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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
29 December 2011 (29.12.2011)

PCT

(10) International Publication Number
WO 2011/163573 A2

(51) International Patent Classification:
E21B 33/06 (2006.01)

(21) International Application Number:
PCT/US2011/041793

(22) International Filing Date:
24 June 2011 (24.06.2011)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/358,662 25 June 2010 (25.06.2010) US

(71) Applicant *(for all designated States except US)*: **MJB OF MISSISSIPPI, INC.** [US/US]; 4735 Old Canton Road, Jackson, MS 39211 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **CALDWELL, William, M.** [US/US]; 16301 Allie Byrd Road, Ocean Springs, MS 39565 (US). **PAYNE, James, P., Jr.** [US/US]; 6608 Pine Burr Drive, Vancleave, MS 39565 (US).

(74) Agent: **BUSH, Kenneth, M.**; Bush Intellectual Property Law Group, LLC, P.O. Box 381146, Birmingham, AL 35238 (US).

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

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: APPARATUS AND METHOD FOR ISOLATING AND SECURING AN UNDERWATER OIL WELLHEAD AND BLOWOUT PREVENTER

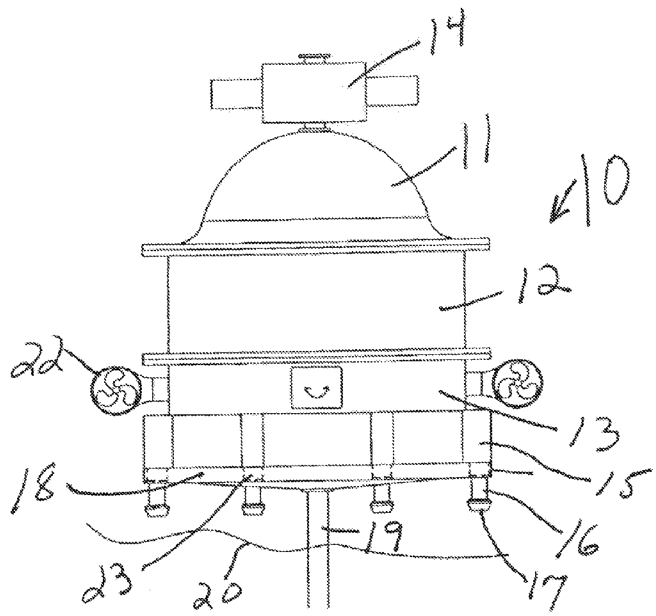


Fig. 4

(57) Abstract: A containment system having a containment dome (10) and a seal plate (18) which is attached to an oil wellhead casing or riser (19) to prevent oil spills and contamination when an oil leak occurs. The containment dome (10) is sealed to the seal plate (18) by a compression mechanism so that oil will not leak from the containment dome (10). The containment dome (10) can provide a wellhead patch (60) to a wellhead system wherein the wellhead patch (60) can interface with a capping stack. Chemicals can be injected into the containment dome (10) to prevent hydrates from forming. All aspects of controlling and operating an oil wellhead can be performed through the containment dome (10) and seal plate (18), and all aspects of installation, regulation, and control of the containment dome (10) can be performed by remote operating vehicles under water.

WO 2011/163573 A2

Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

APPARATUS AND METHOD FOR ISOLATING AND SECURING AN UNDERWATER OIL WELLHEAD AND BLOWOUT PREVENTER

Technical Field

This invention relates to devices for stopping or preventing fluids leaking from oil wellheads and related structures and, more particularly, to a wellhead fluid containment system consisting of a containment dome and seal plate sealed together by compression and providing a method for isolating and securing a deepwater wellhead in case of failure.

Background Art

As demand for oil has increased, oil companies have developed devices and methods to allow deepwater drilling. With drilling platforms used today, oil companies have been able to drill wells at depths that exceed over a mile below the water surface. However, the oil and gas industry has failed to develop an efficient method for isolating and securing the wellhead and blowout preventer in the event of a catastrophic failure, such as encountered recently by the Deepwater Horizon rig operated by British Petroleum (BP). BP made several unsuccessful attempts to terminate or capture the oil and gas escaping into the Gulf of Mexico by placing a containment dome over the leaking wellhead. There are several problems with placing an unsealed containment dome over a leaking wellhead, such as oil escaping from around the unsealed bottom and hydrates forming inside the dome and thereby blocking the lines used to collect the leaking oil.

Disclosure of the Invention

The present invention provides a containment system for an oil wellhead having a seal plate attached to a wellhead casing or riser, a containment dome that fits on the seal plate, and a compression mechanism which compresses the seal plate and the containment dome together to collect and control fluids leaking from devices attached to the wellhead. In use, fluids leaking from an oil wellhead are contained by installing the seal plate on a wellhead casing or riser, lowering the containment dome onto the seal plate, sealing the seal plate to the containment dome by compressing the seal plate and containment dome together, and collecting, containing, and regulating fluids leaking from the wellhead casing or riser, or from devices contained within the containment dome.

Another embodiment of the containment system has a seal plate attached to a wellhead casing or riser, a containment dome that fits on the seal plate wherein the containment dome has a wellhead patch, and a compression mechanism which compresses the plate and the containment dome together to collect and control fluids leaking from devices attached to the wellhead. In use, the seal plate is installed on a wellhead casing or riser. The containment dome having the wellhead patch is lowered onto the seal plate, the seal plate is sealed to the containment dome by compressing them together, and the wellhead patch is extended into a bore of a blowout preventer (BOP) to lock and seal the bore.

Another embodiment of the containment system has a first seal plate attached to a marine riser, a first containment dome that fits on the first seal plate, a compression mechanism which compresses the seal plate and the containment dome together to collect and control fluids leaking from the marine riser, a second seal plate attached to a wellhead casing or riser, and a second containment dome that fits over the first containment dome and the first seal plate, encapsulating a portion of the first containment dome and the first seal plate. The second containment dome has a second compression mechanism which compresses the second seal plate and the second containment dome together to collect and control fluids leaking from devices attached to the wellhead. In use, the first seal plate is installed to a marine riser. The second seal plate is installed to a wellhead casing or riser. A first containment dome is lowered on to the first seal plate, and the first seal plate and the first containment dome are compressed together to collect, control, and regulate fluids leaking from the marine riser. The second containment dome is lowered over the first containment dome and the first seal plate, encapsulating a portion of the first containment dome and the first seal plate. The second containment dome is also lowered on to the second seal plate. The second seal plate and the second containment dome are compressed together to collect, control, and regulate fluids leaking from devices contained within the containment dome.

An advantage of the present invention is a simple method of rapidly placing a containment dome around a leaking portion of an oil wellhead system to prevent oil spills and contamination.

Another advantage is a simple method of confining the leaking oil within a containment dome by sealing the containment dome to a seal plate by compressing the containment dome and seal plate together.

Another advantage is a seal plate that can be attached to an oil wellhead casing or riser during construction of the wellhead or that can be attached to an existing wellhead casing or riser.

Another advantage is a containment dome that can provide a wellhead patch to a wellhead system wherein the wellhead patch can interface with a capping stack.

Another advantage is the ability to inject chemicals into the containment dome, such as methanol, to prevent hydrates from forming.

Another advantage is that the containment dome may be constructed for zero, plus, or minus buoyancy.

Another advantage is that all aspects of controlling and operating an oil wellhead can be performed through the containment dome and seal plate, and all aspects of installation, regulation, and control of the containment dome can be performed by remote operating vehicles (ROVs) under water.

Brief Description of the Drawings

Fig. 1 is an exploded view of an embodiment of the containment system of the present invention having a containment dome and a seal plate.

Fig. 2 is a cross-sectional view of a smaller containment dome having a top section and a base.

Fig. 3 is a detailed cross-sectional view of the edge of the base of a containment dome and seal plate.

Fig. 4 shows a containment dome in position on a seal plate with rams inserted through ram slots in the seal plate to compress the containment dome and seal plate together.

Fig. 5 shows a containment dome having additional features such as vents or injection ports and a base of the containment dome having additional features such as video cameras and high pressure spray nozzles for clearing the wellhead or casings.

Fig. 6 shows an alternate embodiment of the containment dome base having hydraulic rotating mechanisms with rams which have ring gears.

