or purifying the fluid being spaced out of contact with the means for filtering and/or

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conditioning and/or purifying the fluid when the compressible member is mounted in the pressure vessel, the pressure vessel having a third passageway extending through the housing for venting purposes, the third passageway being defined by a wall, and further including

an automatic venting/vacuum breaking device positioned in the third passageway for automatically venting air and for breaking any unwanted vacuum,

the automatic venting/vacuum breaking device including a ball,

a vent sleeve positioned in a chamber formed in the third passageway, the vent sleeve having a downstream end portion and an upstream end portion,

a valve seat positioned at the downstream end portion of the vent sleeve that receives a portion of the ball to close the automatic venting/vacuum breaking device, and

means positioned in the third passageway for sealing between the valve seat and the wall of the third passageway,

the ball having a density slightly greater than the density of the fluid being filtered and/or conditioned and/or purified, the ball being positioned in the vent sleeve, and

the automatic venting/vacuum breaking device remaining in an open position until the ball is pushed by the fluid into engagement with the valve seat to close the third passageway.

**16.** The pressure vessel of claim **15**, further including air directing means formed in the vent sleeve for directing air being vented past the ball and then back toward the ball to prevent the ball from prematurely abutting against the valve seat until most, if not all, of the air has been vented.

**17.** The pressure vessel of claim **16**, the air directing means including

a plurality of cutouts formed in the vent sleeve and extending from the upstream end portion of the vent sleeve toward the downstream end portion of the vent sleeve which direct air to move along past the ball, and

an annular inwardly extending ledge formed on the downstream end portion of the vent sleeve which directs air that has moved past the ball to rebound off back toward the ball.

**18.** The pressure vessel of claim **15**,

the outlet port of the pressure vessel including a tube having a passageway extending through the tube through which fluid that has been filtered and/or conditioned and/or purified moves to exit the pressure vessel,

the tube having an exterior surface portion, and

the exterior surface portion having an annular groove formed therein,

the pressure vessel further including

a flapper valve for reducing possible backflow of fluid from the inlet port of the pressure vessel,

the flapper valve comprising a flexible disc mounted on the tube in the annular groove formed on the tube, the flexible disc having a central opening formed therein through which the tube extends,

the flexible disc extending radially outward from the tube across the first passageway of the pressure vessel, the flexible disc throughout being at substantially the same height of that of the annular groove in which the flexible disc is mounted,

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the flexible disc flexing in a first direction to open the first passageway of the pressure vessel when pushed by inbound fluid entering the pressure vessel to permit inbound flow of fluid to pass it as inbound fluid flows through the first passageway of the pressure vessel, and the flexible disc flexing in a second direction to abut against a portion of an interior wall of the pressure vessel along the first passageway of the pressure vessel to close the first passageway of the pressure vessel when pushed by a back flow of fluid from the pressure vessel along the first passageway of the pressure vessel.

**19.** The pressure vessel of claim **18**, the compressible member being a polyform material,

the tube having a first end portion into which fluid that has been filtered and/or conditioned and/or purified in the pressure vessel moves to exit the pressure vessel,

the tube having an interior surface portion,

the tube having a plurality of fins formed in the interior surface portion of the tube at the first end portion of the tube, the fins extending inwardly into the passageway of the tube and being oriented to extend parallel to a center axis of the tube for blocking the compressible member from entering the tube and plugging the passageway extending therethrough if the compressible member inadvertently breaks loose from where it is positioned in the pressure vessel,

the tube at its first end portion having a plurality of cutouts made therein to permit flow of fluid that has been filtered and/or conditioned and/or purified in the pressure vessel to continue to enter the tube if the compressible member breaks loose from where it is positioned in the pressure vessel and abuts against the first end of the tube, and

air directing means formed in the vent sleeve for directing air being vented past the ball and then back toward the ball to prevent the ball from prematurely abutting against the valve seat until most, if not all, of the air has been vented.

**20.** The pressure vessel of claim **19**, the air direction means including

a plurality of cutouts formed in the vent sleeve and extending from the upstream end portion of the vent sleeve toward the downstream end portion of the vent sleeve which direct air to move along past the ball, and

an annular inwardly extending ledge formed on the downstream end portion of the vent sleeve which directs air that has moved past the ball to rebound off back toward the ball.

**21.** The pressure vessel of claim **20**, the housing comprising

a cover having a top wall, a side wall extending downwardly from the top wall, the side wall of the cover having a lower end portion, and a cover rim formed on the lower end portion of the side wall of the cover, and

a bowl having a bottom wall, a side wall extending upwardly from the bottom wall, the side wall of the bowl having an upper end portion, and a bowl rim formed on the upper end portion of the side wall of the bowl,

the cover rim and the bowl rim being joined together to form a sealed seam portion of the pressure vessel.

**22.** The pressure vessel of claim **15**,

all of the outer surface of the compressible member that faces radially outwardly away from the center axis of the bore toward the means for filtering and/or condi-

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tioning and/or purifying the fluid being spaced out of contact with the means for filtering and/or conditioning and/or purifying the fluid.

