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(71) Demandeur/Applicant:
SPECIALIZED DESANDERS INC., CA

(72) Inventeurs/Inventors:
HEMSTOCK, CHRISTOPHER A., CA;
KMICK, WARREN, CA

(74) Agent: GOODWIN LAW

(54) Titre : APPAREIL DE DESABLAGE ET SON PROCEDE D'UTILISATION

(54) Title: A DESANDING APPARATUS AND A METHOD OF USING THE SAME

(57) **Abrégé/Abstract:**

An apparatus and method for removing particulates from a multiple-phase fluid stream is disclosed. The apparatus has a vessel enclosed by walls, and the vessel has a fluid inlet interface for receiving said multiple-phase fluid stream, a fluid outlet spacing from the fluid inlet interface for discharging gas phase matter, and a passage, such as a spiral path, in the vessel extending from the fluid inlet interface to the fluid outlet. The length of the passage is longer than the distance between the fluid inlet interface and the fluid outlet.



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ABSTRACT

2 An apparatus and method for removing particulates from a multiple-phase fluid
3 stream is disclosed. The apparatus has a vessel enclosed by walls, and the
4 vessel has a fluid inlet interface for receiving said multiple-phase fluid stream, a
5 fluid outlet spacing from the fluid inlet interface for discharging gas phase matter,
6 and a passage, such as a spiral path, in the vessel extending from the fluid inlet
7 interface to the fluid outlet. The length of the passage is longer than the distance
8 between the fluid inlet interface and the fluid outlet.

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1
2 **AN DESANDING APPARATUS AND A METHOD OF USING THE SAME**
3

4 **FIELD OF THE DISCLOSURE**

5 The present disclosure generally relates to an apparatus and a
6 method for removing particulates from multiphase fluid streams, and in particular,
7 relates to an apparatus and a method for removing sands from multiphase fluid
8 streams produced from an oil or gas well while minimizing the abrasion to the
9 equipment involved.
10

11 **BACKGROUND**

12 Production from wells in the oil and gas industry often contains
13 particulates such as sand. These particulates could be part of the formation from
14 which the hydrocarbon is being produced, introduced from hydraulic fracturing, or
15 fluid loss material from drilling mud or fracturing fluids, or from a phase change of
16 produced hydrocarbons caused by changing conditions at the wellbore (Asphalt
17 or wax formation). As the particulates are produced, problems occur due to
18 abrasion and plugging of production equipment. In a typical startup after
19 stimulating a well by fracturing, the stimulated well may produce sand until the
20 well has stabilized, often lasting for several months after production commences.
21 Other wells may produce sand for a much longer period of time.

22 Erosion of the production equipment is severe enough to cause
23 catastrophic failure. High fluid stream velocities are typical and are even
24 purposefully designed for elutriating particles up the well and to the surface. An
25 erosive failure of this nature can become a serious safety and environmental
26 issue for the well operator. A failure such as a breach of high pressure piping or

1 equipment releases uncontrolled high velocity flow of fluid which is hazardous to
2 service personnel. Releasing such fluid to the environment is damaging to the
3 environment resulting in expensive cleanup and loss of production. Repair costs
4 are also high.

5 In all cases, retention of particulates contaminates surface
6 equipment and the produced fluids and impairs the normal operation of the oil
7 and gas gathering systems and process facilities. Therefore, desanding devices
8 are required for removing sand from the fluid stream. Due to the nature of the
9 gases handled, including pressure and toxicity, all vessels and pressure piping in
10 desanding devices must be manufactured and approved by appropriate boiler
11 and pressure vessel safety authorities.

12 In one existing system, a pressurized tank ("P-Tank") is placed on
13 the wellsite and the well is allowed to produce fluid and particulates. The fluid
14 stream is produced from a wellhead and into a P-Tank until sand production
15 ceases. The large size of the P-Tank usually restricts the maximum operating
16 pressure of the vessel to something in the order of 1,000 – 2,100 kPa. In the
17 case of a gas well, this requires some pressure control to be placed on the well to
18 protect the P-Tank. Further, for a gas well, a pressure reduction usually is
19 associated with an increase in gas velocity which in turn makes sand-laden
20 wellhead effluent much more abrasive and places the pressure controlling choke
21 at risk of failure. Another problem associated with this type of desanding
22 technique is that it is only a temporary solution. If the well continues to make
23 sand, the solution becomes prohibitively expensive. In most situations with this
24 kind of temporary solution, the gas vapors are not conserved and sold as a
25 commercial product.

1 Another known system includes employing filters to remove
2 particulates. A common design is to have a number of fiber-mesh filter bags
3 placed inside a pressure vessel. The density of the filter bag fiber-mesh is
4 matched to the anticipated size of the particulates. Filter bags are generally not
5 effective in the removal of particulates in a multiphase condition. Usually
6 multiphase flow in the oil and gas operations is unstable. Large slugs of fluid
7 followed by a gas mist are common. In these cases, the fiber bags become a
8 cause of pressure drop and often fail due to the liquid flow there through. Due to
9 the high chance of failure, filter bags may not be trusted to remove particulates in
10 critical applications or where the flow parameters of a well are unknown. An
11 additional problem with filter bags in most jurisdictions is the cost associated with
12 disposal. The fiber-mesh filter bags are considered to be contaminated with
13 hydrocarbons and must be disposed of in accordance to local environmental
14 regulation.

15 Hydrocyclone or cyclone devices are also known for separating
16 particles from liquid mixture by exploiting the centripetal force. By injecting the
17 liquid mixture into a vessel and spinning therein, heavy or large particles move
18 outward towards the wall of the vessel due to the centripetal force, and spirally
19 move down to the bottom of the vessel. Light components move towards the
20 center of the vessel and may be discharged via an outlet. However, Hydrocyclone
21 devices have difficulty in separating particulates from effluents with more than
22 two phases, and have an associated pressure drop issue that is undesirable in
23 many oilfield situations.

24 In Canadian Patent Number 2,433,741, issued February 3, 2004,
25 and in Canadian Patent Number 2,407,554, issued June 20, 2006, both assigned

1 to the Applicant of the subject patent application, a desander is disclosed having
2 an elongate, horizontal vessel with an inlet at one end and an outlet at the other
3 end. As shown in Figure 1, the desander 10 comprises a cylindrical pressure
4 vessel 11 having a substantially horizontal axis A, a first fluid inlet end 12
5 adapted for connection to the fluid stream F. The fluid stream F typically
6 comprises a variety of phases including gas G, some liquid L and entrained
7 particulates P such as sand. The fluid stream F containing sand enters through
8 the inlet end 12 and is received by a freeboard portion 13. The freeboard area is
9 set by a downcomer flow barrier, or a weir, 14. Accordingly, the velocity of the
10 fluid stream F slows to a point below the entrainment or elutriation velocity of at
11 least a portion of the particulates P in the fluid stream. Given sufficient horizontal
12 distance without interference, the particulates P eventually fall from the freeboard
13 portion 13. Particulates P and liquids L accumulate over time in the belly portion
14 15, and the desanded fluid stream, typically liquid L and gas G, emanates from
15 fluid outlet 16.

16 The accumulated particulates in the vessel require periodical clean-
17 out at sufficient intervals to ensure that the maximum accumulated depth does
18 not encroach on the fluid outlet 16. However, for larger vessels, manual cleaning
19 becomes difficult and time consuming.

20 While the desanding device disclosed in above Canadian patents
21 has been a great success over the past 11 years or so, improvements are
22 possible. Canadian Patent Application Number 2,799,278, filed on December 19,
23 2012, and assigned to the Applicant of the subject application, discloses a
24 desander device having a tilted vessel to remove the need for a downcomer flow
25 barrier. However, this desander requires the vessel to be depressured to remove

1 sand causing downtime and in some cases a hazard for workers as the effluent
2 can contain toxic substances.

3 Therefore, there always exists the desire of further improving the
4 ease with which the vessel can be cleaned and the desire of further improvement
5 in separation efficiency.

6

7 SUMMARY

8 It is an objective of this disclosure to provide a desanding device for
9 removing particulates from a fluid stream.

10 According to one aspect, a pressurized vessel is provided for
11 receiving a high velocity fluid stream from a field piping extending from a
12 wellhead. The vessel removes particulates from the received fluid stream and
13 discharges the desanded fluid stream to downstream equipment.

14 According to another aspect, this disclosure discloses a vessel for
15 removing at least particulates from a multiple-phase fluid stream containing gas
16 and entrained particulates, the vessel comprising:

17 a fluid inlet interface for receiving said fluid stream and manipulating
18 the fluid along a generally horizontal fluid injection direction into the vessel;

19 a fluid outlet located generally at geometric center of the vessel and
20 spaced laterally from the fluid injection direction;

21 a horizontally extending freeboard interface separating a freeboard
22 portion formed adjacent an upper portion of the vessel above the interface and a
23 accumulator portion therebelow, the freeboard portion forming a freeboard cross-
24 sectional area for a freeboard velocity of the fluid stream less than a fluid stream
25 velocity at the fluid inlet interface; and

1 an internal baffle having an open top upwardly extending into the
2 freeboard portion and an open bottom downwardly extending into the
3 accumulator portion, said internal baffle forming an elongated flow path for
4 receiving the fluid stream from the fluid inlet interface and directing the fluid
5 stream therethrough to the fluid outlet; wherein

6 a length of the elongated flow path from the fluid inlet interface to
7 fluid outlet is longer than the distance between the fluid inlet interface and the
8 fluid outlet; wherein

9 said length of the elongated flow path and the freeboard velocity are
10 such that at least a substantial amount of the entrained particulates fall out of the
11 fluid stream and collect in the accumulator portion; and

12 wherein a desanded gas stream flows out of the freeboard portion
13 through the fluid outlet and is free of a substantial portion of the particulates.