Fig. 7 shows a top view of a seal plate and its circumferential ring.

Fig. 8 shows an embodiment wherein a seal plate is in the form of a flange seal plate which can be fastened to a riser above a BOP.

Fig. 9 shows an alternate embodiment of a seal plate which has pulleys on its perimeter.

Fig. 10 shows a containment dome having cable connectors attached at its base.

Fig. 11 shows a common oil drilling package comprising a lower marine riser package, a BOP, and a shear module, being a unitization of a seal plate, a dual ram closing system, well bore instrumentation to provide enhanced well control instrumentation, and two dual gradient modules.

Fig. 12 shows an alternate embodiment wherein external control panels can be attached to the exterior of the containment dome.

Fig. 13 shows a containment system designed to carry and install a wellhead patch.

Fig. 14 shows a combination of a portion of a small containment dome contained within a larger containment dome.

Fig. 15 shows a seal plate sectioned into two equal halves.

Fig. 16 shows a seal plate divided into a larger section and a smaller section.

Fig. 17 shows a half section of a seal plate in position around a casing.

Best Modes for Carrying Out the Invention

While the following description details the preferred embodiments of the present invention, it is to be understood that the invention is not limited in its application to the details of construction and arrangement of the parts illustrated in the accompanying drawings, since the invention is capable of other embodiments and of being practiced in various ways.

The present invention is a containment dome and seal plate providing a method for isolating and securing a deepwater wellhead and associated drilling and completion systems in case of failure. The containment dome and seal plate provide a containment system which will provide a standard for isolating and securing a wellhead at the sea floor and for preventing oil spills. The containment dome is sealed to the seal plate by a compression locking mechanism, thereby isolating the wellhead from the environment while supporting additional natural drive forces for the delivery of the well effluent to the surface support vessel. The containment dome serves as a remotely operated underwater vehicle (ROV) having a base engaging a seal plate preferably mounted about the oil well casings subjacent to a blowout preventer (BOP).

The containment dome top preferably comprises a plurality of access ports that serve as vents or used for injecting chemical inhibitors such as methanol to prevent hydrates from forming while the containment dome is being secured to the seal plate or thereafter. The containment dome base has mechanisms to lock the dome base to the seal plate. It may further have a plurality of underwater cameras and lights so that the alignment of the base with the seal plate can be visually and remotely observed for remote control of the containment dome. The containment dome base may include an exterior module located beneath the base plate or on the containment dome that provides remote operation of encapsulated well components.

The system has provision for enhanced instrumentation of the drilling system to provide early warning of well control anomalies, and once a well control scenario is auctioned, can provide reliable data to the operator of the condition of the well.

In use, with the seal plate in place around the oil well casings, drilling of the wellbore may be performed as normal. However, in the event of a leak the containment dome of the present invention may be lowered and attached to the seal plate as described and shown herein, thereby isolating the wellhead and BOP. The leaking oil can either be contained within the containment dome or diverted out of the containment dome as desired.

A flange seal plate may be attached to the top of a BOP wherein the flange seal plate is a smaller version of the seal plate described above. Having both the seal plate and the flange seal plate provides an option to either isolate the entire wellhead or just the top of the BOP.

A combination of routine drilling services for the well bore may be installed on a wellhead seal plate prior to drilling operations. The drilling rig BOP and marine riser system shall land and attach to the top of the seal plate. These devices may be controlled through the drilling BOP control system, or by any other means permanently installed or connected by robotic tooling, during those periods when the primary drilling BOP control system is dysfunctional. Also, these devices may be constructed to include such drill related services as: riser fluid circulation support, dual gradient drilling systems, enhanced instrumentation for well control management, temporary well capping, and the like.

The containment system can carry and install a wellhead patch, capable of directing well fluids from both the containment enclosure and/or gripping and sealing within the BOP main bore such that a full working pressure of the BOP can be achieved through the wellhead patch to a re-entry or capping stack.

<u>Containment Construction</u>

Fig. 1 shows an illustration of an embodiment of the containment system of the present invention. The containment dome **10** has a top section **11**, a middle section **12**, and a base **13**. The base **13** of the containment dome **10** engages a sealing plate **18** which is attached to the well casing **19** embedded in the sea floor **20**. The seal plate **18** is shown having a pair of BOPs (stacked). If these BOPs are damaged or leaking then oil spill can be prevented by covering them with the containment dome **10**. The upper section **11** of the containment dome is shown having a replacement BOP **14**. Although the containment dome **10** is shown in sections it can be constructed as a single unit of base, midsection, and top section. Base **13** is shown as having hydraulic cylinders **15** with rams **16**. The tips of rams **16** have conical heads **17** wherein the maximum diameter of the heads **17** is greater than the diameter of the rams **16**. Seal plate **18** is shown as having ram slots **23** which are wider at one end to accommodate the maximum diameter of the conical heads **17** and narrower at the opposite end which accommodates the diameter of the ram **16** but the conical head **17** cannot pass through the narrower opposite end (see fig. 7). The base **13** has hydraulic rotation mechanisms **22** consisting of propellers which will rotate the base clockwise or counterclockwise relative to the seal plate **18**. The conical heads **17** can be inserted through the wider end of the ram slots **23** and the base **13** is rotated so that the rams **16** enter into the narrow end of the ram slots. The ram slots **23** can be retrieved into the hydraulic cylinders **15** and the conical heads **17** will compress the base **13** onto the seal plate **18** by the force of the hydraulic cylinders **15**. A seal is therefore formed between the base **13** of the containment dome **10** and the seal plate **18** by compression. The containment dome is preferably constructed of carbon composite materials to provide maximum strength-weight control but not limited to using only carbon composite materials. Any material that meets required specifications suitable for well conditions may be used. The seal plate **18** is attached to well casings or pipe **19** by either bolts or an industry standard quick connect.

Fig. 2 illustrates a cross section of a smaller containment dome **10** having a top section **11** and a base **13**. The seal plate **18** has an annular flange **25** which fits into an annular recess **24** in the bottom of the base **13**. Rams **16** are shown inserted into ram slots **23**. Base **13** may also have recesses **26** to accommodate O-rings. Fig. 3 illustrates a detailed view of the edges of base **13** and seal plate **18**. The annular flange **25** is shown inserted into the annular recess **24** and O-rings **27** are shown positioned into recesses **26**. The ram **16** is shown withdrawn into the hydraulic cylinder **15** so that the conical head **17** causes the seal plate **13** to be compressed against the base **13**. Fig. 4 also shows the containment dome **10** in position on the seal plate **18** with the rams **16** inserted through the ram slots **23**. Fig. 5 shows that the containment dome **10** can have additional features such as vents or injection ports **30** and the base **13** can have additional features such as video cameras **31** and high pressure spray nozzles **32** for clearing the wellhead or casings. Fig. 6 shows an alternate embodiment of the base **13** having hydraulic rotating mechanisms **33** with rams **34** which have ring gears **35**. The ring gears **35** engage a circumferential ring gear **36** on the seal plate **18**. Rotation of the rams **34** by the hydraulic rotating mechanisms **33** can rotate the base **13** clockwise or counter clockwise relative to the seal plate **18**. Fig. 7 shows a top view of the seal plate **18** and its circumferential ring gear **36**. Ram slots **23** are also shown. The conical heads **17** are inserted through the larger opening **38** of the ram slot **23** and then the base **13** is rotated so that the rams **16** are moved into the smaller openings **37** of the ram slots **23**. The rams **16** can then be withdrawn into the hydraulic cylinders **15** causing the base **13** of the containment dome **10** and the seal plate **18** to be compressed together.

Fig. 8 shows an embodiment where a seal plate is in the form of a flange seal plate **41** which can be fastened to a riser **40** above the BOP **21**. This will allow the placement of a small containment dome **10** to enclose a cut riser above the BOP **21**.

