

(57) Abstract: A system for producing oil and/or gas, including a subsea structure defining an interior of the system, the structure subject to a water current; a covering exterior to the subsea structure, covering at least a portion of an outside surface of the subsea structure; a vortex induced vibration suppression device exterior to the covering; the covering including a first mechanism and the vortex induced vibration suppression device including a second mechanism, wherein the first mechanism and the second mechanism are adapted to maintain the vortex induced vibration suppression device in a location along a length of the subsea structure.



For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

VORTEX INDUCED VIBRATION SUPPRESSION SYSTEMS AND METHODS

Field of the Invention

5 This invention is related to vortex induced vibration suppression devices that can be attached to offshore structures to reduce drag and/or vortex induced vibration (VIV).

Background of the Invention

10 Whenever a bluff body in a fluid environment, such as a cylinder, is subjected to a current in the fluid, it is possible for the body to experience vortex-induced vibrations (VIV). These vibrations may be caused by oscillating hydrodynamic forces on the surface which can cause
15 substantial vibrations of the structure, especially if the forcing frequency is at or near a structural natural frequency.

 Drilling for and/or producing hydrocarbons or the like from subterranean deposits which exist under a body of water
20 exposes underwater drilling and production equipment to water currents and the possibility of VIV. Equipment exposed to VIV may include structures ranging from the smaller tubes of a riser system, anchoring tendons, or lateral pipelines to the larger underwater cylinders of the hull of a minispar or
25 spar floating production system (a "spar").

 Risers as used herein are defined to be a non-exclusive example of a marine element subject to VIV. Generally a riser system is used for establishing fluid communication between the surface and the bottom of a water body. The
30 principal purpose of the riser is to provide a fluid flow path between a drilling vessel and a well bore and to guide a drill string to the well bore.

 A typical riser system may include one or more fluid-conducting conduits that extend from the surface to a

structure (e.g., wellhead) on the bottom of a water body. For example, in the drilling of a submerged well, a drilling riser usually consists of a main conduit through which the drill string is lowered and through which the drilling mud is
5 circulated from the lower end of the drill string back to the surface. In addition to the main conduit, there may be provided auxiliary conduits such as, for example, choke and kill lines, pressurized fluid lines, hard pipes, and electrical lines, which extend relatively parallel to the
10 main conduit. These auxiliary conduits and lines are commonly referred to as umbilical elements and/or umbilicals.

There are generally two kinds of water current induced stresses to which elements of a riser system may be exposed. The first kind of stress as mentioned above is caused by
15 vortex-induced alternating forces that vibrate the underwater structure in a direction perpendicular to the direction of the current. These are referred to as vortex-induced vibrations (VIV). When water flows past the structure, vortices are alternately shed from each side of the
20 structure. This produces a fluctuating force on the structure transverse to the current. These vibrations can, depending on the stiffness and the strength of the structure and any welds, lead to unacceptably short fatigue lives. In fact, stresses caused by high current conditions have been
25 known to cause structures such as risers to break apart and fall to the ocean floor. The second type of stress is caused by drag forces which push the structure in the direction of the current due to the structure's resistance to fluid flow. The drag forces may be amplified by vortex induced vibrations
30 of the structure. For instance, a riser pipe that is vibrating due to vortex shedding will disrupt the flow of water around it more so than a stationary riser. This

results in greater energy transfer from the current to the riser, and hence more drag.

Many methods have been developed to reduce vibrations of sub sea structures. Some of these methods to reduce
5 vibrations caused by vortex shedding from subsea structures operate by stabilization of the wake. These methods include streamlined fairings, wake splitters and flags. Streamlined or teardrop shaped, fairings that swivel around a structure have been developed that almost eliminate the shedding or
10 vortexes. Other conventional methods to reduce vibrations caused by vortex shedding from sub sea structures operate by modifying the boundary layer of the flow around the structure to prevent the correlation of vortex shedding along the length of the structure. Examples of such methods include
15 the use of helical strakes around a structure, or axial rod shrouds and perforated shrouds.

Copending U.S. Patent Application Publication 20040175240, having attorney docket number TH2293, discloses an apparatus for suppressing vortex induced vibrations on a
20 marine element of a riser system wherein the riser system comprises at least one umbilical element. Systems comprising and methods of using said apparatus to suppress vortex induced vibrations. The apparatus, systems, and methods comprise module elements which provide: i) a surface around a
25 marine element for installing VIV suppression devices; and ii) passages for housing the at least one umbilical element. U.S. Patent Application Publication 20040175240 is herein incorporated by reference in its entirety.

When fairings or other VIV suppression devices are
30 installed around a subsea structure, a collar is also installed, so that the suppression device is kept from moving along the length of the subsea structure. Collars add to the

cost, complexity, and time involved for installing VIV suppression devices.

There is a need in the art for improved apparatus and methods for suppressing VIV.

5 There is a need in the art for apparatus and methods for suppressing VIV that do not suffer from the disadvantages of the prior art.

There is a need in the art for apparatus and methods for providing VIV suppression to a riser system comprising
10 umbilical elements and for providing protection to the umbilical elements.

There is a need for systems and methods of installing VIV suppression devices without the need for collars.

These and other needs will become apparent to those of
15 skill in the art upon review of this specification, including its drawings and claims.

Summary of the Invention

In one aspect, the invention provides a system for producing oil and/or gas, comprising a subsea structure
20 defining an interior of the system, the structure subject to a water current; a covering exterior to the subsea structure, covering at least a portion of an outside surface of the subsea structure; a vortex induced vibration suppression device exterior to the covering; the covering comprising a
25 first mechanism and the vortex induced vibration suppression device comprising a second mechanism, wherein the first mechanism and the second mechanism are adapted to maintain the vortex induced vibration suppression device in a location along a length of the subsea structure.

30 In another aspect, the invention provides a method of producing oil and/or gas, comprising installing a subsea structure in a body of water, wherein the subsea structure is subject to one or more water currents; installing a covering

exterior to the subsea structure, covering at least a portion of an outside surface of the subsea structure; installing a vortex induced vibration suppression device exterior to the covering; engaging a first mechanism on the covering with a
5 second mechanism on the vortex induced vibration suppression device to maintain the vortex induced vibration suppression in a location along a length of the subsea structure.

Advantages of the invention may include one or more of the following:

- 10 improved apparatus and methods for suppressing VIV;
apparatus and methods for suppressing VIV that do not suffer from the disadvantages of the prior art;
- apparatus and methods for providing VIV suppression to a riser system comprising umbilical elements and for providing
15 protection to the umbilical elements; and/or
- systems and methods of installing VIV suppression devices without the need for collars.

Brief Description of the Figures

Figure 1 illustrates an oil and/or gas production
20 system.

Figure 2a illustrates an oil and/or gas production system.

Figure 2b illustrates a side view of a riser with foam.

Figure 2c illustrates a cross-sectional view of a riser
25 with foam.

Figure 2d illustrates a side view of a riser with foam.