14 The internal baffle prevents the fluid stream from travelling from the
15 inlet interface directly to the outlet. According to one aspect, the internal baffle is
16 a generally upright spiral plate and the elongated flow path is a spiral flow path
17 along the spiral plate.

18 According to another aspect, the vessel is elongated in the vertical
19 direction, having a hemispherical or semi-elliptical upper section, a cylindrical
20 middle section and a conical base section.

21 The freeboard portion in the upper portion of the vessel
22 accommodates gas, and the accumulator portion below the freeboard portion
23 collects particulates separated from the fluid stream.

24 The freeboard portion has a cross-sectional area greater than that
25 of the inlet interface. As a result, fluid stream velocity drops after the fluid stream

1 is injected into the vessel, and particulates cannot be maintained in suspension.
2 The conical base portion of the vessel is at such an angle whereby particulates
3 will migrate towards the bottom of the vessel. A drain may be used for removing
4 particulates.

5 The drain may comprise an inlet valve adjacent and fluidly
6 connected to the drain; a particulate accumulation chamber; and a discharge
7 valve, wherein the particulate accumulation chamber is sandwiched between the
8 inlet valve and the discharge valve.

9 The desanding device does not exploit centrifugal forces to
10 separate particulates from the fluid stream. Rather, it employs gravity for
11 separating particulates from the fluid stream.

12 According to another aspect, a method of removing at least
13 particulates from a multiple-phase fluid stream containing at least gas and
14 particulates, the method comprising:

15 injecting, at a first fluid velocity, said fluid stream along a generally
16 horizontal fluid injection direction into a vessel via a fluid inlet interface;

17 directing, at a second fluid velocity slower than said first fluid
18 velocity, said fluid stream along an elongated flow path in the vessel from the
19 fluid inlet interface to a fluid outlet to allow at least a substantial amount of the
20 entrained particulates fall out of the fluid stream and move into an accumulator
21 portion, said fluid outlet being spaced laterally from the fluid injection direction,
22 and the length of said flow path being longer than the direct distance between
23 said fluid inlet interface and fluid outlet;

1 collecting desanded gas in a freeboard portion, said freeboard
2 portion being above the accumulator portion and being separated therefrom by a
3 freeboard interface; and

4 discharging the desanded gas from the freeboard portion via the
5 fluid outlet; wherein

6 said desanded gas is free of a substantial portion of the
7 particulates.

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1 **BRIEF DESCRIPTION OF THE DRAWINGS**

2 Figure 1 is a cross-sectional side view of Applicant's prior art
3 elongated horizontal desander illustrating downcomer flow barrier, fluid streams,
4 falling trajectory of particulates, and accumulations of separated liquid,
5 particulates and particulate-free fluid discharge;

6 Fig. 2 is a cross-sectional view of a desanding device, according to
7 one embodiment;

8 Figure 3 is a top plan view along the line A-A of the desanding
9 device of Fig. 2;

10 Figure 4 is a top plan view of a replaceable nozzle of Fig. 3;

11 Figure 5 is a perspective view of the internal baffle;

12 Figures 6A to 6D illustrate some alternative embodiments of the
13 internal baffle, showing an internal baffle having an Archimedean spiral cross-
14 section, a logarithmic spiral cross-section, a rectangular, piecewise-linear spiral
15 cross-section, and a pentagonal, piecewise-linear spiral cross-section,
16 respectively; and

17 Figure 7 is a top plan view of the desanding device, according to an
18 alternative embodiment.

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1 particulate collection structure 104. In this embodiment, the vessel 102 is oriented
2 along a vertical axis, and may be partitioned, from top to bottom, into a gas dome
3 section 106 for accommodating gas separated from the injected multiphase fluid
4 stream, a fluid separation section 108 for separating injected multiphase fluid
5 stream, and a particulate drop out section 110 for receiving particulate and liquid
6 separated from the injected fluid stream.

7 In this embodiment, the gas dome section 106 is welded to the fluid
8 separation section 108, and the fluid separation section 108 is welded to the
9 particulate drop out section 110 to form the vessel 102. However, those skilled in
10 the art would readily understand that they may alternatively be coupled using
11 other means, e.g., proper fasteners such as bolts and flanges.

12 The gas dome section 106 has a semi-elliptical or hemispherical
13 head 112, and comprises a fluid outlet 114 thereon for discharging separated gas
14 from the vessel 102. Here, the fluid outlet 114, in the form of a vertically oriented
15 cylindrical tube, is located at the center of the head 112. The fluid outlet 114
16 comprises a discharge end 116 extending out of the vessel, and a bottom end
17 118. In this embodiment, the bottom end 118 of the fluid outlet 114 extends into
18 the fluid separation section 108, and is positioned at the horizontal center thereof.
19 The vertical position of the bottom end 118 of the fluid outlet 114 determines the
20 position of a freeboard interface 140, defining a freeboard portion 138 thereabove
21 and an accumulator portion 142 therebelow.

22 The fluid separation section 108 is cylindrical with a cylindrical side
23 wall 120, which comprises a fluid inlet interface 122 thereon for receiving a
24 multiphase fluid stream. The fluid separation section 108 has a volume sufficient
25 for removing particulates from the fluid injected therein. Also, the fluid separation

1 section 108 has a cross-section area larger than that of the fluid inlet interface
2 such that the velocity of the fluid in the vessel is reduced comparing to that in the
3 fluid inlet interface. In some embodiments, the diameter and height of the fluid
4 separation section 108 are determined based on the inlet fluid velocity in the
5 intended use scenario.

6 The fluid inlet interface 122 is positioned at a location sufficiently
7 above the bottom end 118 of the fluid outlet 114 to ensure that the fluid inlet
8 interface 122 is in the freeboard portion 138 and that the turbulence that the
9 injected fluid stream applies to the particulates P and liquid L in the accumulator
10 portion 142 is minor.

11 Referring to Fig. 3, the fluid inlet interface 122 extends substantially
12 horizontally from the wall 120 into the interior space of the fluid separation section
13 108, and is oriented generally tangential to the side wall 120 of the fluid
14 separation section 108 for directing the fluid stream along an internal baffle 124.
15 The horizontally-oriented, fluid inlet interface 122 also allows it to be easily
16 connected to conventional wellhead that is typically in a rectilinear or orthogonal
17 arrangement.

18 The fluid inlet interface 122 comprises a coupling end 202 for
19 coupling to a wellhead or a piping connected to a wellhead using a flange, and a
20 discharge end 204 for discharging injected fluid stream into the fluid separation
21 section 108. A replaceable nozzle 206 having a flange is inserted between the
22 flange 202 and external inlet piping (not shown). The replaceable nozzle 206
23 extends into the vessel 102 and does not form a pressure boundary such that
24 any wear therein would not compromise any pressure rating of the vessel.

1 Fig. 4 illustrates one form of the replaceable nozzle 206. As shown,
2 the nozzle 206 comprises a connective piping 222 in the form of a cylindrical
3 tube, an end wall 226 at the distal end thereof, and a gap 224 intermediate the
4 connective piping 222. The end wall 226 diverts injected fluid from immediately
5 and erosively impinging the wall of the vessel for deflecting from, and
6 maintaining, the integrity of the pressure boundary. The end wall 226 is
7 sufficiently downstream such that it does not significantly impact the incoming
8 fluid stream under normal operation, and diverts injected fluid when the injected
9 fluid is unstable or becomes slug flow. In this embodiment, the end wall 226 is
10 formed by securing a cap to the distal end of the connective piping 222. However,
11 those skilled in the art will appreciate that other methods may alternatively be
12 used to form the end wall 226.

13 The gap 224 is oriented horizontally inwardly, and in an
14 embodiment, formed by cutting off a portion of the side wall of the connective
15 piping 222. The gap 224 is set to a sufficient length to minimize the pressure drop
16 that may occur when fluid stream is injected into the vessel 102 through the
17 nozzle 206.

18 Referring back to Figs. 2 and 3, the fluid separation section 108
19 also comprises an internal baffle 124 made of a proper material, such as steel,
20 plastic or the like, capable of maintaining its shape against the fluid stream
21 flowing therewithin. In this embodiment, the baffle 124 is a generally upright,
22 spiral plate that is horizontally and spirally extending from the inner side of wall
23 120 at a location 208 adjacent the wall of the fluid inlet interface 122 to about a
24 central location 210 proximate to the fluid outlet 114, as shown in Fig. 3.

1 With reference to Figs. 2 and 5, the baffle 124 has an open top 123
2 extending upwardly into the freeboard portion 138, and an open bottom 125
3 downwardly extending into the accumulator portion 142. The baffle 124 divides at
4 least a portion of the interior space of the fluid separation section 108 into a spiral
5 passage 212 between the fluid inlet interface 122 and the fluid outlet 114.
6 Therefore, the length of the passage 212, i.e., the shortest distance of travel
7 through the passage 212 from one end near the fluid inlet interface 122 to the
8 other end near the fluid outlet 114, is much longer than the direct distance the
9 inlet interface 122 and the outlet 114.