Fig. 9 shows an alternant embodiment of a seal plate **18** which has pulleys **42** on its perimeter. The pulleys **42** are supported by support members **43** on the seal plate **18**. Fig. 10 shows a containment dome **10** having cable connectors **44** attached at its base **13**. Cables **45** are connected to the cable connecters **44**, inserted around the pulleys **42**, and extended upwards to a buoyancy control device **46** and cable connecting ring **47**. As the buoyancy control device **46** rises to the surface the containment dome **10** will lower on to seal plate **18**. Continued upward force on the cables **45** will compress the containment dome **10** and seal plate **18** together. Other methods may also be used to secure the containment dome **10** to the seal plate **18**. For example, the containment dome **10** may have a plurality of connection points for attaching cables to sea anchors for the purpose of winching and compressing the containment dome **10** against the seal plate **18**. In addition, locking pins or bolts may be inserted through the base **13** and the seal plate **18** and tightened to compress the base **13** onto seal plate **18**.

<u>Shear Ram Module Basis</u>

The seal plate **18** can be constructed integral to any type of unitized module desired or combination of modules. Fig. 11 illustrates a common drilling package consisting of: a lower marine riser package **50**, a BOP **51**, and a shear module **52**, being a unitization of a seal plate **18**, a dual ram closing system, well bore instrumentation to provide enhanced well control instrumentation and two dual gradient modules **53**. The dual gradient modules **53** are connected to the shear module **52** with connector pipes **54**. The dual gradient modules **53** use a by-pass flowline-riser system for their operations just as that required for well control operations. A hydraulic power riser used in dual gradient drilling can provide the chemical injection delivery system required for well control operations during well control operations. These lines **55** can extend out from the shear module **52**. The seal plate **18** is connected to wellhead **56**. Flow lines **57** can extend out from the dual gradient modules **53** to pipe risers and be supported by buoyancy devices **58**. The shear module **52** can be configured as just an outlet spool (omitting the BOP rams) on the seal plate **18**. The dual gradient modules **53** can remain in the circuit during well control operations, or can be removed and the flow lines **57** connected in their stead. The dual gradient modules **53** have booster pumps capable of raising flow line pressure to over 5,000 psi above seafloor pressures. Risers required for the containment system should have a flow rate capacity of 50,000 BOPD at flowing pressure differentials to ambient of up to 2,000-psid. Where these equipment spreads are used for dual gradient drilling support, these risers will need a working pressure of up to 10,000-psid (to ambient).

The control of this containment system can be from BOP systems and/or from risers used to take the by-pass flow to the surface. The risers can be made on site using stalking standards of pipe in a fashion similar to that of the drilling rig operations and in multi-service vessels. The buoyancy devices can be of syntactic foam, air cans, or inflatable balloon-like chambers. These too can be operated by the multi-service vessels. Flexible pipe risers to the surface can be supported by a multi-service vessel with a return line to the drilling rig, in the case of dual gradient drilling, to a tanker, in the case of a well control situation, or to the drilling rig directly in another dual gradient situation.

<u>A BOP Based Containment System</u>

A typical well site may have a conductor pipe, a wellhead, a shear module, a BOP, a low marine riser package, and a riser. Encapsulating all these devices within the containment dome may restrict access needed to perform routine operations on these devices, particularly access to standard internal control panels in the shear module and low marine riser package. Therefore, external control panels **80** (see Fig. 11) can be attached to the seal plate **18**, and bypass plumbing **81** from the internal standard control panels may be extended through the seal plate **18** to the external control panels **80** for remote operation once encapsulation and containment is achieved. The additional control panels provide operation of all systems that have been encapsulated, including hydraulic power and/or chemical injection. Another embodiment to address the need to access control of the shear module, BOP, and LMRP once they are encapsulated with the containment dome is to integrate exterior control panels into the containment dome structure. Fig. 12 shows external control panels **100** (for the LMRP) and **101** (for the shear module) attached to the exterior of the containment dome **10**. The containment dome **10** may have internal plumbing connecting the external control panels **100**, **101** to the quick connects **102** located at base **13** of containment dome **10**. The seal plate **18** has a conical sealing surface **103** to aid with containment dome alignment. The seal plate **18** has recessed ports **104** located around the top surface of seal plate **18**. The recessed ports 104 will accept the quick connects **102** on base **13** of containment dome **10** and provide a path through seal plate **18** for hydraulic power and/or chemical injection to all encapsulated devices. Fig. 12 also displays a typical BOP **51** and LMRP **50** that are to be encapsulated in the event that a leaking component cannot be replaced or repaired without causing additional impact to the environment. Fig. 12 further displays an optional smaller sealing plate **105** located above the LMRP **50** for the purpose of attaching a smaller dome to encapsulate a flex joint and cut off riser.

Fig. 13 illustrates a containment system designed to carry and install a wellhead patch **60** with the capability of directing well fluids from both the containment dome and/or gripping and sealing within the BOP main bore such that a full working pressure of the BOP can be achieved through the wellhead patch **60** to a reentry or capping stack. Fig. 13 further shows a capping stack interface **61**, a rotational valve port **62**, a slip assembly **63**, a packoff seal **64**, bypass flow lines **65** from the dual gradient modules **53**, and a stack flex joint **66**. The Wellhead patch is integral with the containment dome and is thus run as one unit. It can be attached on a casing riser or be attached beneath the capping stack. Once the containment dome is landed, the patch extends into the BOP to lock and seal to the bore. The side port **65** continues to allow containment based bypass flows until the vertical tie back determines well integrity level and, thus, defines the way forward. With a capping stack, the side ports can be closed to give full pressure integrity to the vertical access, and well control procedures can begin. This configuration facilitates holding greater than 2000-psi in the containment dome. The wellhead patch generates the required bore of 9” for entry to the 9-5/8” casing, or 12-3/4” for entry into the 13-3/8” casing string.

Fig. 14 illustrates a combination of a portion of a small containment dome **90** contained within a larger containment dome **96**. The smaller dome **90** is shown enclosing a marine riser **93**, and having a main high pressure flow line **94** and a bypass line **95**. The small containment dome **90** is attached to flange seal plate **92**. The larger containment dome **96** is shown as having a main low pressure flow line **98**, a bypass line **99**, and enclosing a low marine riser package (LMRP) **50**, a BOP **51**, and a shear module **52**.The larger containment dome **96** is attached to seal plate **97**.

The smaller containment dome system uses a containment dome greatly reduced in size compared to the larger containment dome, and the seal plate **92** is integrated permanently into the drilling riser system. This system addresses the control of the well bore only, eliminating the complexities of well control and control system intervention. In this system the seal plate **92** is integrated into the marine riser above a lower flex joint or the top of the (LMRP). The containment domes and the seal plates are passive devices in terms of well control and form an emissions control from the perspective of the riser only.

This containment system having the smaller containment dome provides a narrow level of encapsulation while facilitating the establishment of well control through the total BOP assembly. The containment domes have the required guidance, locking, sealing and intervention functions to effectively capture and divert well effluent to a surface recovery vessel, and permit the safe re-entry of tools into the well bore for well control operations. The riser systems are either integral to the containment dome handling system, or horizontal take-offs to independent risers, for the recovery of the produced fluids. Surface systems are capable of processing a water-hydrocarbon mixture, stripping water, and storing and offloading hydrocarbon. A suite of robotic tools enable the access of the containment dome to the (LMRP)-based seal plate, establishing control of the BOP via ROV control panels and providing essential observation and instrumentation of the field operations at the well site. This containment system is compatible with all shore base facilities required to support equipment availability.

The use of this containment system involves the permanent installation of the seal plate into all deepwater and high risk drilling BOPs prior to the installation of the BOP on the wellhead. As such, the equipment is a permanent part of such BOP. The containment dome can be sized to be a “one size fits all” design, as there is little variance in flex joint design, and a standard for industry wide use could be easily defined. The upper interface of the containment dome may include an 18-3/4” housing profile on a spool capable of engaging the bore of the dysfunctional BOP assemblage, sealing to the BOP bore, and enabling a capping stack to be connected and pressure tested.

The fundamental basis for the use of this containment system is that the BOP controls and Marine Riser have been severed, forming a debris field issuing from the well site and necessitating the removal of the riser remnant and the production of a capping stack interface to the top of the LMRP. This also assumes that the LMRP cannot be easily/safely removed from the lower stack.

As in any situation where riser or umbilical debris has buckled and fallen over the BOP, this debris must first be cut away and removed from the well site. A probable point of failure is the upper neck of the flex joint, where maximum bending stresses occur when the riser buckles. Buckling of the neck section will require the cutting of this pipe section to permit a full bore entry to the BOP well bore.