Figure 2e illustrates a cross-sectional view of a riser with foam.

Figure 2f illustrates a side view of a riser with foam.

Figure 2g illustrates a cross-sectional view of a riser
30 with foam.

Figure 3a illustrates an oil and/or gas production system.

Figure 3b illustrates a side view of a riser with foam.

Figure 3c illustrates a cross-sectional view of a riser with foam.

Figure 3d illustrates a side view of a riser with foam.

5 Figure 3e illustrates a cross-sectional view of a riser with foam.

Figure 4 illustrates an oil and/or gas production system.

Detailed Description

10 Referring now to Figure 1 there is illustrated offshore system 100. System 100 includes surface structure 102 near the water surface, which is connected to riser 104, which riser 104 is connected to subsurface structure 106, which is adjacent to seafloor 108. The water has current 110, which
15 may cause vortex-induced vibration of riser 104. To counter VIV, fairings 114 may be installed along the length of riser 104. Collars 112 are needed to keep fairings from moving along the length of riser 104.

Referring now to Figure 2a, system 200 is illustrated.
20 System 200 includes surface structure 202 near the surface of the water, which is connected to riser 204. Riser 204 is also connected to subsurface structure 203 near the seafloor 208. Exterior to riser 204 is foam 206, which may serve to insulate and/or provide buoyancy to riser 204. Current 210
25 is in the water, which may cause VIV on riser 204 and foam 206. Grooves 212 are formed at various locations along the length of foam 206. To attach fairings 214 to foam 206, fairing holders 216 are placed within grooves 212, and attached to fairings 214. Two or more fairing holders 216
30 may be used for each fairing 216.

Referring now to Figure 2b, riser 204 is shown with foam 206 exterior to the riser, grooves 212 have been formed in foam 206, along the length of riser 204.

Referring now to Figure 2c, there is a cross-sectional view of riser 204 and foam 206. Riser 204 is in the interior. Exterior to riser 204 is foam 206, which is illustrated as two sections, 206a and 206b, which maybe
5 connected around riser 204. Internal pockets 222 house lines 220, for example hydraulic lines, electrical lines, choke and kill lines, or other lines as are needed. Split-half pockets 226, defined between sections 206a and 206b, also house lines 220, and external pockets 224 also house lines 220.

10 Referring now to Figure 2d, riser 204 and foam 206 are illustrated with grooves 212 spaced along the length of riser 204. Fairing holders 216 have been placed in grooves 212.

Referring now to Figure 2e, a cross-sectional view of riser 204 and foam 206 is shown. Fairing holder 216 may have
15 opening 216a around part of foam 206. Fairing holder 216 may be rotated to access external pockets 224 so that lines 220 can be inserted into pockets 224 and held in place by fairing holder 216.

Referring now to Figure 2f, riser 204 with foam 206,
20 grooves 212, and with fairing holders 216 in the grooves 212 are shown. Fairing 214 has been attached to fairing holders 216.

Referring now to Figure 2g, cross-sectional view of riser 204 and foam 206 is shown. Fairing 214 has been
25 attached to fairing holder 216 by connectors 215, for example, pins, screws, bolts, welding, or other methods of connection as are known in the art.

Referring now to Figure 3a, system 300 is shown, which includes surface structure 302 near the surface of the water,
30 and subsurface structure 303 near seafloor 308. Riser 304 connects surface structure 302 with subsurface structure 303. Foam 306 is around riser 304. Grooves 312 may be provided at various locations along the length of foam 306. Fairing 314

are mounted around foam 306. Fairings 314 include one or more key inserts 316 which may be inserted into groove 312, and allow fairing 314 to rotate around foam 306, but secures fairing 314 along the length of foam 306.

5 Referring now to Figure 3b, riser 304 with foam 306 is shown, where grooves 312 are formed in foam 306 along the length of foam 306.

Referring now to Figure 3c, a cross-sectional view of riser 304 and foam 306 is shown, with grooves 312, and with
10 various lines 320 provided in internal pockets 322, external pockets 324, and split-half pockets 326.

Referring now to Figure 3d, riser 304 and foam 306 with grooves 312 is illustrated. Fairings 314 have been attached to foam 306, with key inserts 316 of fairings 314 inserted
15 into grooves 312.

Referring now to Figure 3e, a cross-sectional view of riser 304 and foam 306 is illustrated. Groove 312 is formed in foam 306. Various lines 320 are included in internal pockets 322, external pockets 324, and split-half pockets
20 326. To attach fairing 314 to foam 306, fairing 314 is held open and pulled around foam 306, and key insert 316 is inserted into groove 312. When fairing halves are aligned, screws 332 are attached to insert 330 to hold the two halves of fairing 314 together.

25 In some embodiments, key insert 316 may be a single insert, for example, covering from about 15° to about 270° around the radius of foam 306. In some embodiments, several key inserts 316, for example from about 2 to about 10, may be provided on the interior of fairing 314 and inserted into
30 groove 312.

Referring now to Figure 4, system 400 is illustrated with surface structure 402 and subsurface structure 403 connected by riser 404. Foam 406 is provided exterior to

riser 404. Ledges 412 are formed in foam 406. Fairings 414 may be installed between ledges 412. Fairing 414 maybe used to counter VIV effects caused by current 410 in the water.

Illustrative Embodiments

5 In one embodiment, there is disclosed a system for producing oil and/or gas, comprising a subsea structure defining an interior of the system, the structure subject to a water current; a covering exterior to the subsea structure, covering at least a portion of an outside surface of the
10 subsea structure; a vortex induced vibration suppression device exterior to the covering; the covering comprising a first mechanism and the vortex induced vibration suppression device comprising a second mechanism, wherein the first mechanism and the second mechanism are adapted to maintain
15 the vortex induced vibration suppression device in a location along a length of the subsea structure. In some embodiments, the subsea structure is selected from an umbilical, a riser, and a tendon. In some embodiments, the covering comprises foam adapted to provide buoyancy and/or thermal insulation to
20 the subsea structure. In some embodiments, the vortex induced vibration suppression device comprises a fairing. In some embodiments, the first mechanism comprises one or more grooves in the covering. In some embodiments, the second mechanism comprises one or more inserts adapted to fit into
25 the one or more grooves. In some embodiments, the second mechanism comprises one or more vortex induced vibration suppression device holders adapted to fit into the one or more grooves. In some embodiments, the first mechanism comprises one or more ledges extending exterior to the
30 covering. In some embodiments, the second mechanism comprises one or more shoulders on the vortex induced vibration suppression device adapted to interface with the one or more ledges.