10 In this embodiment, the spiral walls of baffle 214 are equally spaced
11 such that the spiral passage 212 formed by the baffle 124 is generally of the
12 same width throughout the entire passage. The height of the baffle is determined
13 by the cross-sectional area of the passage 212 within the baffle 214, and is
14 related to the distance between two neighboring spiral walls, i.e., the width of the
15 spiral passage. Generally, a larger height of the baffle is required if the width of
16 the spiral passage is narrower to achieve the cross-sectional area corresponding
17 to the designed flow velocity. For example, in one embodiment, the width of the
18 spiral passage is about 6 inches, and the height of the baffle is about 18 inches.

19 Referring again to Fig. 2, the particulate drop out section 110 is
20 enclosed by a conical-shaped side wall 126 coupled to the fluid separation
21 section 108 thereabove at its top opening 128, and narrowing down to the bottom
22 opening 130 that is coupled to the particulate collection structure 104. The slope
23 of the side wall 126, characterized by the inclination angle β between the wall 126
24 and a horizontal plane, is selected to be steep enough, e.g., the angle β being
25 about or larger than the angle of repose of a bank of wet particulates, to allow

1 particulates and liquid to migrate towards the bottom of the vessel 102 and enter
2 the particulate collection structure 104.

3 In this embodiment, the particulate collection structure 104
4 comprises a sand accumulation chamber 134 sandwiched between an inlet valve
5 132 and a discharge valve 136. The inlet valve 132 is connected to the vessel
6 102 on top thereof and to the sand accumulation chamber 134 therebelow, and
7 the sand accumulation chamber 134 is in turn connected to the discharge valve
8 136 therebelow. As will be described in more detail later, the inlet valve 132 may
9 be set to the open position and the discharge valve 136 set to the closed position
10 in normal operation to allow the sand accumulation chamber 134 to collect
11 particulates and liquid from the vessel 102.

12 Conventional pressure safety valves 115 and other gas phase
13 related devices and instrumentation (not shown) are reliably located on the wall
14 of vessel 102 in the freeboard portion 138.

15 Although not shown in the figures, the vessel 102 is supported by
16 supporting structure to maintain the vessel 102 in its vertical orientation. In some
17 use scenarios, the desanding device 100 is set up at an oil and gas well site. The
18 connective piping 222 of the replaceable nozzle 206 is connected to a wellhead,
19 and the fluid outlet 114 is connected to downstream equipment.

20 In operation, a fluid stream is injected into the vessel 102 from the
21 wellhead through the nozzle 206. The end wall 226 breaks any high velocity slug
22 flow entering the vessel 102 through the inlet interface 122, and protects the
23 pressure boundary of the vessel 102. The gap 224 on the nozzle 206 is of
24 sufficient length such that the end wall 226 impedes injected fluid flow only in the
25 event of slug flow, and does not impose a significant pressure drop otherwise.

1 After entering the vessel, the fluid flow travels through the passage
2 212 along a spiral flow path. Under the influence of gravity, particulates and liquid
3 in the fluid flow fall through the fluid separation section 108 towards the bottom of
4 the vessel 102 via a trajectory path along the passage 212. A freeboard interface
5 140 forms in a horizontal plane at about the bottom end 118 of the fluid outlet
6 114. An accumulator portion 142 is formed below the freeboard interface 140 for
7 receiving liquid L and particulates P. A freeboard portion 138 is formed above the
8 interface 140 for accommodating gas G.

9 In this embodiment, the freeboard interface 140 is a substantially
10 circular, gas/liquid interface between the accumulator and freeboard portions 142
11 and 138. The bottom end 118 of the fluid outlet 114 is horizontally located about
12 the centre of the circular freeboard interface 140, and the inlet interface 122 is
13 oriented tangential to the outer edge thereof. The interface 140 is broken
14 continuously by the spiral shaped baffle 124 as illustrated in Figure 3. As a
15 result, the trajectory of the fluid stream F, from inlet interface 122, converges with
16 the freeboard interface 140. The trajectory for dropping particulates P from the
17 liquid L is governed by the fluid properties and the geometry of the cylindrical
18 section of the Desander. Once the particulates and liquid have dropped into the
19 accumulator section, they are separated from the active flow stream and migrate
20 towards the particulate collection structure 104. Since the slope of the walls 126
21 of the particulate drop out section 110 is steeper than the angle of repose of the
22 sand bank, particulates and liquid fall through the open inlet valve 132 into the
23 sand accumulation chamber 134.

24 Once the particulates and liquid fill the particulate collection
25 structure 104, they continue to accumulate in the accumulator portion 142. In

1 cases that the fluid stream contains more liquid than particulates, the
2 accumulated particulates and liquid in the accumulator portion 142 has a liquid
3 surface, which grows upward towards the freeboard interface 140 with the
4 accumulation of particulates and liquid.

5 Gas G is accumulated in the freeboard portion 138, and is
6 discharged from the fluid outlet 114 while particulates P and liquid L are
7 accumulated in the accumulator portion 142. At a steady state, the level of the
8 liquid surface grows to the freeboard interface 140, and reaches the bottom end
9 118 of the fluid outlet 114. Therefore, oil and other liquids are re-entrained with
10 the gas G exiting at the fluid outlet 114. Such a steady state may last for a long
11 time until the accumulated particulates also reach the bottom end 118 of the fluid
12 outlet 114, when desanding fails. Such desanding failure is prevented by
13 periodically removing accumulated particulates from the particulate collection
14 structure 104 (described later).

15 In cases that the fluid stream contains more particulates than liquid,
16 particulates are accumulated faster than liquid. Desanding would be
17 compromised if the accumulated particulates reach the bottom end 118 of the
18 fluid outlet 114. Such an occurrence is prevented by periodically removing
19 accumulated particulates from the particulate collection structure 104.

20 Velocity of gas in the freeboard portion 138 may increase as the
21 gas approaches the fluid outlet 114, however this occurs only after the
22 particulates P have dropped out of the gas phase of the flow stream. Liquid in
23 the accumulator portion 142 is considered stagnant, governed only by fluid drag
24 from the motion of the liquid in the cylindrical section, and will have minimal

1 velocity. Particulates falling into this section can be considered removed from the
2 flow stream.

3 Referring to Fig. 2 again, in the accumulator portion 142,
4 particulates accumulate and flow down the vessel 102 at an angle of repose.
5 Since the slope of the walls 126 of the particulate drop out section 110 is steeper
6 than the angle of repose of the sand bank, the sand will migrate towards the
7 particulate collection structure 104.

8 The slope of the walls 126 of the particulate drop out section 110,
9 characterized by the inclination angle β between the wall 126 and a horizontal
10 plane, can be determined for a given diameter of vessel 102 to accommodate the
11 estimated angle of repose of the sand bank. In this embodiment, as the
12 particulate drop out section 110 is of a conical shape, the inclination angle β
13 generally the same anywhere in the particulate drop out section 110.

14 Unlike the prior art desanders that require shutting down the
15 operation to depressurize the vessel for removing accumulated particulates, the
16 removal of accumulated particulates can be conducted periodically with the
17 vessel 102 being pressurized and in operation. For this purpose, the valves 132
18 and 136 are controlled manually by an operator or automatically with a timer or
19 an ultrasonic sand detector to periodically open and close. Typically, an interlock
20 is used to prevent the inlet and discharge valves from being open at the same
21 time. In particular, the valve 132, between the sand vessel 102 and the sand
22 accumulation chamber 134 is normally open except at the time of particulate
23 removal, allowing particulates to fall into the sand accumulation chamber 134.
24 The discharge valve 136 is normally closed except at the time of particulate
25 removal.

1 To remove particulates while maintaining the desanding device 100
2 in operation, the valve 132 is first closed. Valve 136 is then opened allowing the
3 particulates contained in the sand accumulation chamber 134 to exit. After
4 removing particulates from the sand accumulation chamber 134, valve 136 is
5 closed and valve 132 is then reopened to allow particulates in the particulate drop
6 out section 110 to migrate into the sand accumulation chamber 134. Persons
7 skilled in the art appreciate that the particulate drop out section 110 has sufficient
8 space to store particulates inside the vessel 102 during the particulates-removing
9 process, and the volume of the sand accumulation chamber 134 is sufficiently
10 large to discharge enough particulates within a cleaning cycle so as not to cause
11 a backup of particulates into valve 132 thereby preventing the valve to close.
12 Both valves 132 and 136 are required to have service rated for abrasive slurries.

13 As an alternate, if line washing is desired and the downstream
14 piping is able to support the pressure, valve 132 can be left open. Valve 136 is
15 opened only for a short period of time, sufficient to allow the volume of the sand
16 accumulation chamber 134 to be evacuated.

17 Compared to prior art desanders, the desanding device 40 does not
18 require a weir for setting a freeboard portion, and has the advantage of requiring
19 less horizontal operational space. For example a desander as described in US
20 6,983,852, assigned to the Applicant of the subject application, includes a
21 horizontally oriented vessel having a nominal 0.3 meter (i.e., 12 inches) diameter
22 and a 3.048 meters (i.e., 10 feet) length. Another desander as described in the
23 same US patent but for a different operational condition includes a vessel having
24 a 0.3 meter (i.e., 12 inches) diameter and a 6.096 meters (i.e., 20 feet) length.
25 Both desanders are fitted with a downcomer weir to set the freeboard portion. To

1 compare, a desanding device 100 has a vessel diameter of 1.2 meters (i.e., 48
2 inches). The height of the fluid separation section 108 is 0.45 meter (i.e., 18
3 inches). The inclination angle β of the wall 126 of the particulate drop out section
4 110 is 45 degrees or greater.