Once clear access is achieved, the containment dome is lowered to a close proximity to the stricken BOP. By-pass flow lines and chemical injection lines are connected to the containment dome via independent risers. The containment dome is addressed to the BOP and landed while MeOH or other inhibitors are pumped into the containment dome to minimize hydrate formation. The containment dome base is latched and locked to the seal plate. By-pass flows are stimulated by constriction of the open capping stack bore and/side outlets. The well bore is interrogated using survey tools to determine the extent of damage to the well, and therefore the best approach to the well kill operations. Should well integrity be confirmed, the wellhead patch is engaged in the stricken BOP bore (a hydraulic ram based operation) and the pack-off seals and slip system set and tested. The side ports in the wellhead patch should be closed after the capping stack has been sealed and outlet lines to the well control system tested and verified as functional. Well kill operations can then begin.

The containment dome is not intended to support full shut-in pressure, however these pressure loads are possible. This task is reserved for an upper spool of the containment dome after it is inserted into the bore of the BOP and its seals are energized. A series of well integrity tests must be performed on the well before closure of the upper spool side ports is possible. At that time the ports are closed and by-pass flows via the off-take lines can be stopped and full well control can be established through the capping stack.

The containment dome (as in Fig. 13) can be manipulated or run by a multitude of vessels, but as the containment dome is small enough to be operated through a rig's moon pool, and as this class of vessel has deck load capacity for fluid processing, a drilling rig is likely to be more efficient in the delivery of the containment dome to the BOP. The running system also serves as the tool to install the upper spool of the containment dome into the LMRP bore where the spool seals are energized and the seal pressure tested to full well rated pressure.

The drilling rig runs the handling tool and capping stack on the marine riser, and, with all side ports open to the environment and the capping stack equally open to the environment, engages the 18-3/4”-15-ksi spool profile on top of the containment dome. Kill and choke lines of the marine riser can (in measured circumstances) be used because the flow bypass lines or vent valves on the upper spool can be opened to ensure a low pressure engagement of the containment dome to the upper spool.

Though the upper spool to which the capping stack is attached will reduce the bore of the dysfunctional BOP, it will allow tools to be passed through, (by stripping through the capping stack's annular preventers) and into the well bore. This assumes that the well bore is passable and is not littered with debris to prevent standard clearing and kill operations to proceed.

Fig. 15 shows the seal plate **18** sectioned into two equal halves. The seal plate **18** can be constructed into sections to be positioned around a pipe or casing. Fig. 16 shows a seal plate **18** divided into a larger section **69** and a smaller section **70**. Fig. 17 shows an illustration of a half section of a seal plate **18** in position around a casing **19**. Fig. 17 further shows a BOP connector **71**, a high pressure wellhead **72**, a low pressure wellhead **73**, hinge lock pockets **74** for connecting one half of the section plate **18** to the other half, packing or an inflatable seal **75** between the plate **18** and casing **19**, and a slip assembly **76**. The segmented seal plate **18** in two pieces may be hinged on one side and bolted or pinned on the other side, creating compression around a riser pipe or casing.

The method of deploying the containment system of the present invention begins by installing a seal plate on a wellhead prior to drilling operations. The drilling rig BOP and marine riser system are positioned on and attached to the top interface of the seal plate. The seal plate has compatible connections with BOP and marine riser systems to allow remote operation through the seal plate and/or containment dome once containment or encapsulation has occurred. By installing a two-piece seal plate to existing wells the existing BOP and marine riser package on those wells may still be used and be protected by the containment system. In addition, a smaller seal plate may be installed at the flex joint of a marine riser prior to drilling operations or even on existing operating wells. The smaller seal plate allows for a smaller containment dome to encapsulate the cutoff riser pipe instead of encapsulating BOP and marine riser.

Once the seal plates are installed, all components on the seal plates are capable of being stored, installed, and operated by either the offshore drilling rig attached to the wellhead or a primary intervention vessel with lesser capabilities, but one with greater agility and range of motion than the offshore drilling rig which will be essentially tied to the immediate wellhead location.

The containment system may be stored on an offshore drilling rig ready for immediate deployment in the event of a catastrophic blowout of the oil well. In an emergency situation the drilling rig is designed to disconnect from the riser and position itself out of harm's way. Once the damage has been assessed the drilling rig may return to the site and the containment dome can be deployed to encapsulate the leaking structure below.

Containment domes can be stored at warehouse facilities having quick access to the ocean, or even on a primary intervention vessel that is on standby, in the event the offshore drilling rig is dysfunctional or even destroyed. Additional emergency response vessels may be used to clean debris around BOP and marine riser packages. Once a debris field is removed the primary intervention vessel may lower the containment dome over the side of ship or through a moon pool and connect it to the seal plate located below the BOP and marine riser packages. Remote operating vehicles (ROVs) may be deployed to aid in the alignment and securing of the containment dome and the seal plate. With the containment dome attached, the well flow may be shut off or redirected with bypass risers attached to the containment dome. The bypass risers can regulate internal pressures of the containment dome and direct flow to the surface where the flow is collected by shuttle tankers and/or processing stations.

The foregoing description has been limited to specific embodiments of this invention. It will be apparent, however, that variations and modifications may be made, by those skilled in the art, to the disclosed embodiments of the invention, with the attainment of some or all of its advantages and without departing from the spirit and scope of the present invention. For example, any types of suitable metals and plastics may be used in the construction of the seal plate and containment dome. The seal plate and containment dome may be locked together in addition to being compressed together. The seal plate and containment dome may be constructed in any suitable shape.

It will be understood that various changes in the details, materials, and arrangements of the parts which have been described and illustrated above in order to explain the nature of this invention may be made by those skilled in the art without departing from the principle and scope of the invention as recited in the following claims.

Claims

1. A containment system for an oil wellhead, comprising:
   a) a seal plate attached to a wellhead casing or riser;
   b) a containment dome that fits on said seal plate; and
   c) a compression mechanism which compresses said seal plate and said containment dome together to collect and control fluids leaking from devices attached to the wellhead.

2. The containment system of claim 1 further comprising one or more blowout preventers contained within said containment dome when said containment dome is placed on said seal plate.

3. The containment system of claim 2 further comprising a low marine riser package and shear module within said containment dome when said containment dome is placed on said seal plate.

4. The containment system of claim 1 further comprising a blow out preventer on the exterior of said containment dome.

5. The containment system of claim 4 further comprising vents or injection ports, video cameras, or high pressure spray nozzles on the exterior of said containment dome.

6. The containment system of claim 1 further comprising one or more dual gradient modules attached to said seal plate and having connector pipes passing through said seal plate and connecting to devices adjacent to or on said seal plate, and said dual gradient modules having fittings for flow lines for chemical injection and/or hydraulic power.

7. The containment system of claim 6 further comprising one or more external control panels having connector pipes passing through said seal plate and connecting to devices adjacent to or on said seal plate.

8. The containment system of claim 1 further comprising said seal plate having pulleys

and said containment dome having cable connectors with cables, wherein said cables are inserted around the pulleys and extended upwards with continued upward force thereby compressing the containment dome and seal plate together.

9. The containment system of claim 1 wherein said seal plate is in two pieces so that said seal plate can be positioned around an existing wellhead casing or riser.

10. The containment system of claim 1 wherein said containment dome has zero, plus, or minus buoyancy.

11. A containment system for an oil wellhead, comprising:
    a) a seal plate attached to a wellhead casing or riser;
    b) a containment dome that fits on said seal plate, said containment dome having a wellhead patch; and
    c) a compression mechanism which compresses said seal plate and said containment dome together to collect and control fluids leaking from devices attached to the wellhead.

12. The containment system of claim 11 wherein said wellhead patch extends into a bore of a blowout preventer to lock and seal said bore.