In one embodiment, there is disclosed a method of producing oil and/or gas, comprising installing a subsea structure in a body of water, wherein the subsea structure is subject to one or more water currents; installing a covering exterior to the subsea structure, covering at least a portion of an outside surface of the subsea structure; installing a vortex induced vibration suppression device exterior to the covering; engaging a first mechanism on the covering with a second mechanism on the vortex induced vibration suppression device to maintain the vortex induced vibration suppression in a location along a length of the subsea structure. In some embodiments, the first mechanism comprises one or more grooves in the covering, and wherein the second mechanism comprises one or more inserts, wherein engaging comprises fitting the one or more inserts into one or more grooves. In some embodiments, the first mechanism comprises one or more ledges extending exterior to the covering, and wherein the second mechanism comprises one or more shoulders on the vortex induced vibration suppression device, wherein engaging comprises placing one or more vortex induced vibration suppression devices between the one or more ledges.

Those of skill in the art will appreciate that many modifications and variations are possible in terms of the disclosed embodiments, configurations, materials and methods without departing from their spirit and scope. Accordingly, the scope of the claims appended hereafter and their functional equivalents should not be limited by particular embodiments described and illustrated herein, as these are merely exemplary in nature.

30

C L A I M S

1. A system for producing oil and/or gas, comprising:
 - a subsea structure defining an interior of the system,
 - 5 the structure subject to a water current;
 - a covering exterior to the subsea structure, covering at least a portion of an outside surface of the subsea structure;
 - a vortex induced vibration suppression device exterior
 - 10 to the covering;
 - the covering comprising a first mechanism and the vortex induced vibration suppression device comprising a second mechanism, wherein the first mechanism and the second mechanism are adapted to maintain the vortex induced
 - 15 vibration suppression device in a location along a length of the subsea structure.
2. The system of claim 1, wherein the subsea structure is selected from an umbilical, a riser, and a tendon.
- 20 3. The system of one or more of claims 1-2, wherein the covering comprises foam adapted to provide buoyancy and/or thermal insulation to the subsea structure.
- 25 4. The system of one or more of claims 1-3, wherein the vortex induced vibration suppression device comprises a fairing or a helical strake.
- 30 5. The system of one or more of claims 1-4, wherein the first mechanism comprises one or more grooves in the covering, for example a circumferential groove.

6. The system of claim 5, wherein the second mechanism comprises one or more inserts adapted to fit into the one or more grooves.
- 5 7. The system of claim 5, wherein the second mechanism comprises one or more vortex induced vibration suppression device holders adapted to fit into the one or more grooves.
8. The system of one or more of claims 1-7, wherein the
10 first mechanism comprises one or more ledges extending exterior to the covering, for example circumferential ledges.
9. The system of claim 8, wherein the second mechanism comprises one or more shoulders on the vortex induced
15 vibration suppression device adapted to interface with the one or more ledges.
10. The system of one or more of claims 1-9, wherein the first mechanism comprises one or more holes, threaded holes,
20 or axial slots in the covering.
11. The system of claim 10, wherein the second mechanism comprises one or more spikes, screws, bolts, or attachments adapted to mate with the one or more holes, threaded holes,
25 or axial slots in the covering.
12. A method of producing oil and/or gas, comprising:
installing a subsea structure in a body of water,
wherein the subsea structure is subject to one or more water
30 currents;
installing a covering exterior to the subsea structure,
covering at least a portion of an outside surface of the subsea structure;

installing a vortex induced vibration suppression device exterior to the covering;

engaging a first mechanism on the covering with a second mechanism on the vortex induced vibration suppression device
5 to maintain the vortex induced vibration suppression in a location along a length of the subsea structure.

13. The method of claim 12, wherein the first mechanism comprises one or more grooves in the covering, and wherein
10 the second mechanism comprises one or more inserts, wherein engaging comprises fitting the one or more inserts into one or more grooves.

14. The method of one or more of claims 12-13, wherein the
15 first mechanism comprises one or more ledges extending exterior to the covering, and wherein the second mechanism comprises one or more shoulders on the vortex induced vibration suppression device, wherein engaging comprises placing one or more vortex induced vibration suppression
20 devices between the one or more ledges.