5 Persons skilled in the art appreciate that various alternative
6 embodiments are readily available. For example, although in above description,
7 the fluid inlet interface 122 is located in the fluid separation section 108, in an
8 alternative embodiment, the fluid inlet interface 122 may be located in the gas
9 dome section 106 to allow a longer flow path for the fluid stream. However, the
10 manufacturing cost may be higher.

11 Those skilled in the art would appreciate that, instead of being
12 hemispherical in shape, the gas dome section 106 may alternatively be of other
13 shapes, depending, in part, upon the design and pressure-resistance
14 requirements. For example, in one alternative embodiment, the gas dome section
15 106 may be cylindrical having a cylindrical side wall and a circular head. In
16 another embodiment, the gas dome section 106 may be semi-elliptical head.
17 Similarly, other sections of the vessel 102 may be of other shapes in alternative
18 embodiments. In an alternative embodiment that the desander is used for
19 removing particulates from low pressure fluid stream, one or more sections of the
20 vessel 102, e.g., the gas dome section 106, may be of other shapes, e.g., a cubic
21 having rectangular shaped side walls and a rectangular head.

22 Those skilled in the art appreciate that the particulate collection
23 structure 104 may alternatively comprise different components. For example, in
24 some alternative embodiments, the particulate collection structure 104 may be a
25 simple sand sump having no valve.

1 Those skilled in the art appreciate that, in some alternative
2 embodiments, some or all of the gas dome section 106, the particulate drop out
3 section 110 and the particulate collection structure 104 may not be required. For
4 example, in an alternative embodiment, the vessel 102 does not comprise a gas
5 dome, and the fluid separation section 108 is enclosed by a head having a fluid
6 outlet in a configuration similar to the description above. In yet another
7 embodiment, the vessel 102 does not comprise a particulate drop out section
8 110, and the fluid separation section 108 is enclosed by a floor that comprises an
9 opening for dropping out particulates and liquid separated from the injected fluid.
10 Still as another example, alternatively, the fluid separation device 40 does not
11 comprise a particulate collection structure 104. The drop out section 110
12 comprises a valve at its bottom opening. The valve is closed when the fluid
13 separation device 40 is in operation, and is open for cleaning out particulates
14 accumulated in the particulate drop out section 110.

15 The baffle 124 in the fluid separation section 108 may be of
16 different shapes in alternative embodiments. For example, the cross-sectional
17 shape of the baffle 124 may be a spiral curve of different types, such as
18 Archimedean spiral, Cornu spiral, Fermat's spiral, hyperbolic spiral, lituus,
19 logarithmic spiral, spiral of Theodorus, or the like, depending on the design. As
20 another example, the cross-sectional shape of the baffle 124 may be a spiral
21 formed by straight line segments. Figs. 6A to 6D show some examples of various
22 cross-sectional shape of the baffle 124 that may be adopted in various alternative
23 embodiments.

24 In above embodiments, the baffle 124 extends from the inner side
25 of wall 120 at a location 208 adjacent the wall of the fluid inlet interface 122 such

1 that the wall of the fluid inlet interface 122 smoothly aligned to the baffle 124. In
2 an alternative embodiment as shown in Fig. 7, the baffle 124 extends from the
3 inner side of wall 120 at a location 302 slightly away from the wall of the inlet
4 interface 122 such that the wall of the inlet interface 122 transits to the baffle 124
5 via a step 304.

6 Although in above description, the fluid inlet interface 122 is
7 oriented horizontally and thus is perpendicular to the vertical axis, in some
8 alternative embodiments, the fluid inlet interface 122 may be oriented in other
9 orientations including an incline to the vertical axis.

10 In an alternative embodiment, a different nozzle, e.g., a replaceable
11 nozzle as set forth in Applicant's Patent CA 2,535,215 issued May 8, 2008, may
12 be used. Those skilled in the art will also appreciate that, in some alternative
13 embodiment, no nozzle is used, and the fluid inlet interface 122 is connected
14 directly to the wellhead.

15 The desanding devices described in this disclosure generally exploit
16 the effect of gravity to separate particulates from the multiphase fluid stream
17 injected into a vessel having a limited size, which provide significant advantage
18 for use in oil and gas sites that offer limited operational space.

19 Other embodiments of the desanding device are also readily
20 available. For example, in an alternative embodiment, a desanding device
21 comprises a vessel in the form of a bent cylindrical pipe having a fluid inlet
22 interface at a first end and a fluid outlet at a second end. The first end is
23 configured slightly higher than the second end. Multiphase fluid stream injected
24 into the vessel via the inlet interface travels through a spiral flow path.
25 Particulates and liquid are separated from the fluid and fall down to an

1 accumulator portion in the vessel due to the effect of gravity, and gas is
2 accumulated in a freeboard portion above the accumulator portion, and is
3 discharged out of the vessel via the fluid outlet. The vessel may also comprise a
4 drain for cleaning out particulates and liquid separated from injected fluid stream.

5 As appreciated by persons skilled in the art, the desanding devices
6 in the embodiments described above are made of suitable material, such as steel
7 or the like, with specifications satisfying relevant safety code requirement.

8

1 **THE EMBODIMENTS OF THE INVENTION FOR WHICH AN**
2 **EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS**
3 **FOLLOWS:**
4

5 1. A vessel for removing at least particulates from a multiple-
6 phase fluid stream containing gas and entrained particulates, the vessel
7 comprising:

8 a fluid inlet interface for receiving said fluid stream and manipulating
9 the fluid along a generally horizontal fluid injection direction into the vessel;

10 a fluid outlet located generally at geometric center of the vessel and
11 spaced laterally from the fluid injection direction;

12 a horizontally extending freeboard interface separating a freeboard
13 portion formed adjacent an upper portion of the vessel above the interface and a
14 accumulator portion therebelow, the freeboard portion forming a freeboard cross-
15 sectional area for a freeboard velocity of the fluid stream less than a fluid stream
16 velocity at the fluid inlet interface; and

17 an internal baffle having an open top upwardly extending into the
18 freeboard portion and an open bottom downwardly extending into the
19 accumulator portion, said internal baffle forming an elongated flow path for
20 receiving the fluid stream from the fluid inlet interface and directing the fluid
21 stream therethrough to the fluid outlet; wherein

22 a length of the elongated flow path from the fluid inlet interface to
23 fluid outlet is longer than the distance between the fluid inlet interface and the
24 fluid outlet; wherein

25 said length of the elongated flow path and the freeboard velocity are
26 such that at least a substantial amount of the entrained particulates fall out of the

- 1 fluid stream and collect in the accumulator portion; and
2 wherein a desanded gas stream flows out of the freeboard portion
3 through the fluid outlet and is free of a substantial portion of the particulates.
4
- 5 2. The vessel of claim 1 wherein the effective amount of the
6 entrained liquids and particulates fall through the open bottom of the internal
7 baffle and into the liquid portion.
8
- 9 3. The vessel of claim 1 or 2 wherein the internal baffle is a
10 generally upright spiral plate and the elongated flow path is a spiral flow path
11 along the spiral plate.
12
- 13 4. The vessel of any one of claims 1 to 3 wherein the fluid inlet
14 interface is on the vessel at a location higher than the bottom end of the fluid
15 outlet.
16
- 17 5. The vessel of any one of claims 1 to 4 wherein the fluid inlet
18 interface is oriented for directing the fluid stream along the internal baffle.
19
- 20 6. The vessel of any one of claims 1 to 5 wherein the fluid inlet
21 interface directs the fluid stream away from the vessel wall.
22

1 7. The vessel of any one of claims 1 to 6 wherein the vessel
2 further comprises:

3 a hemispherical head portion containing the freeboard portion;
4 a lower portion containing the accumulator portion.

5

6 8. The vessel of any one of claims 1 to 6 wherein the vessel
7 further comprises:

8 A semi-elliptical head portion containing the freeboard portion;
9 a lower portion containing the accumulator portion.

10

11 9. The vessel of claim 7 or 8 wherein the internal baffle is
12 located in the lower portion for forming the elongated flow path between the fluid
13 inlet interface and the fluid outlet.

14

15 10. The vessel of any one of claims 1 to 9 wherein the
16 accumulator portion further comprises a conical portion at the bottom thereof for
17 receiving the entrained liquids and particulates and having a lower drain for liquid
18 and particulates.

19

20 11. The vessel of claim 10 wherein the drain further comprises:

21 an inlet valve adjacent and fluidly connected to the drain;

22 a particulate accumulation chamber; and

23 a discharge valve, wherein

24 the particulate accumulation chamber is sandwiched between the
25 inlet valve and the discharge valve.

1

2 12. An apparatus of claim 10 or 11 wherein the slope of the wall
3 of conical portion is about or greater than the angle of repose of a bank of wet
4 particulates.

5

6 13. An apparatus of any one of claims 1 to 12 wherein the cross-
7 sectional shape of the internal baffle is selected from the group consisting of an
8 Archimedean spiral, a Cornu spiral, a Fermat's spiral, a hyperbolic spiral, a lituus,
9 a logarithmic spiral, and a spiral of Theodorus.