13. The containment system of claim 12 wherein said wellhead patch has a capping stack interface.

14. The containment system of claim 13 further comprising one or more dual gradient modules attached to said seal plate.

15. A containment system for an oil wellhead, comprising:
    a) a first seal plate attached to a marine riser;
    b) a first containment dome that fits on said first seal plate;
    c) a compression mechanism which compresses said seal plate and said containment dome together to collect and control fluids leaking from said marine riser;
    d) a second seal plate attached to a wellhead casing or riser; and

e) a second containment dome that fits over said first containment dome and said first seal plate, and encapsulates a portion of said first containment dome and said first seal plate, wherein said second containment dome has a second compression mechanism which compresses said second seal plate and said second containment dome together to collect and control fluids leaking from devices attached to the wellhead.

16. The containment system of claim 15 wherein said first containment dome and said second containment dome have one or more bypass lines.

17. The containment system of claim 15 wherein said second seal plate has one or more control panels.

18. A method for the containment of fluids leaking from an oil wellhead, comprising the steps of:

1) installing a seal plate on a wellhead casing or riser;
2) lowering a containment dome onto said seal plate;
3) sealing said seal plate to said containment dome by compressing said seal plate and said containment dome together; and
4) collecting, containing, and regulating fluids leaking from said wellhead casing or riser or devices contained within said containment dome when said containment dome and said seal plate are compressed together.

19. The method of claim 18 where in the containment dome encapsulates a blowout preventer and marine riser system.

20. The method of claim 19 further comprising the step of redirecting oil well flow with bypass risers attached to said containment dome.

21. The method of claim 20 further comprising the step regulating internal pressures of said containment dome with said bypass risers.

22. The method of claim 21 further comprising the step of injection chemicals into said containment dome to prevent the formation of hydrates.

23. The method of claim 22 wherein all aspects of controlling and operating an oil wellhead are performed through the containment dome and seal plate, and all aspects of installation, regulation, and control of the containment dome are performed by remote operating vehicles under water.

24. A method for the containment of fluids leaking from an oil wellhead, comprising the steps of:
    1) installing a seal plate on a wellhead casing or riser;
    2) lowering a containment dome onto said seal plate, said containment dome having a wellhead patch; and
    3) sealing said seal plate to said containment dome by compressing said seal plate and said containment dome together.

25. The method of claim 24 further comprising the step of extending said wellhead patch into a bore of a blowout preventer to lock and seal said bore.

26. A method for the containment of fluids leaking from an oil wellhead, comprising the steps of:
    1) installing a first seal plate to a marine riser;
    2) installing a second seal plate to a wellhead casing or riser;
    3) lowering a first containment dome on to said first seal plate;
    4) compressing said first seal plate and said first containment dome together to collect, control, and regulate fluids leaking from said marine riser;
    5) lowering a second containment dome over said first containment dome and said first seal plate, encapsulating a portion of said first containment dome and said first seal plate with said second containment dome;
    6) lowering said second containment dome on to said second seal plate; and
    7) compressing said second seal plate and said second containment dome together to collect, control, and regulate fluids leaking from devices contained within said containment dome when said containment dome and said seal plate are compressed together.

27. The method of claim 26 further comprising diverting fluid contained in said first

containment dome and in said second containment dome to a surface recovery vessel.

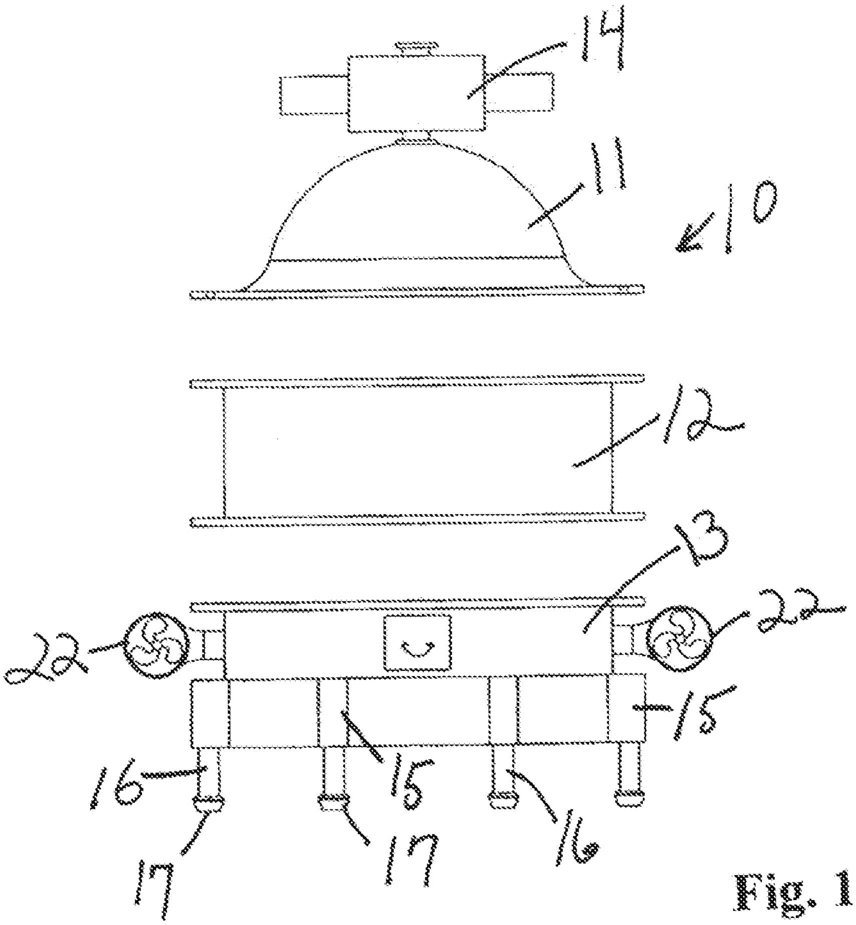
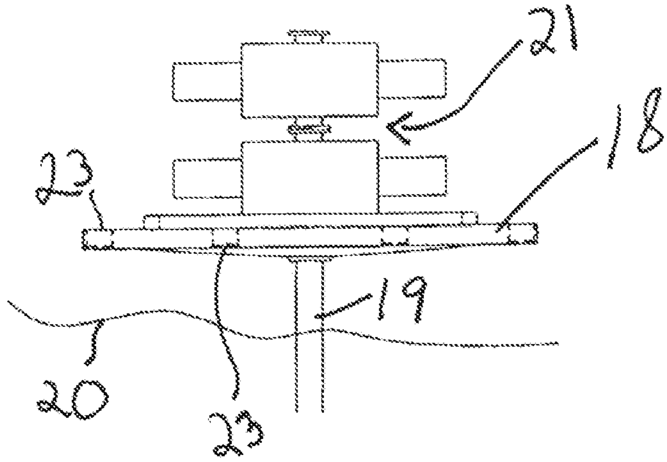