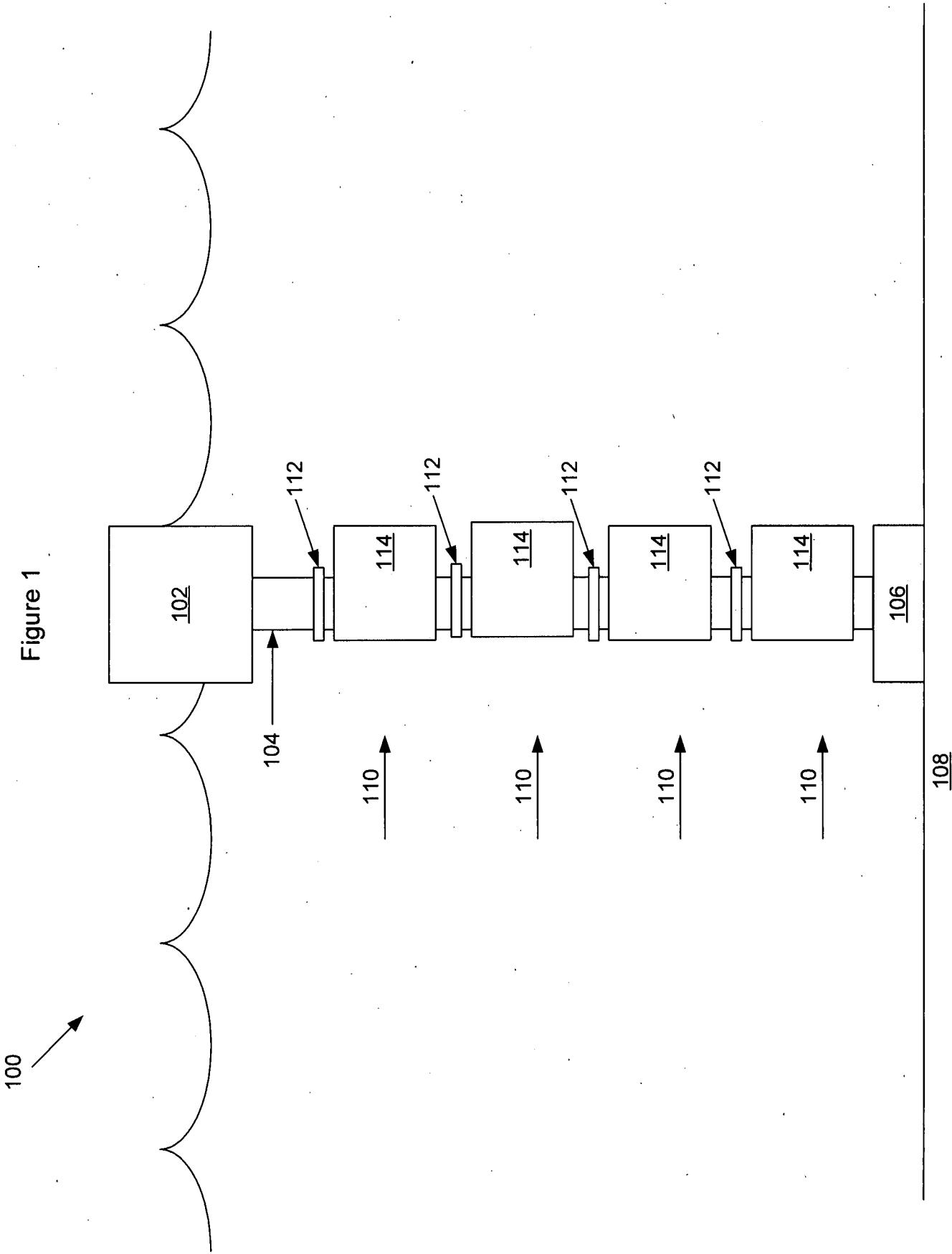


Figure 2a

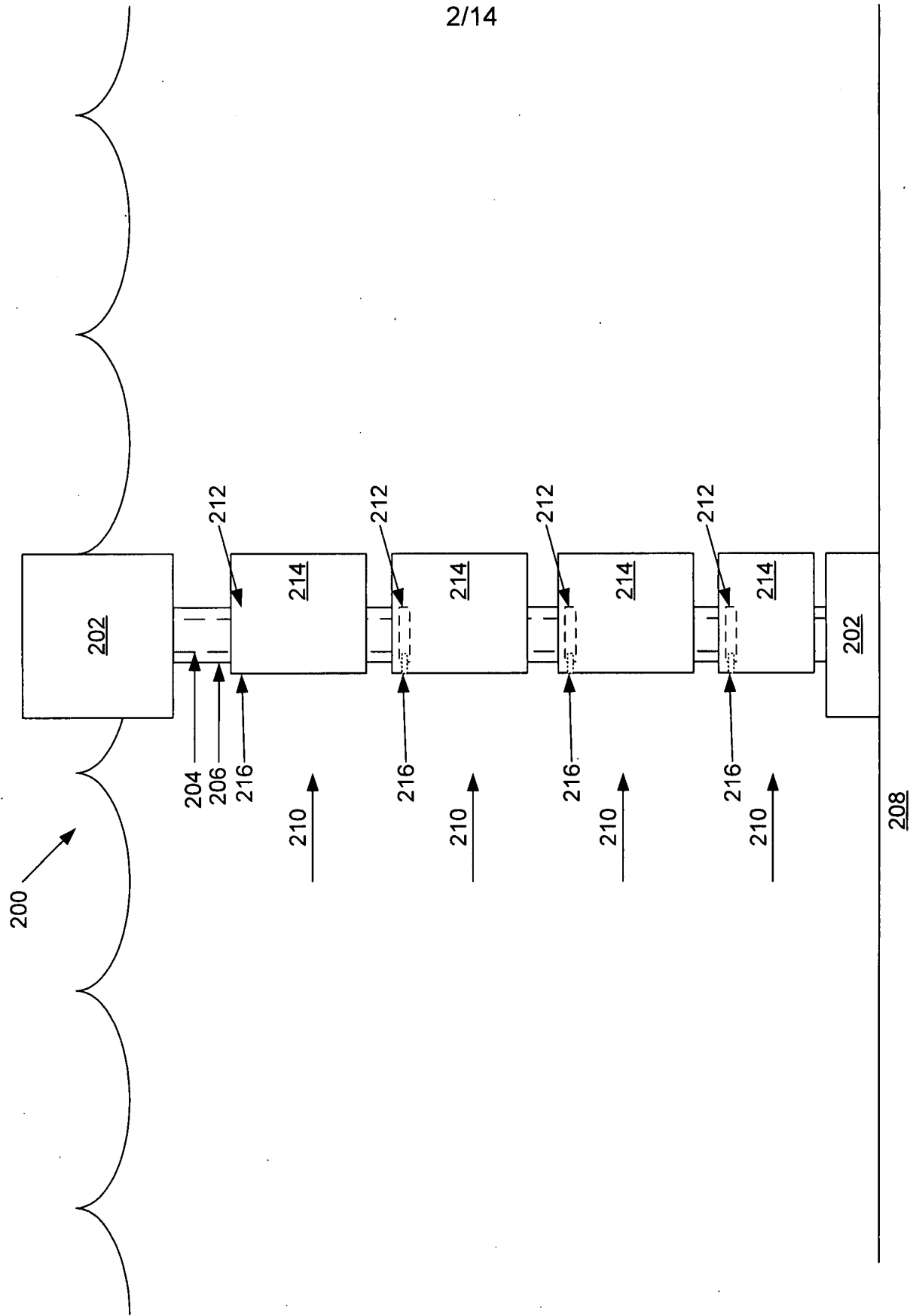


Figure 2b

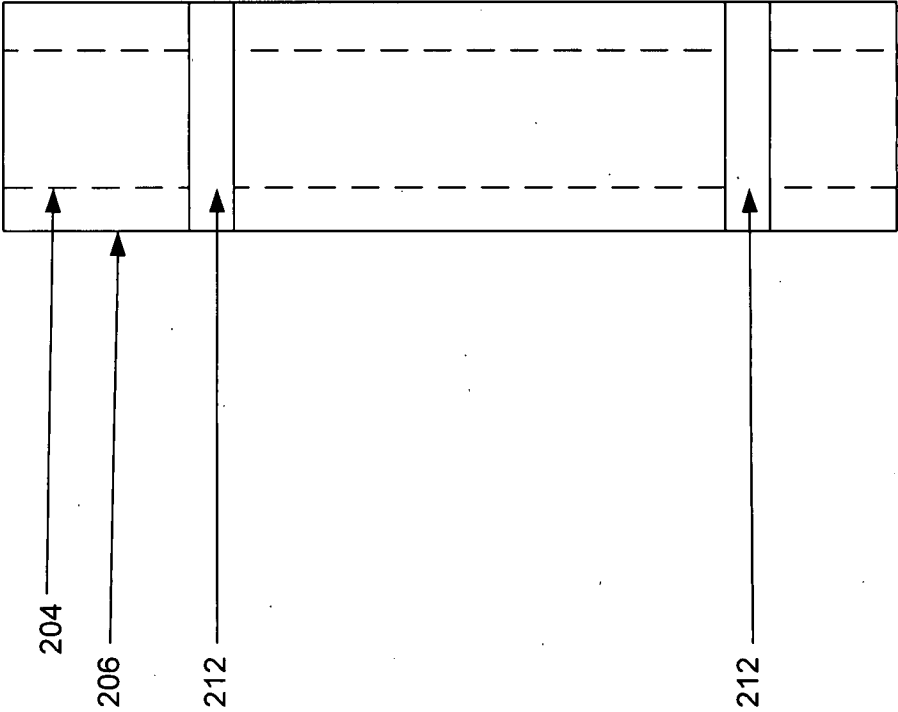