10

11 14. A method of removing at least particulates from a multiple-
12 phase fluid stream containing at least gas and particulates, the method
13 comprising:

14 injecting, at a first fluid velocity, said fluid stream along a generally
15 horizontal fluid injection direction into a vessel via a fluid inlet interface;

16 directing, at a second fluid velocity slower than said first fluid
17 velocity, said fluid stream along an elongated flow path in the vessel from the
18 fluid inlet interface to a fluid outlet to allow at least a substantial amount of the
19 entrained particulates fall out of the fluid stream and move into an accumulator
20 portion, said fluid outlet being spaced laterally from the fluid injection direction,
21 and the length of said flow path being longer than the direct distance between the
22 fluid inlet interface and the fluid outlet;

23 collecting desanded gas in a freeboard portion, said freeboard
24 portion being above the accumulator portion and being separated therefrom by a
25 freeboard interface; and

1 discharging the desanded gas from the freeboard portion via the
2 fluid outlet; wherein

3 said desanded gas is free of a substantial portion of the
4 particulates.

5

6 15. A method of claim 13 wherein said directing said fluid stream
7 along an elongated flow path in the vessel comprises:

8 directing, at a second fluid velocity slower than said first fluid
9 velocity, said fluid stream along a spiral flow path in the vessel from the fluid inlet
10 interface to the fluid outlet.

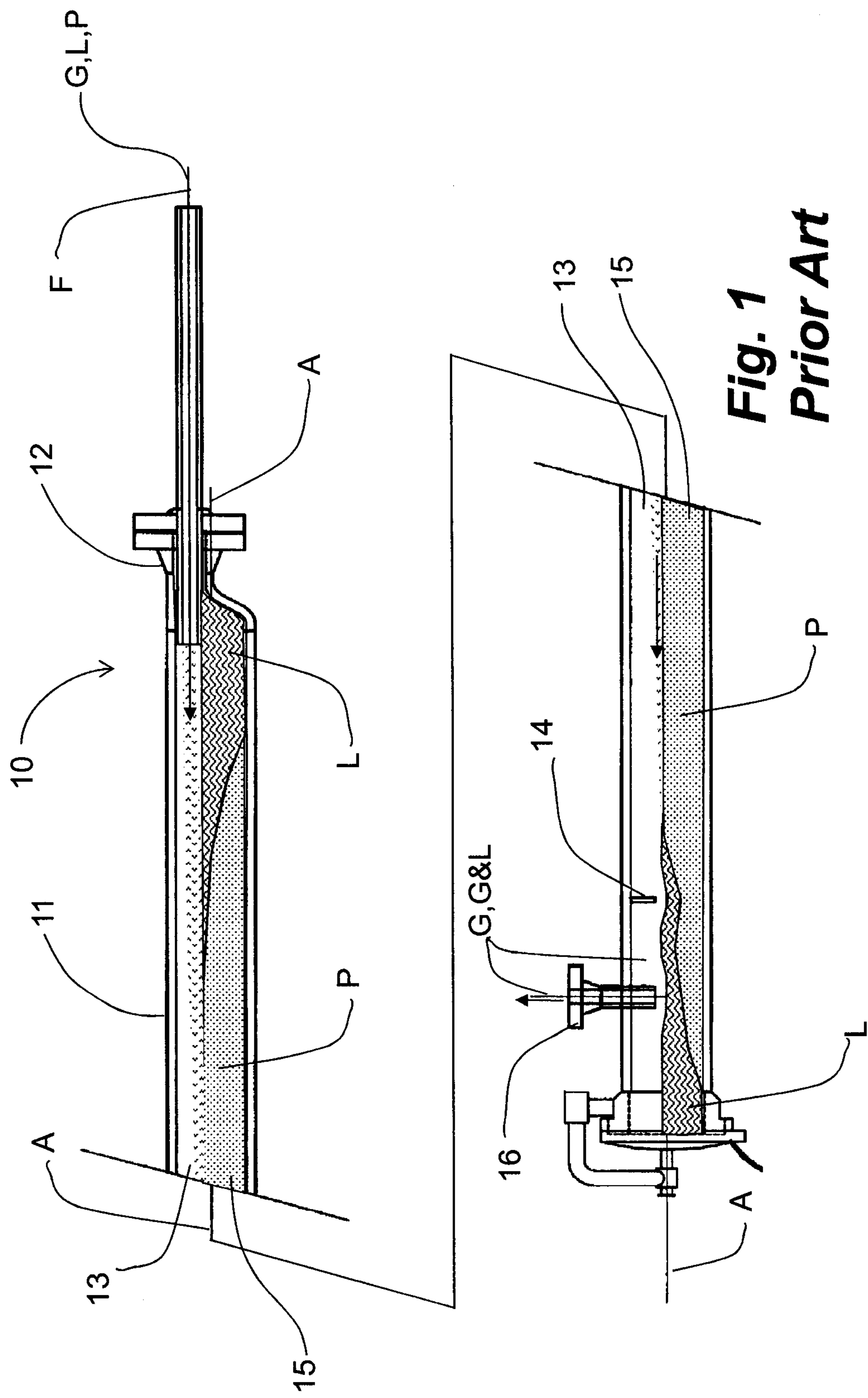
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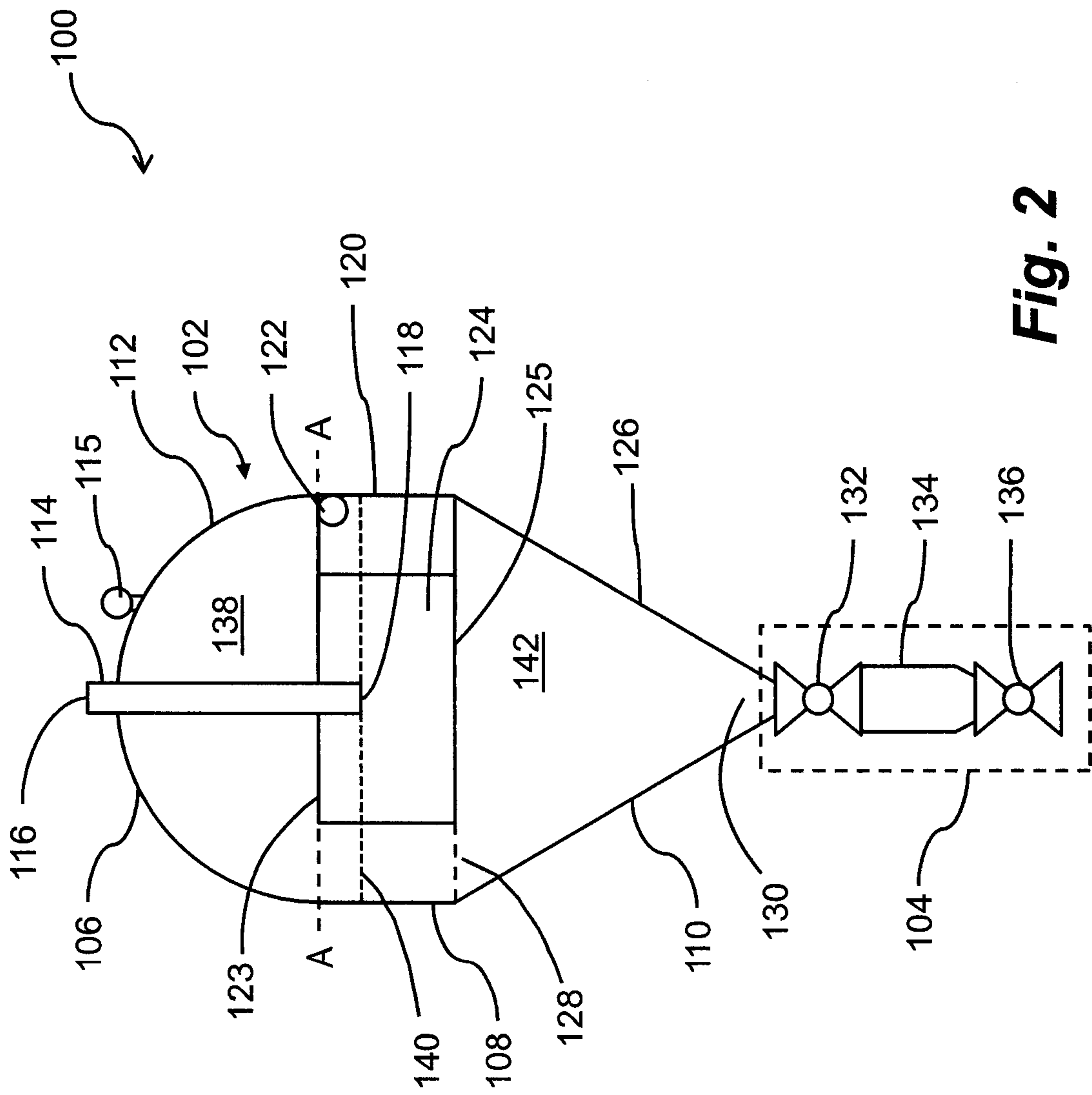