Fig. 1



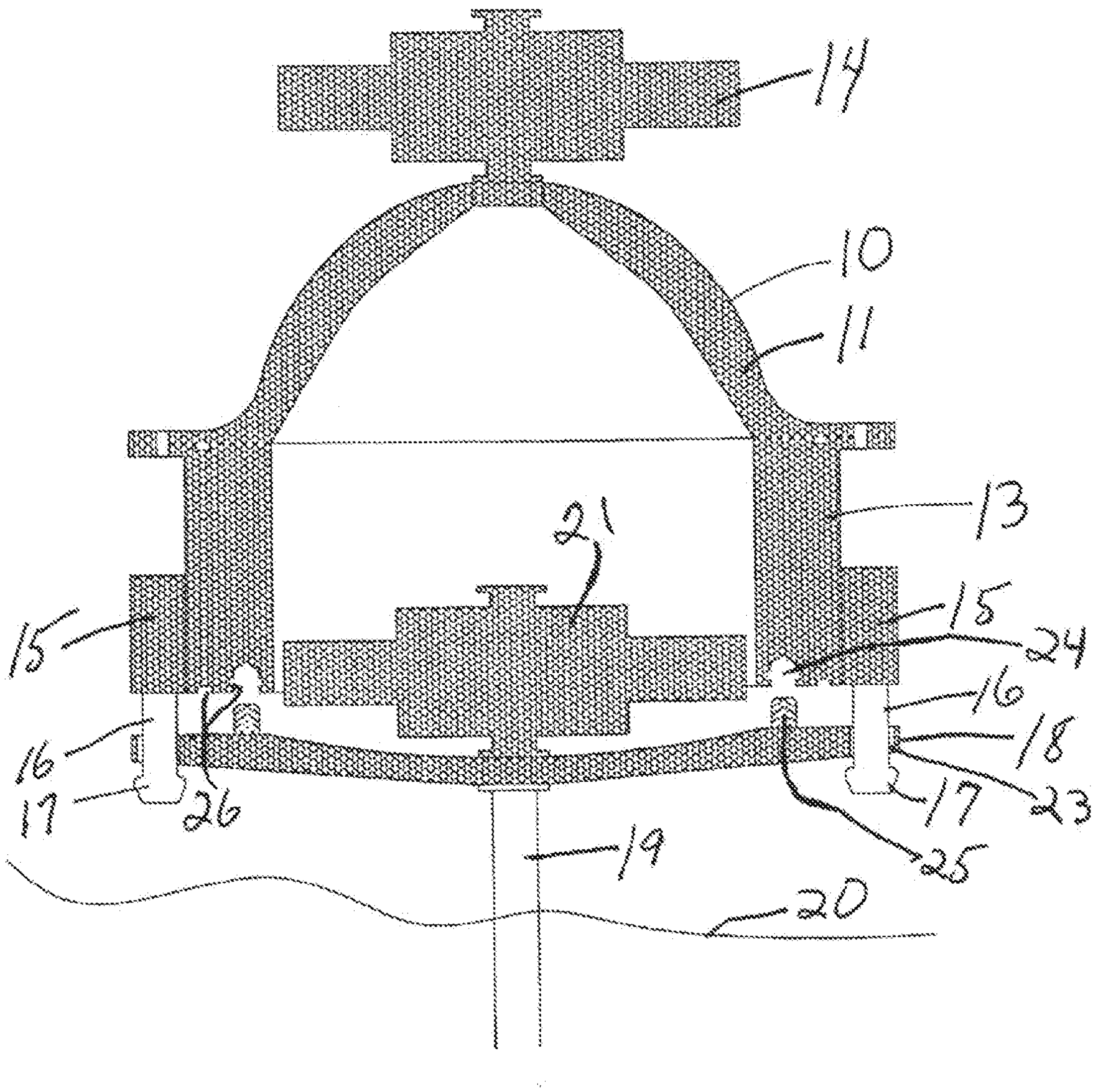


Fig. 2

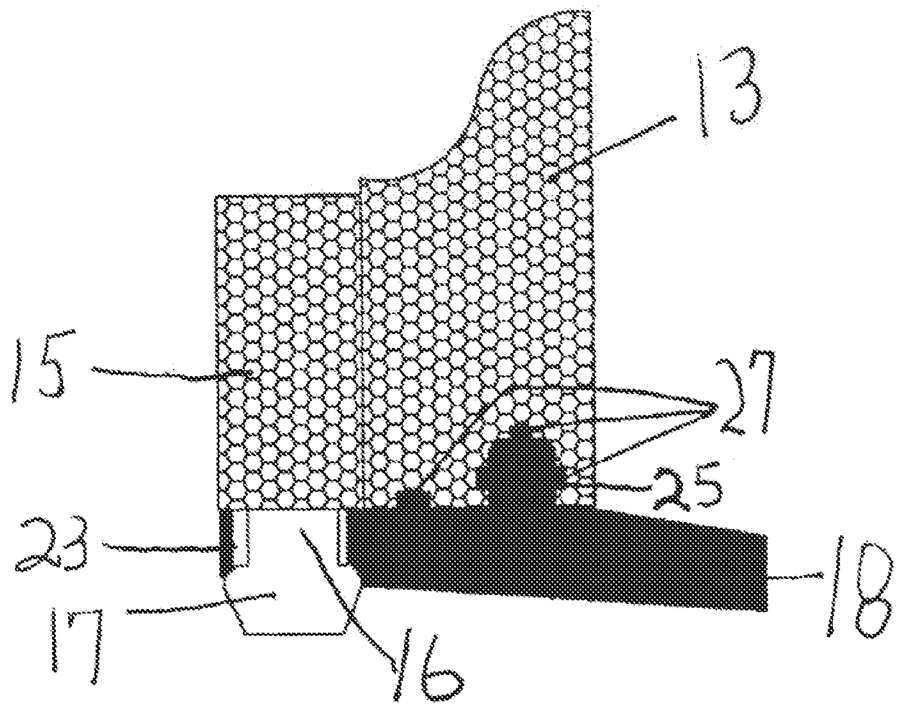


Fig. 3

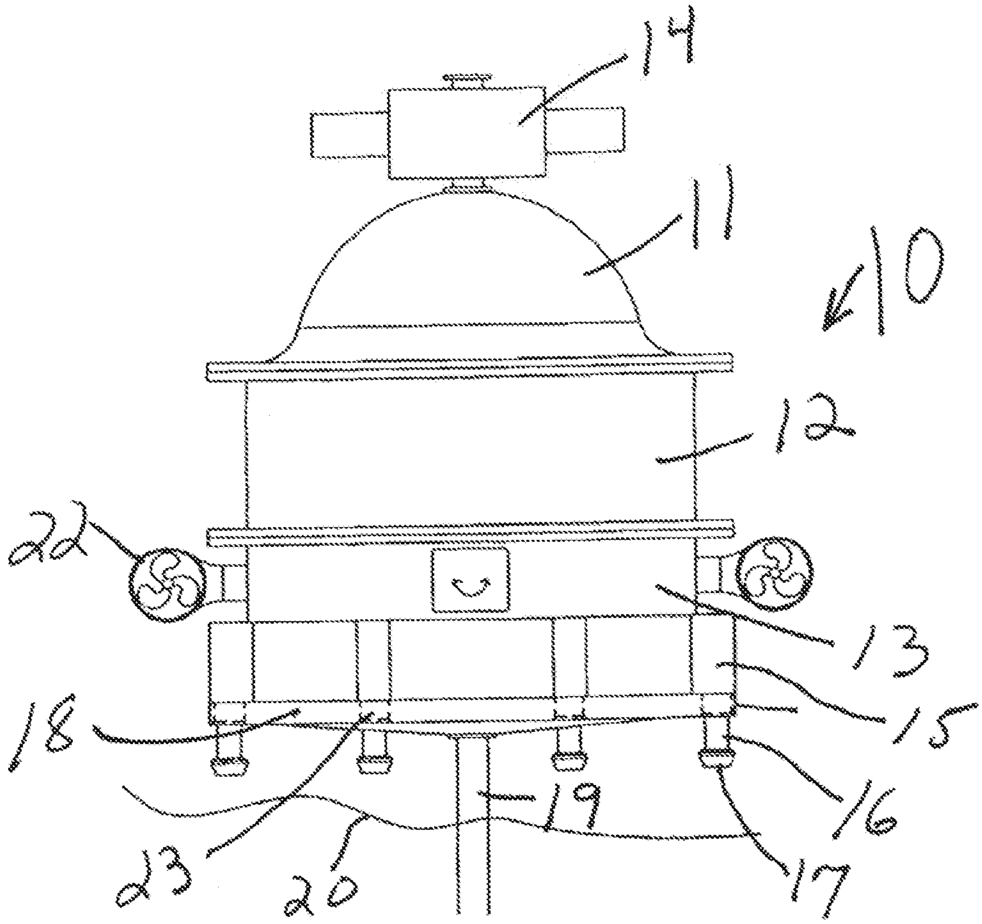