Figure 2c

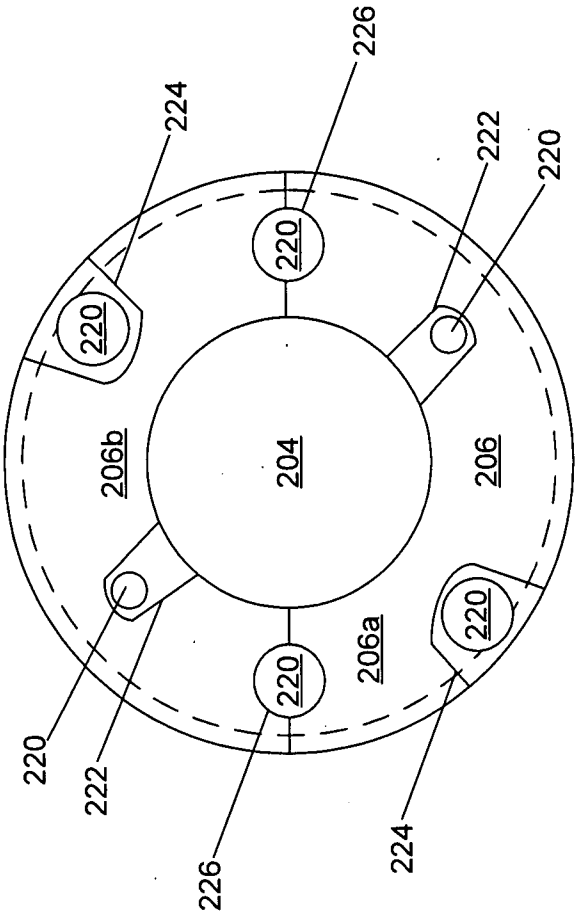


Figure 2d

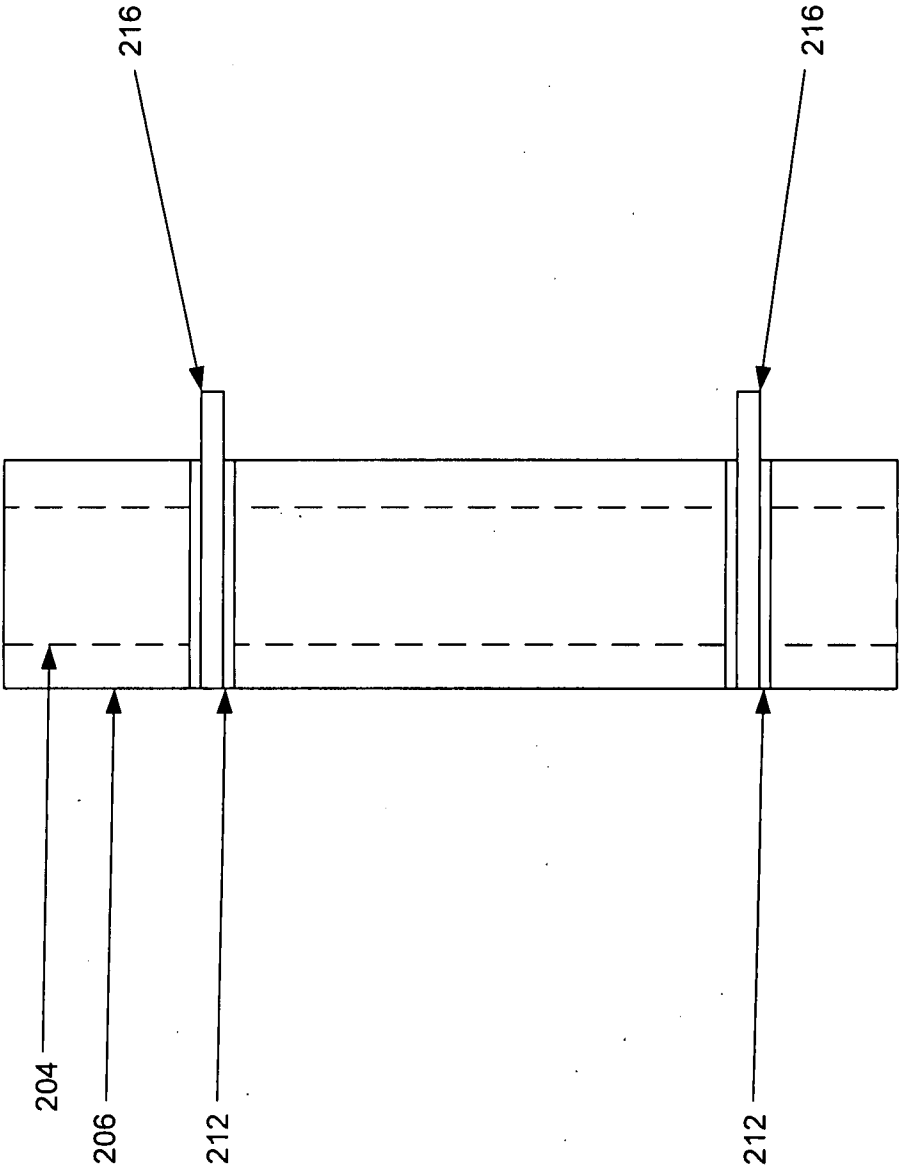