Fig. 2

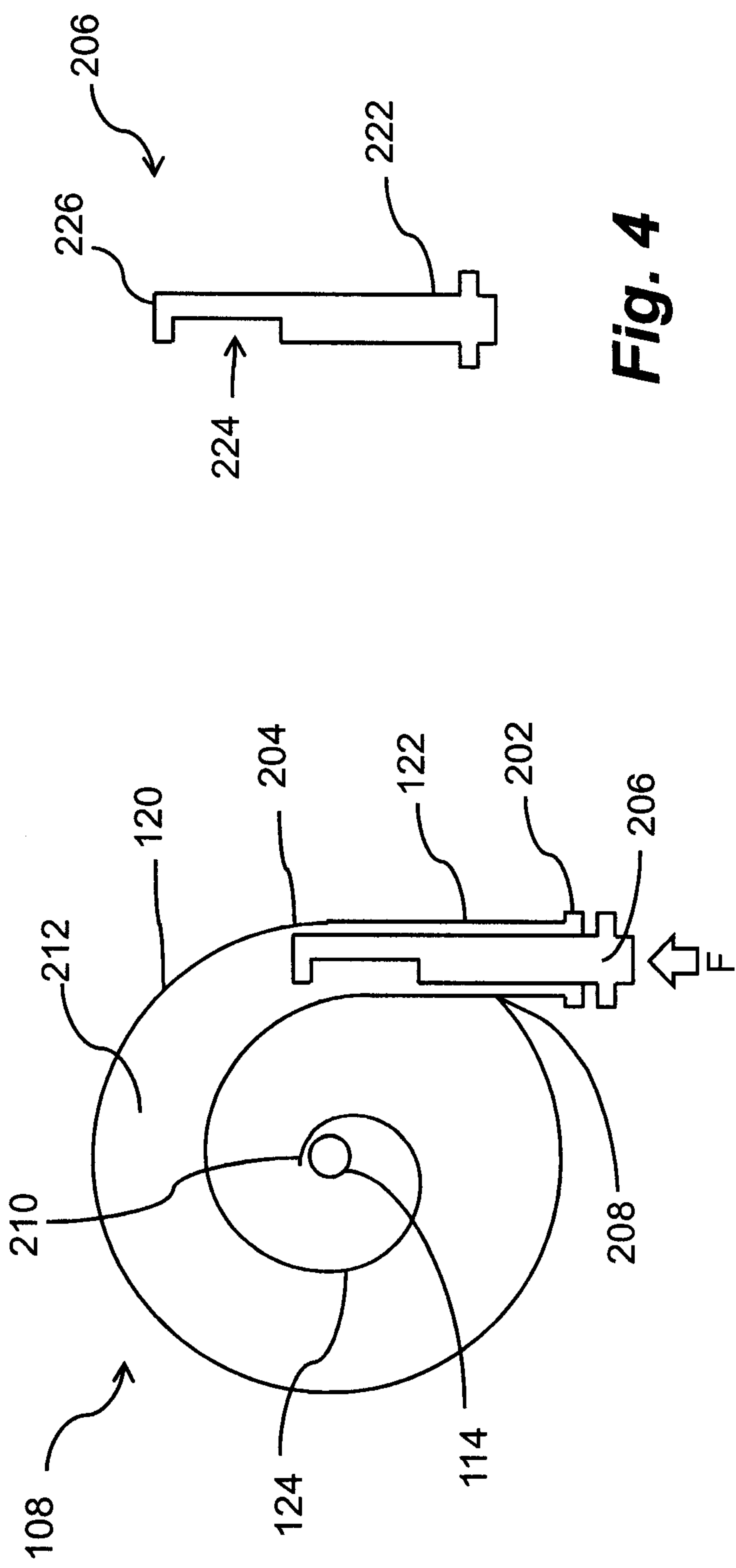


Fig. 3

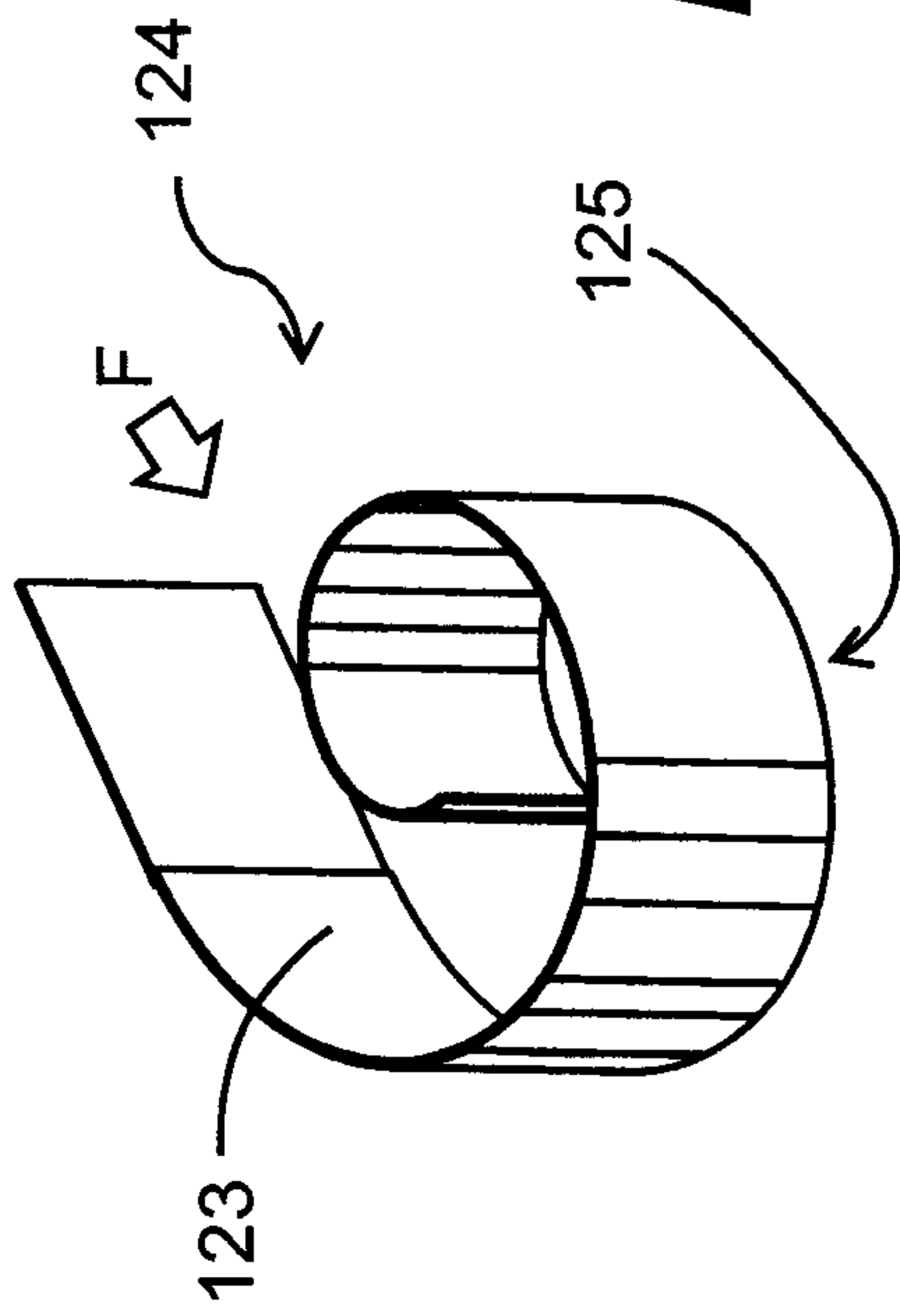
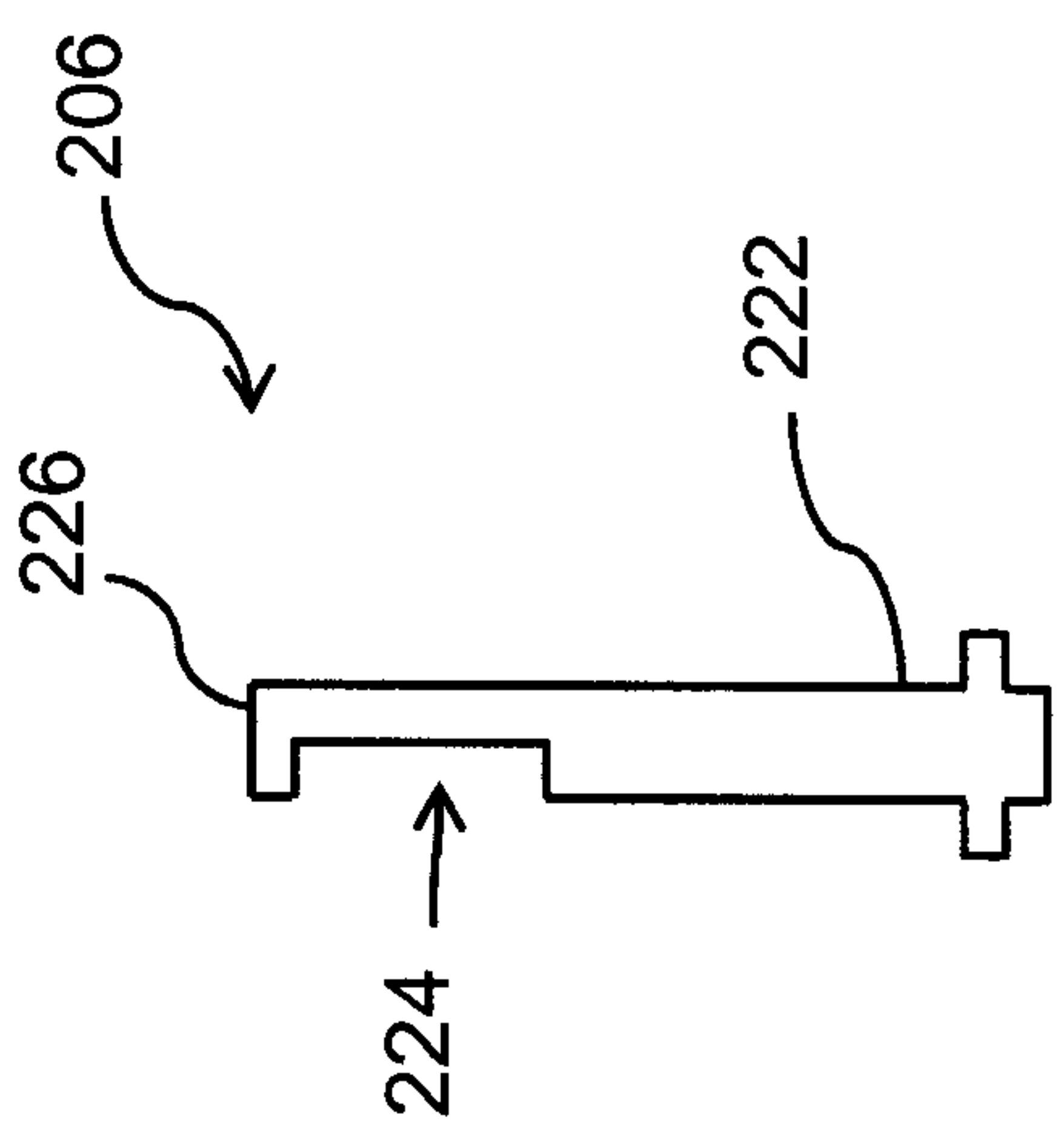