Fig. 4

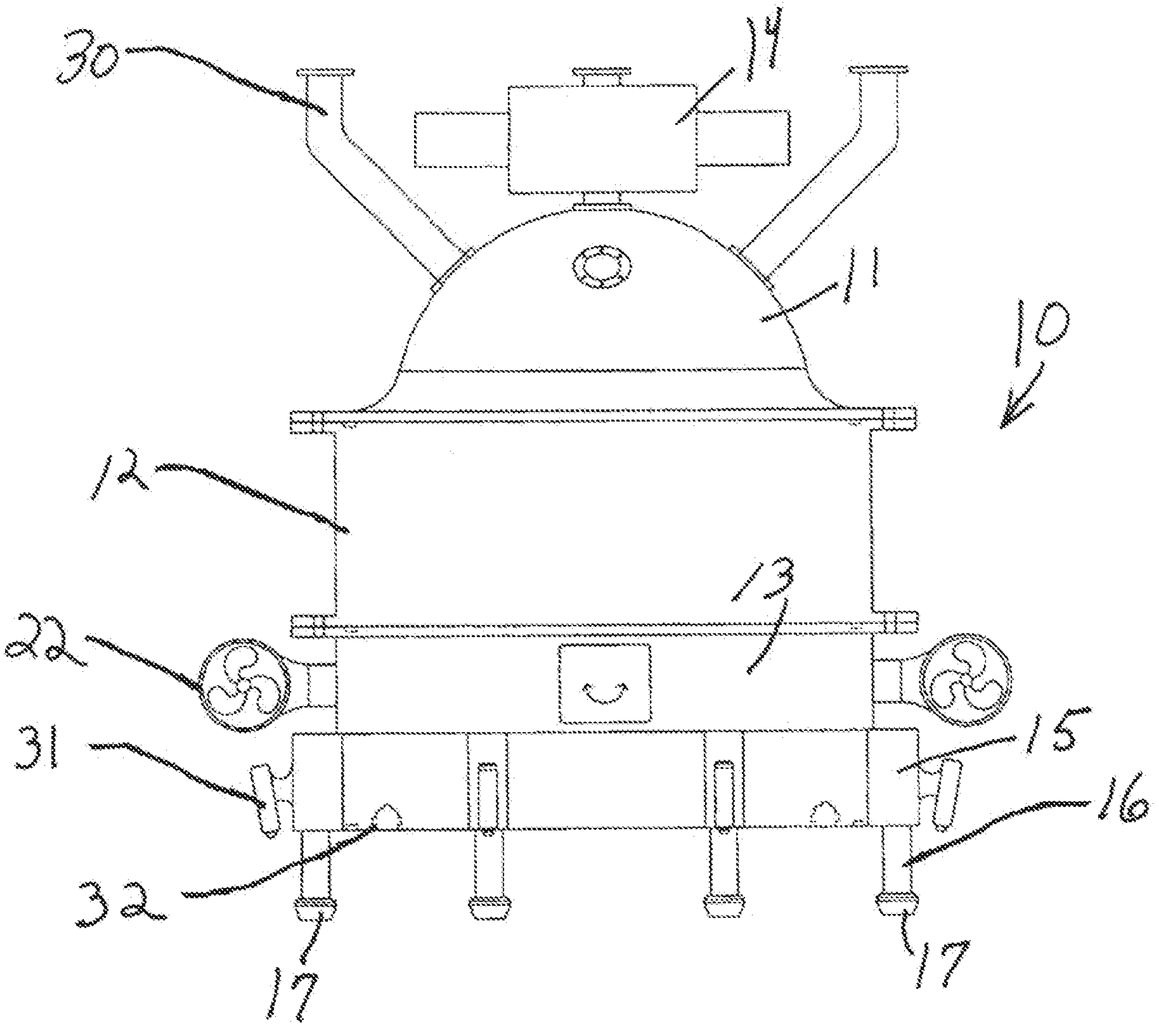


Fig. 5

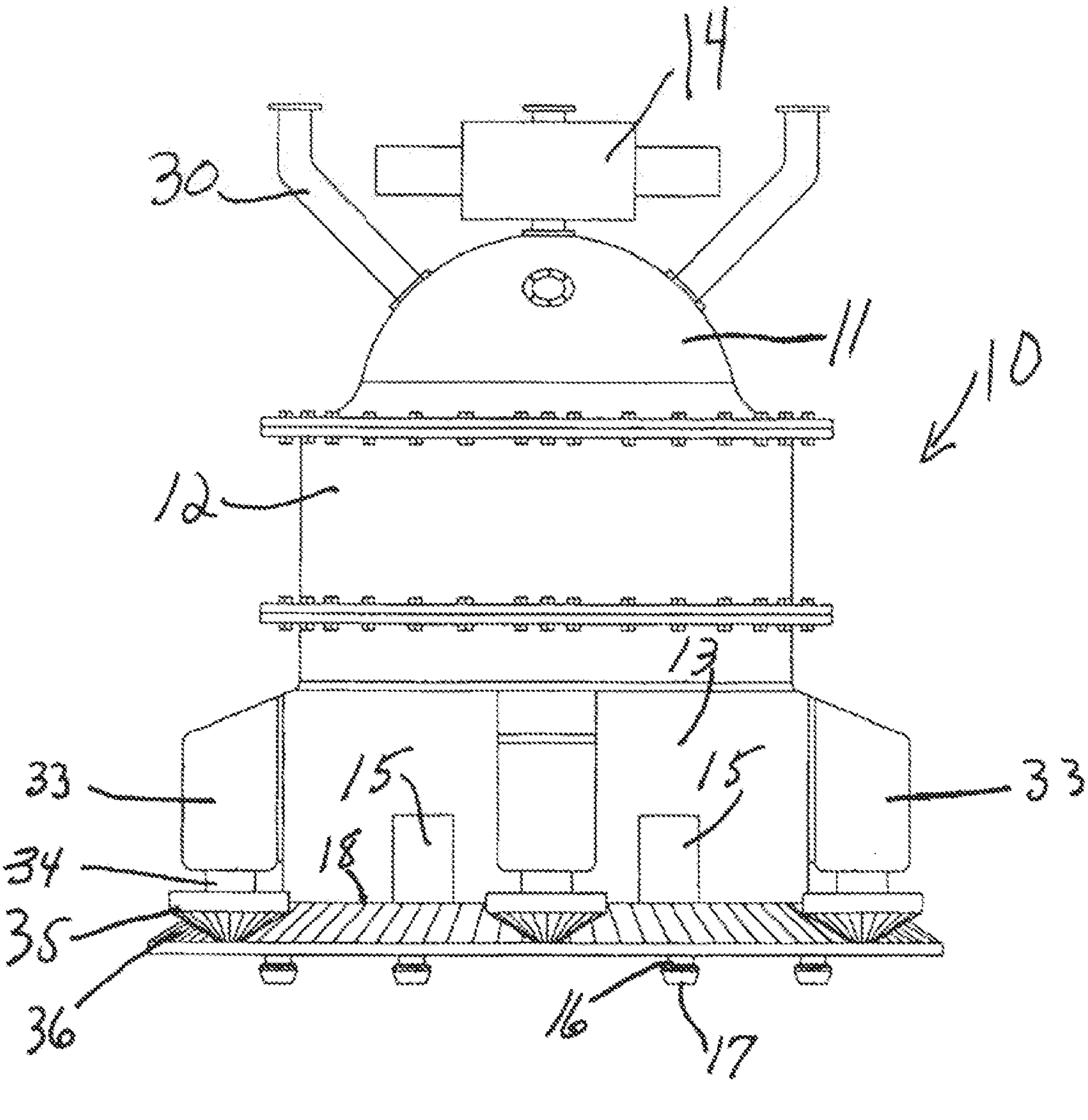


Fig. 6