Figure 2e

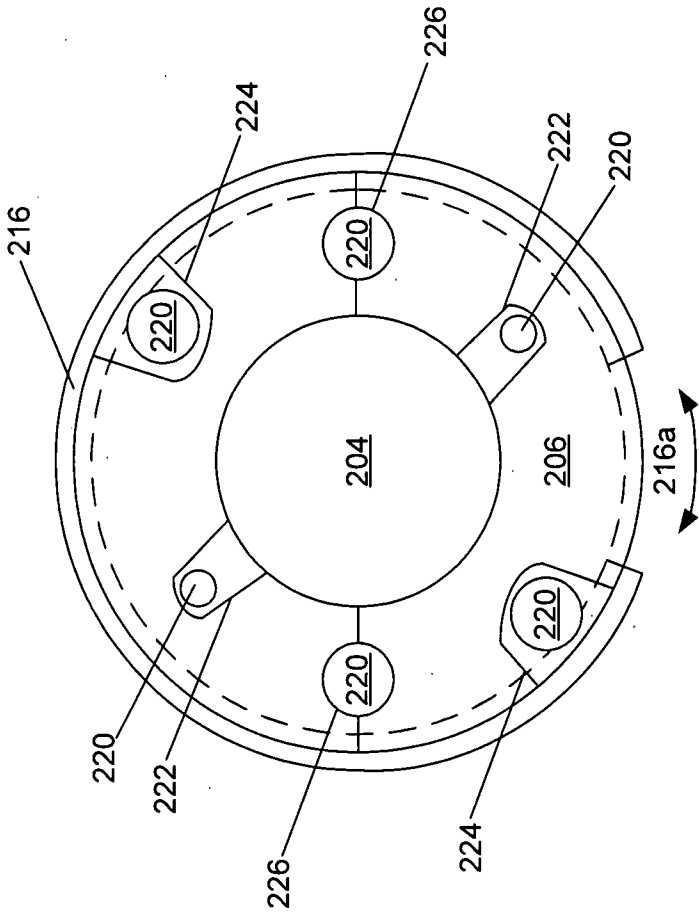
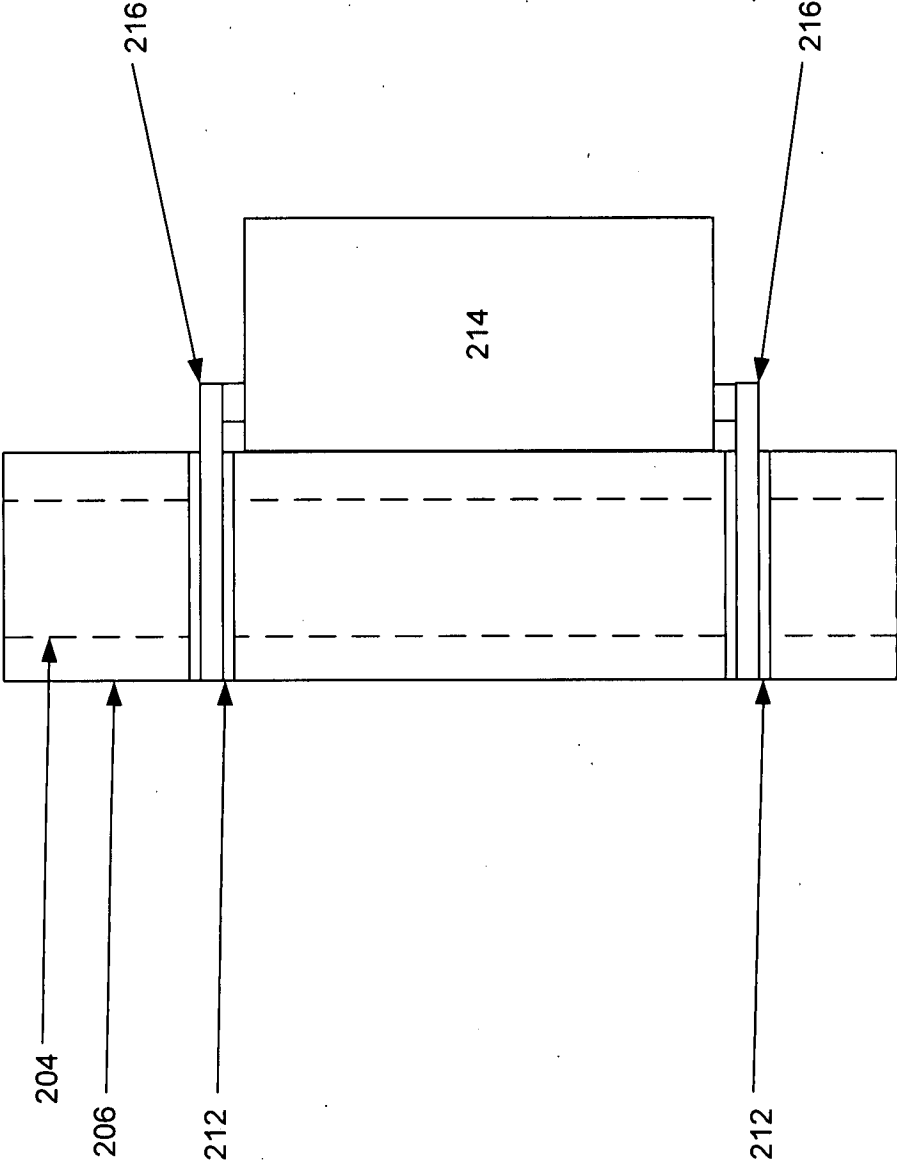
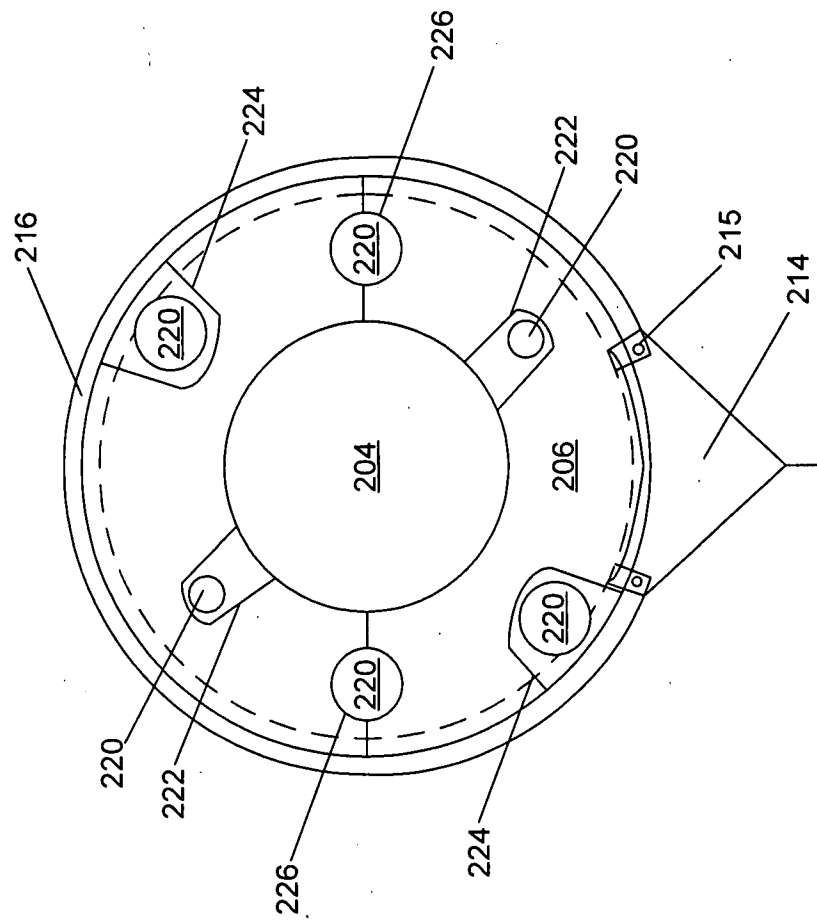