**23.** A pressure vessel for filtering and/or conditioning and/or purifying a fluid, comprising 5  
 a housing,  
 means positioned in the pressure vessel for filtering and/or conditioning and/or purifying the fluid,  
 an inlet port for passage of fluid into the pressure vessel,  
 a first passageway extending from the inlet port to the means for filtering and/or conditioning and/or purifying the fluid, 10  
 an outlet port for passage of fluid from the pressure vessel,  
 a second passageway extending from the means for filtering and/or conditioning and/or purifying the fluid to the outlet port, 15  
 a third passageway extending through the housing for venting purposes, the passageway being defined by a wall, and  
 an automatic venting/vacuum breaking device positioned in the third passageway for automatically venting air and for breaking any unwanted vacuum, 20  
 the automatic venting/vacuum breaking device including a ball,  
 a vent sleeve positioned in a chamber formed in the third passageway, the vent sleeve having a downstream end portion and an upstream end portion, 25  
 a valve seat positioned at the downstream end portion of the vent sleeve that receives a portion of the ball to close the automatic venting/vacuum breaking device, 30  
 and  
 means positioned in the third passageway for sealing between the valve seat and the wall of the third passageway,  
 the ball having a density slightly greater than the density of the fluid being filtered and/or conditioned and/or purified, the ball being positioned in the vent sleeve, 35  
 and  
 the automatic venting/vacuum breaking device remaining in an open position until the ball is pushed by the fluid into engagement with the valve seat to close the third passageway. 40

**24.** The pressure vessel of claim **23**, further including air directing means formed in the vent sleeve for directing air being vented past the ball and then back toward the ball to prevent the ball from prematurely abutting against the valve seat until most, if not all, of the air has been vented. 45

**25.** The pressure vessel of claim **24**, the air directing means including 50  
 a plurality of cutouts formed in the vent sleeve and extending from the upstream end portion of the vent sleeve toward the downstream end portion of the vent sleeve which direct air to move along past the ball, and an annular inwardly extending ledge formed on the downstream end portion of the vent sleeve which directs air that has moved past the ball to rebound off back toward the ball. 55

**26.** The pressure vessel of claim **23**, the outlet port of the pressure vessel including a tube having a passageway extending through the tube through which fluid that has been filtered and/or conditioned and/or purified moves to exit the pressure vessel, 60  
 the tube having an exterior surface portion, and  
 the exterior surface portion having an annular groove formed therein, 65

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the pressure vessel further including  
 a flapper valve for reducing possible backflow of fluid from the inlet port of the pressure vessel,  
 the flapper valve comprising a flexible disc mounted on the tube in the annular groove formed on the tube, the flexible disc having a central opening formed therein through which the tube extends,  
 the flexible disc extending radially outwardly from the tube across the first passageway of the pressure vessel, the flexible disc throughout being at substantially an equal height of that of the annular groove in which the flexible disc is mounted,  
 the flexible disc flexing in a first direction to open the first passageway of the pressure vessel when pushed by inbound fluid entering the pressure vessel to permit inbound flow of fluid to pass it as inbound fluid flows through the first passageway of the pressure vessel, and the flexible disc flexing in a second direction to abut against a portion of an interior wall of the pressure vessel along the first passageway of the pressure vessel to close the first passageway of the pressure vessel when pushed by a back flow of fluid from the pressure vessel along the first passageway of the pressure vessel. 65

**27.** The pressure vessel of claim **26**, further including air directing means formed in the vent sleeve for directing air being vented past the ball and then back toward the ball to prevent the ball from prematurely abutting against the valve seat until most, if not all, of the air has been vented.

**28.** The pressure vessel of claim **27**, the air directing means including  
 a plurality of cutouts formed in the vent sleeve and extending from the upstream end portion of the vent sleeve toward the downstream end portion of the vent sleeve which direct air to move along past the ball, and an annular inwardly extending ledge formed on the downstream end portion of the vent sleeve which directs air that has moved past the ball to rebound off back toward the ball.

**29.** A pressure vessel for filtering and/or conditioning and/or purifying a fluid, comprising  
 a housing,  
 means positioned in the pressure vessel for filtering and/or conditioning and/or purifying the fluid,  
 an inlet port for passage of fluid into the pressure vessel,  
 a first passageway extending from the inlet port to the means for filtering and/or conditioning and/or purifying the fluid,  
 an outlet port for passage of fluid from the pressure vessel,  
 a second passageway extending from the means for filtering and/or conditioning and/or purifying the fluid to the outlet port,  
 the outlet port of the pressure vessel including a tube stationarily fixed in place within the pressure vessel, the tube having a passageway extending through the tube through which fluid that has been filtered and/or conditioned and/or purified moves to exit the pressure vessel,  
 the tube having an exterior surface portion, and  
 the exterior surface portion having an annular groove formed therein,  
 the pressure vessel further including  
 a flapper valve for reducing possible backflow of fluid from the inlet port of the pressure vessel,  
 the flapper valve comprising a flexible disc mounted on the tube in the annular groove formed on the tube, the

flexible disc having a central opening formed therein  
through which the tube extends,  
the flapper valve having means for mounting the flexible  
disc at its central opening to the tube in the annular  
groove formed on the tube to stationarily fix the disc at 5  
its central opening in place on the tube and prevent the  
disc at its central opening from changing its position in  
the pressure vessel,  
the flexible disc extending radially outwardly from the  
tube across the first passageway of the pressure vessel, 10  
the flexible disc throughout being at substantially the  
same height of that of the annular groove in which the  
flexible disc is mounted,  
the flexible disc flexing in a first direction to open the first  
passageway of the pressure vessel when pushed by 15  
inbound fluid entering the pressure vessel to permit  
inbound flow of fluid to pass it as inbound fluid flows  
through the first passageway of the pressure vessel, and  
the flexible disc flexing in a second direction to abut  
against a portion of an interior wall of the pressure 20  
vessel along the first passageway of the pressure vessel  
to close the first passageway of the pressure vessel  
when pushed by a back flow of fluid from the pressure  
vessel along the first passageway of the pressure vessel.

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