Fig. 5

Fig. 4



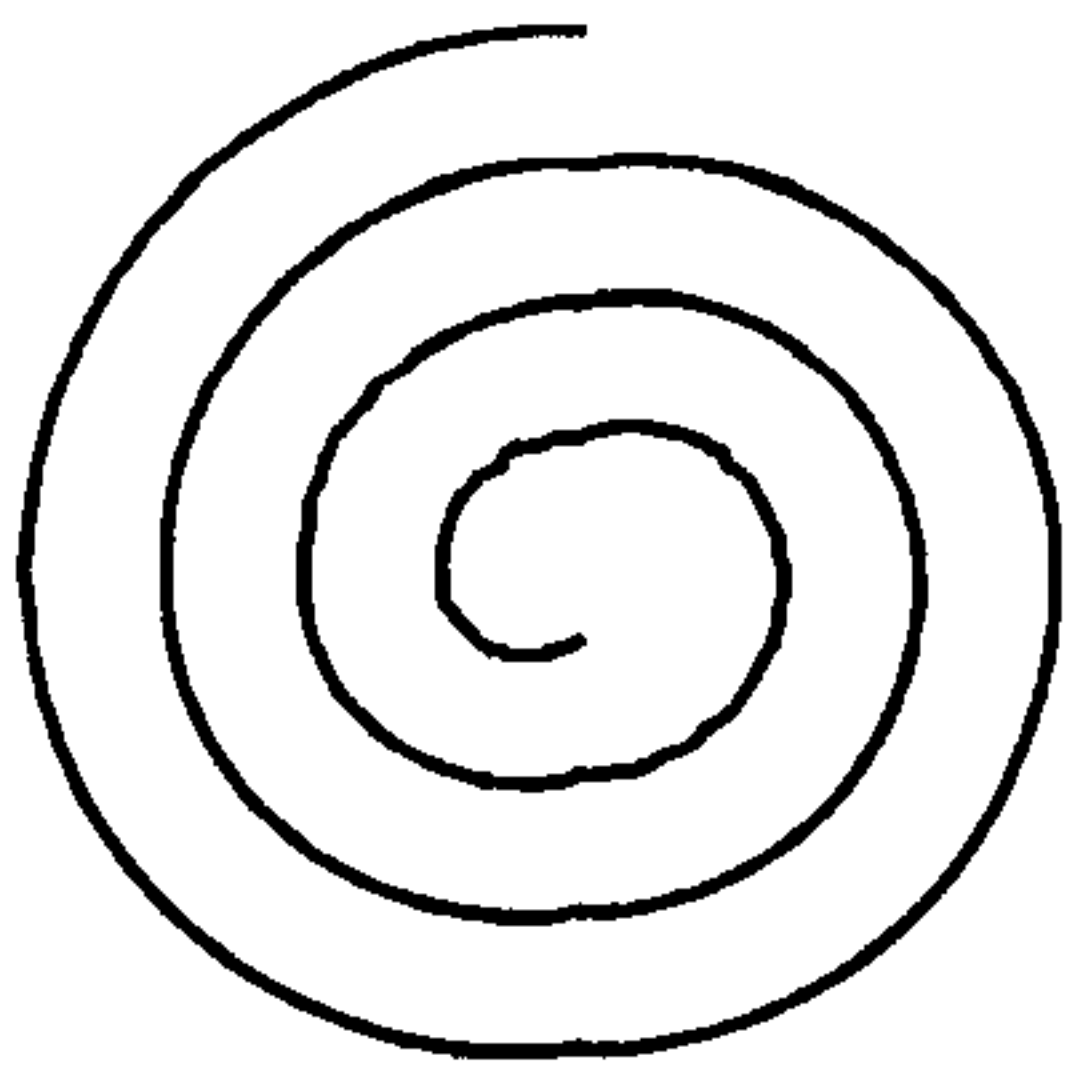


Fig. 6A

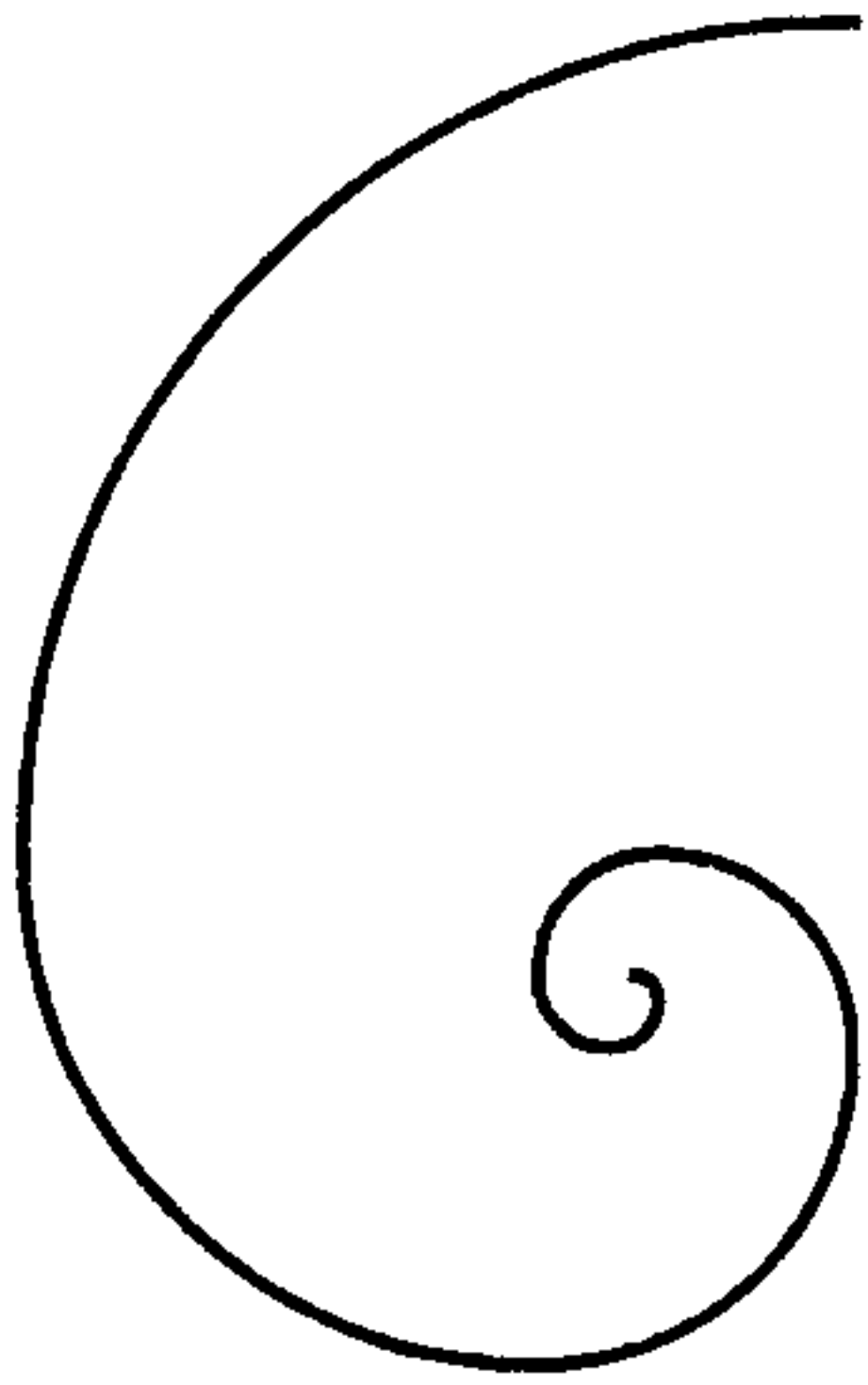


Fig. 6B