Figure 2f



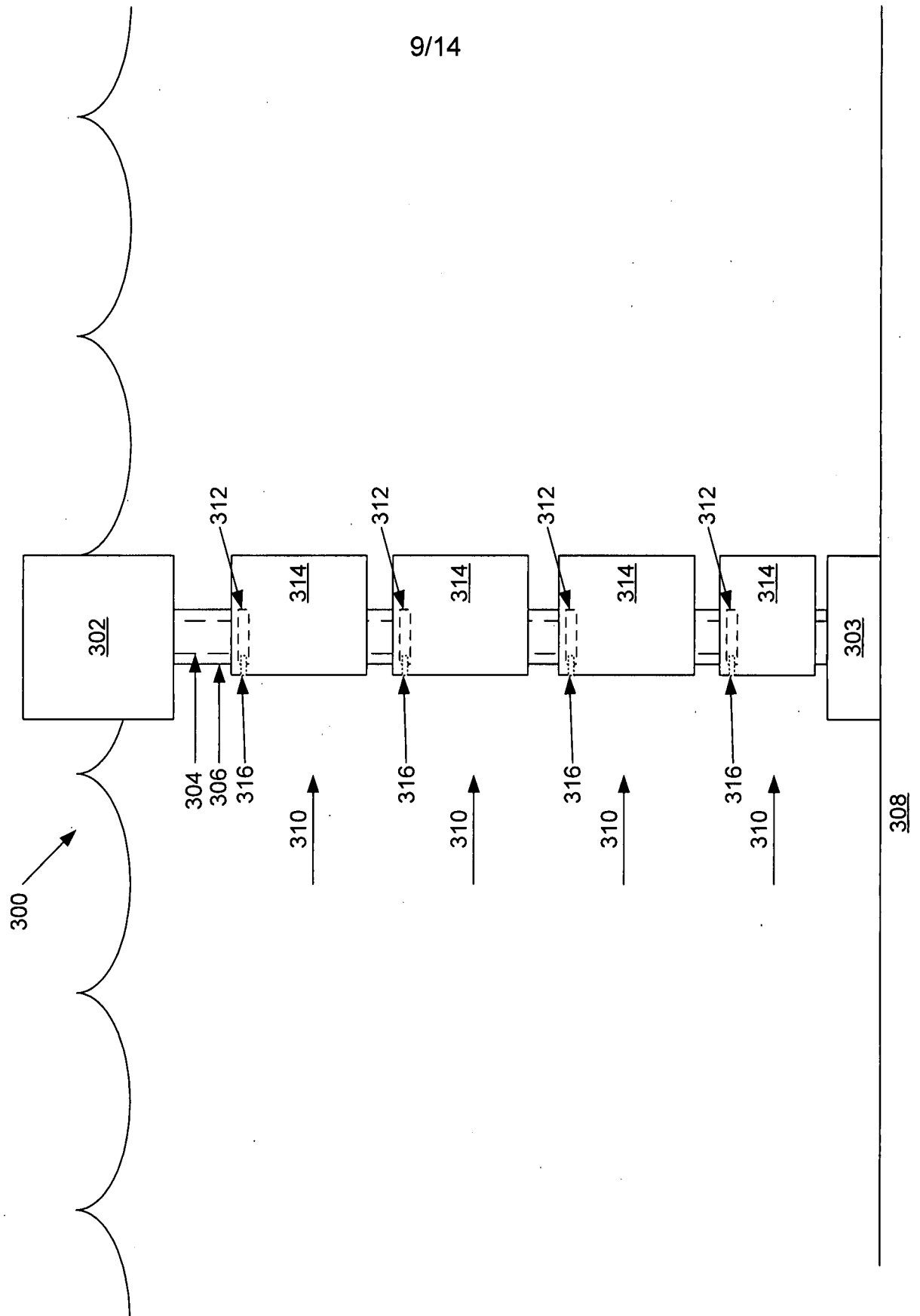
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Figure 2g



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Figure 3a



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Figure 3b

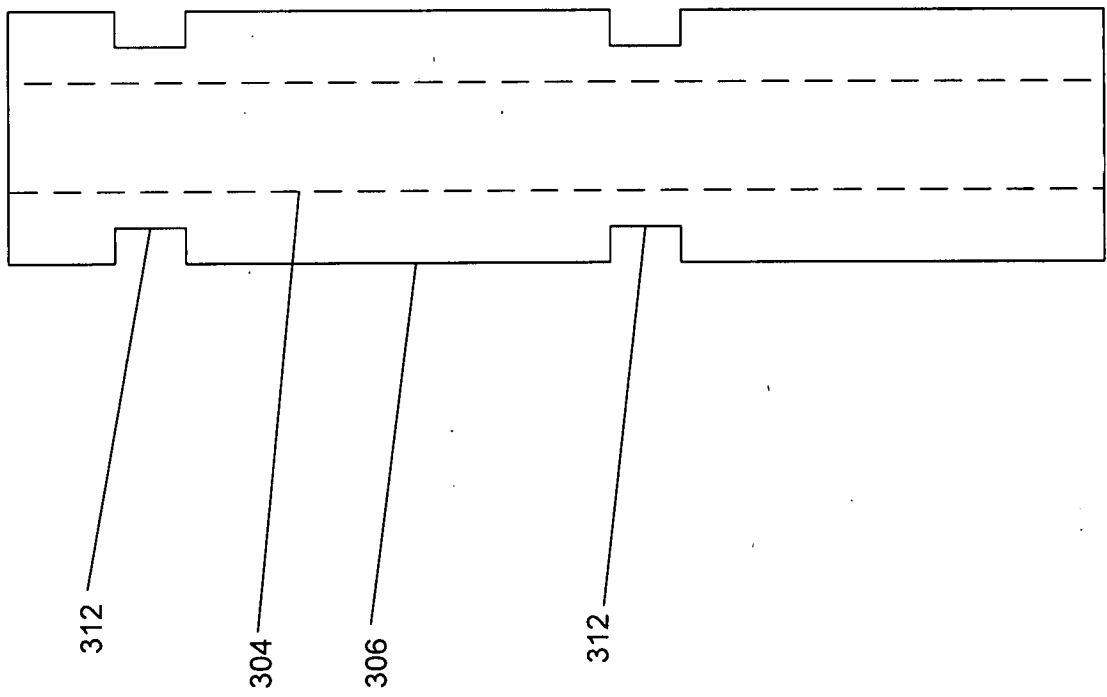


Figure 3c

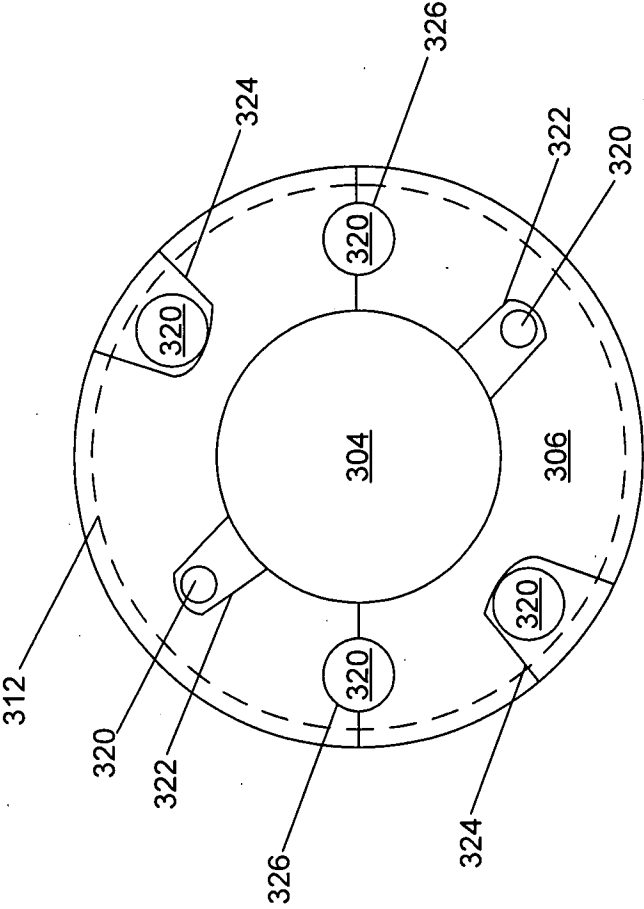


Figure 3d

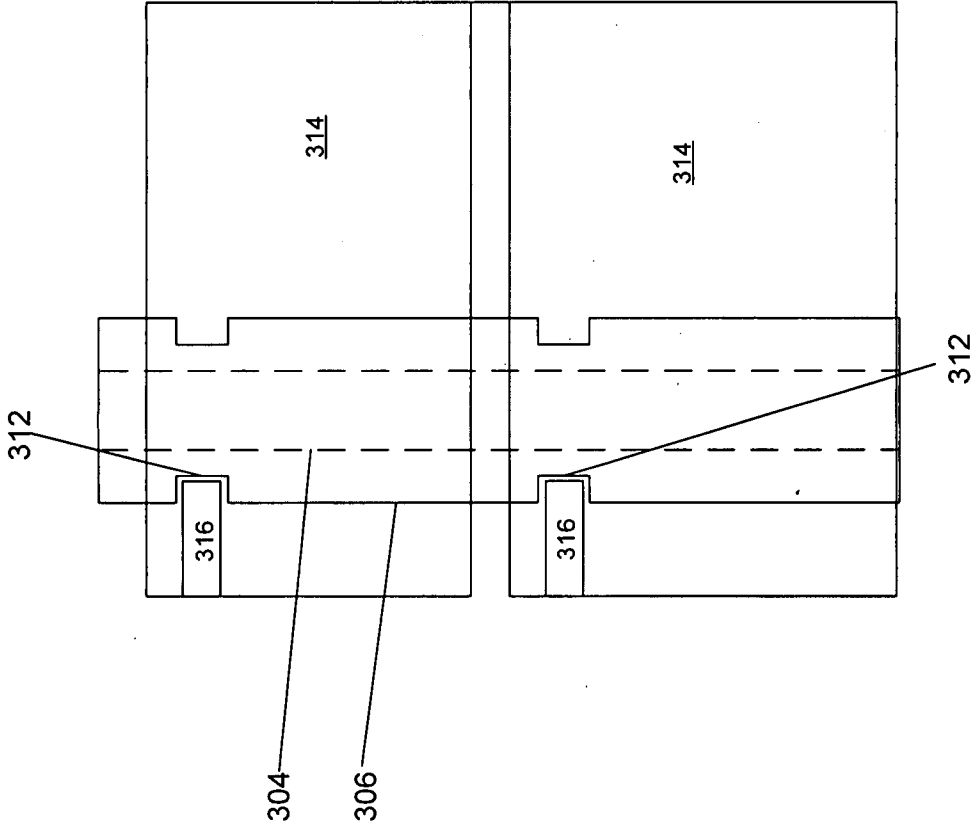


Figure 3e

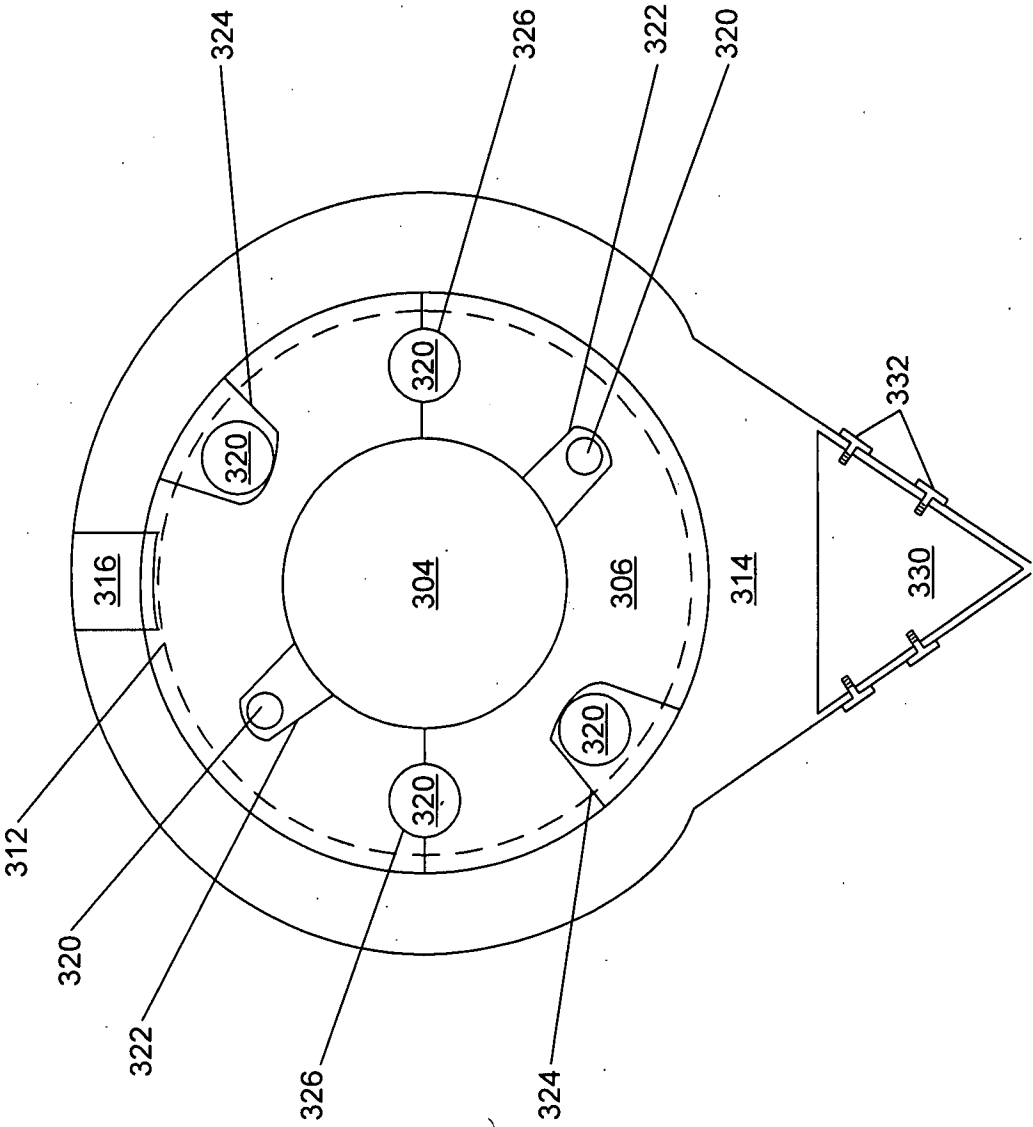


Figure 4