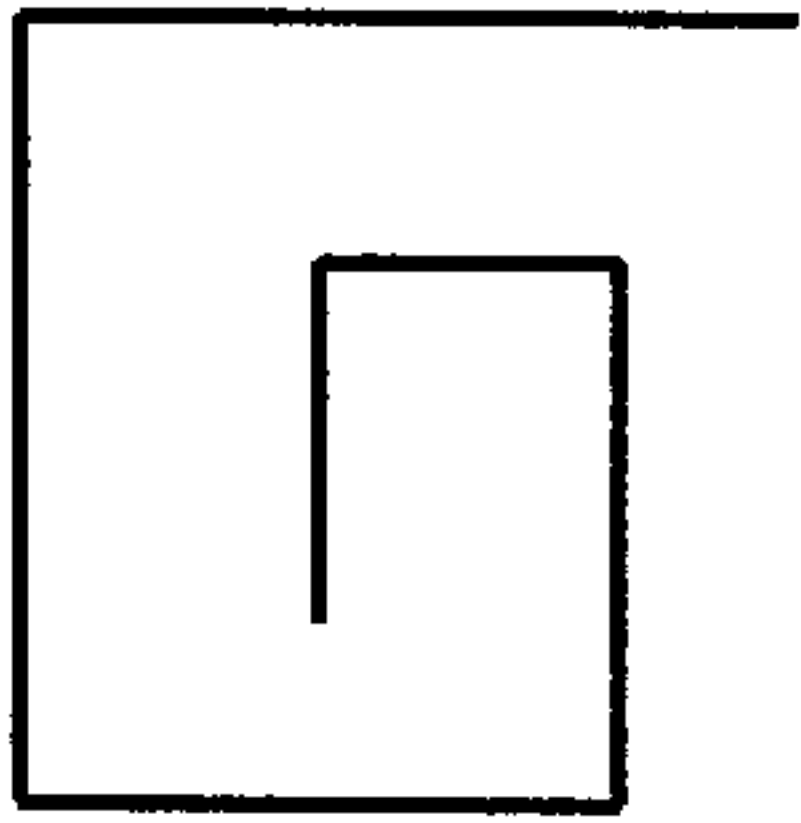


Fig. 6C

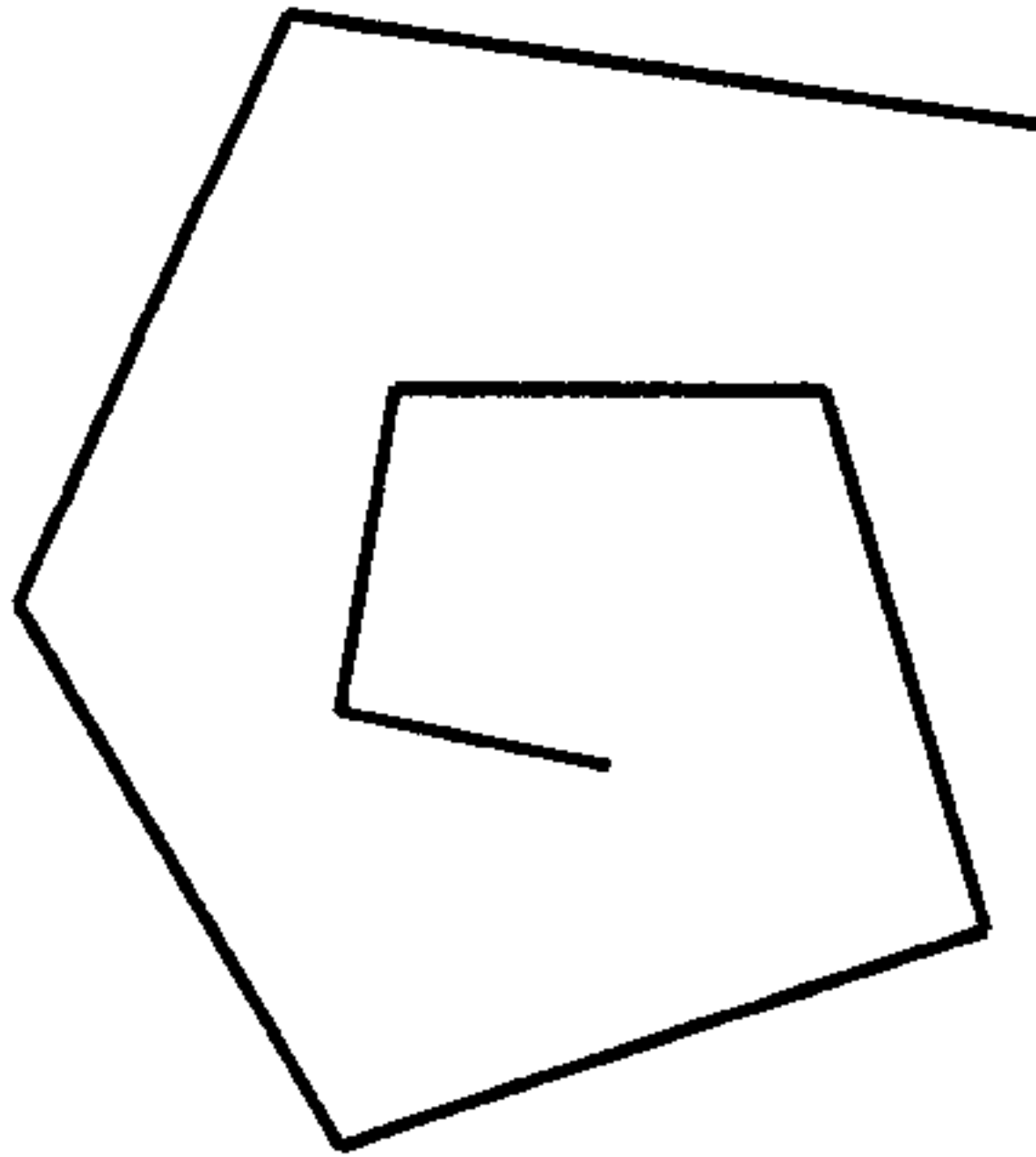


Fig. 6D

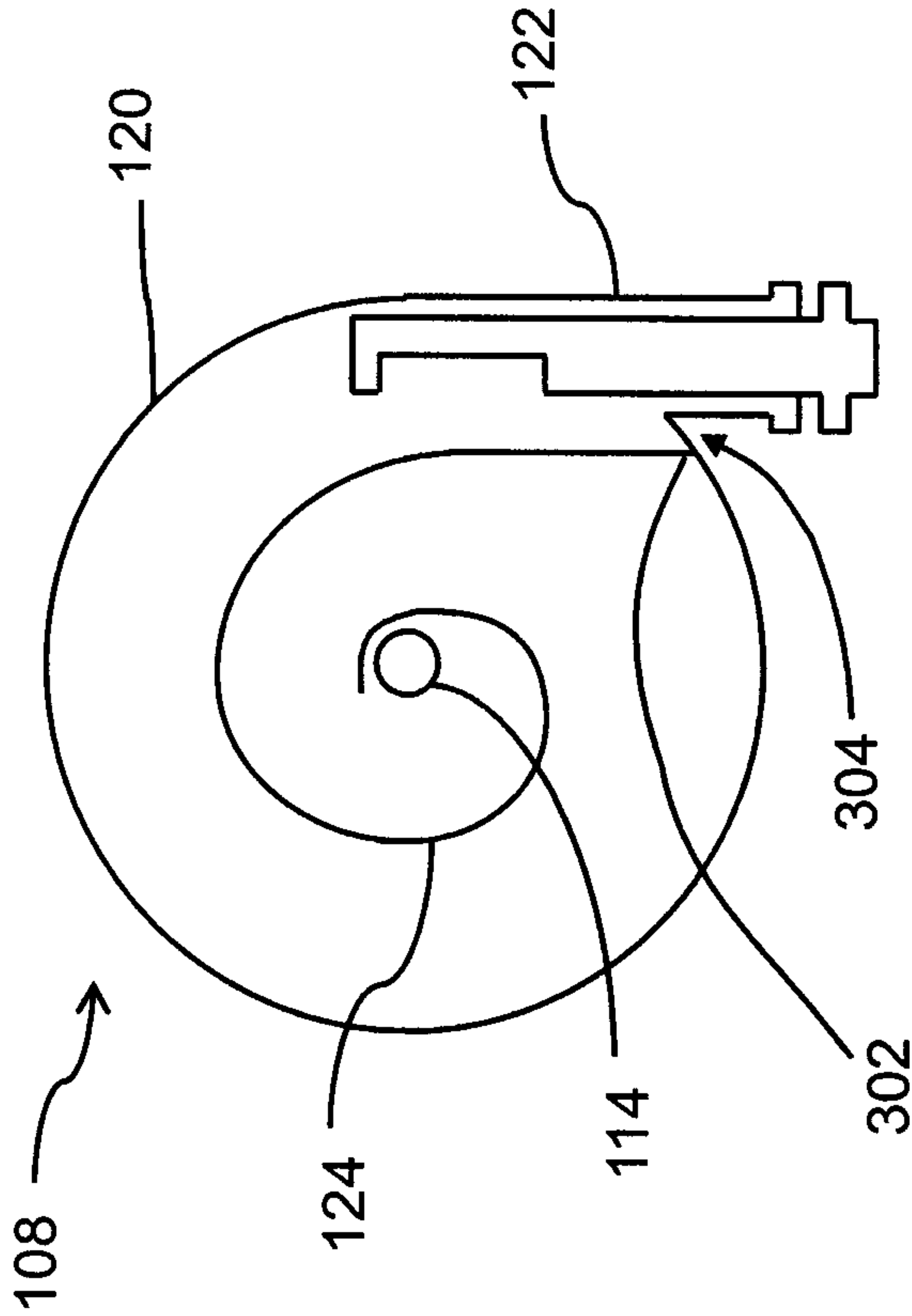


Fig. 7