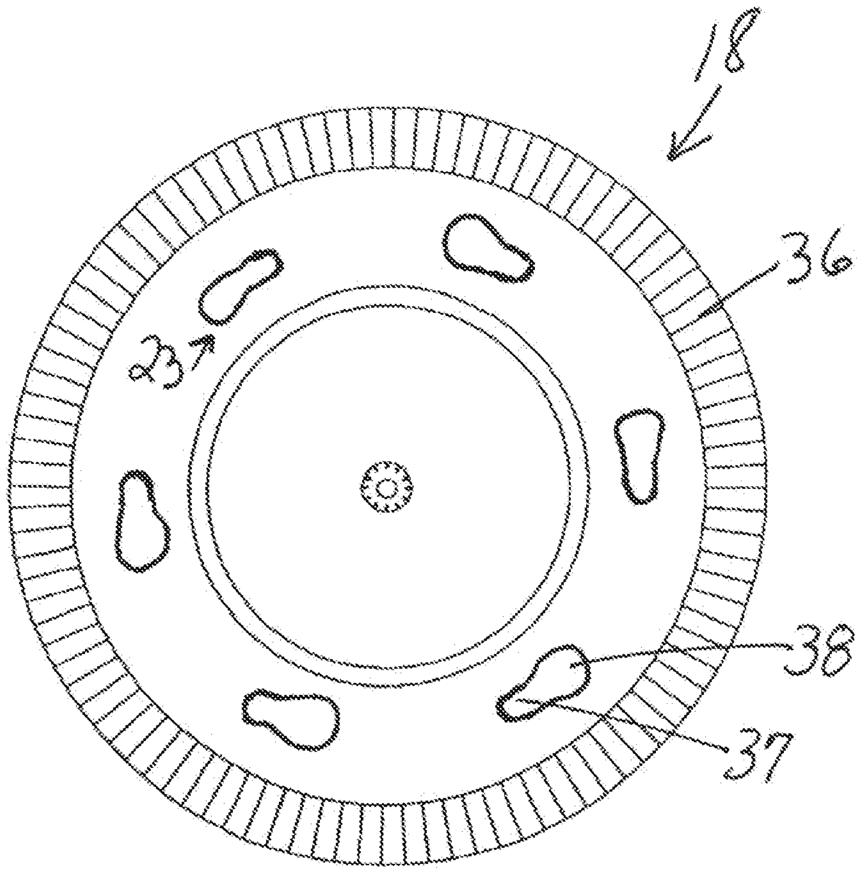


Fig. 7

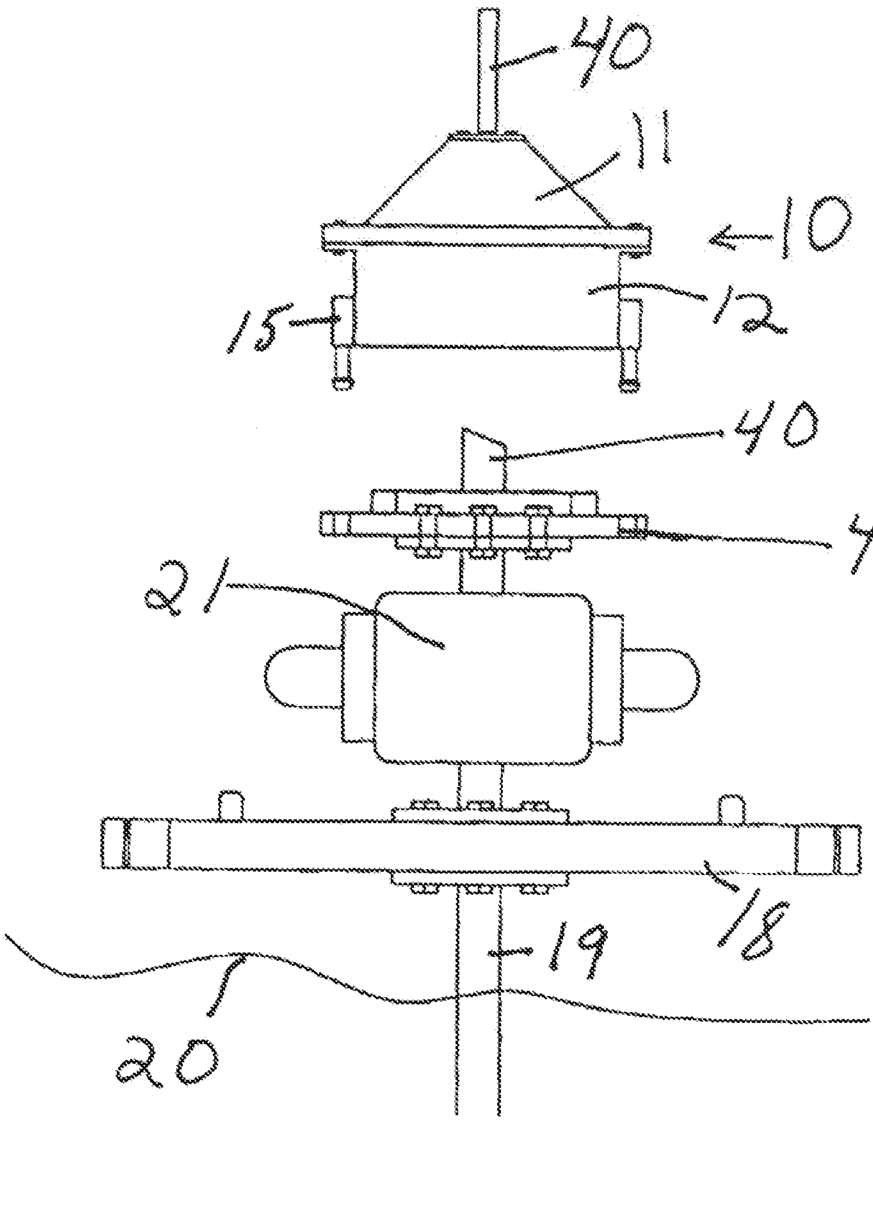


Fig. 8

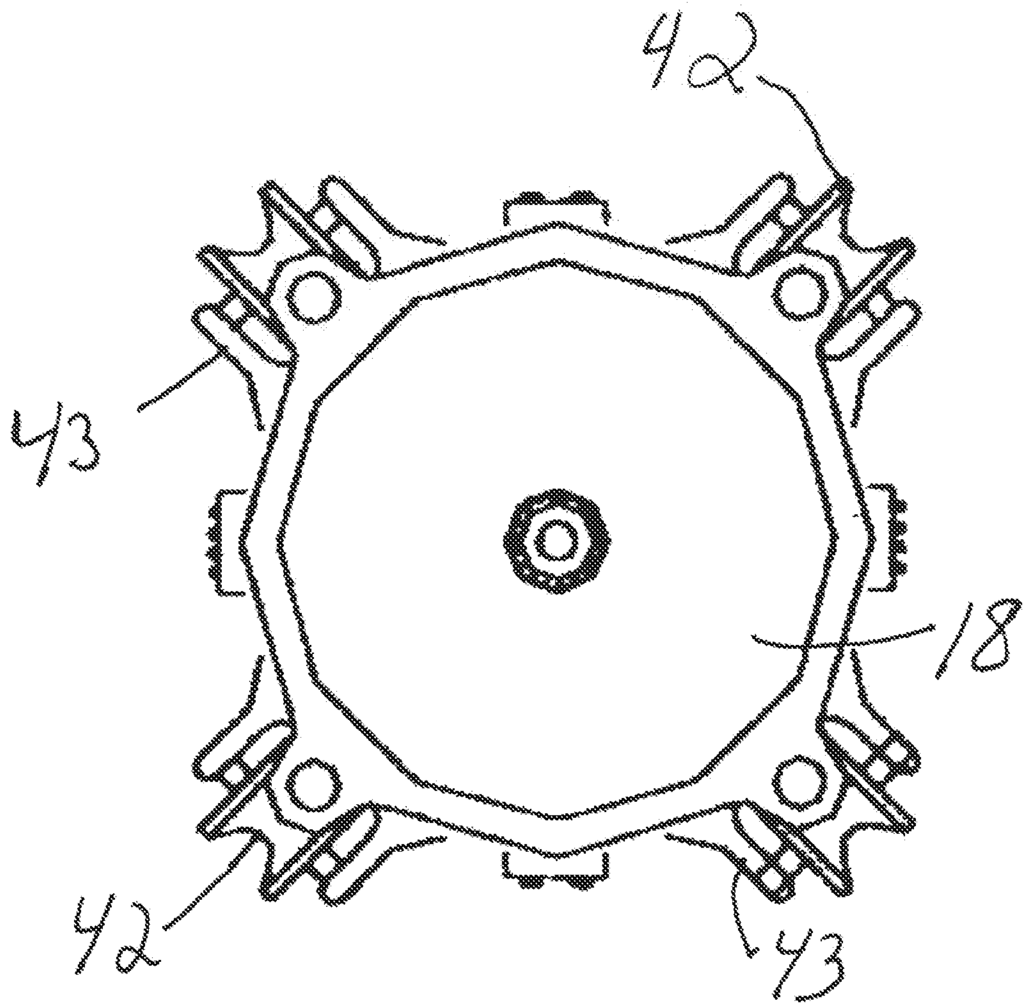


Fig. 9

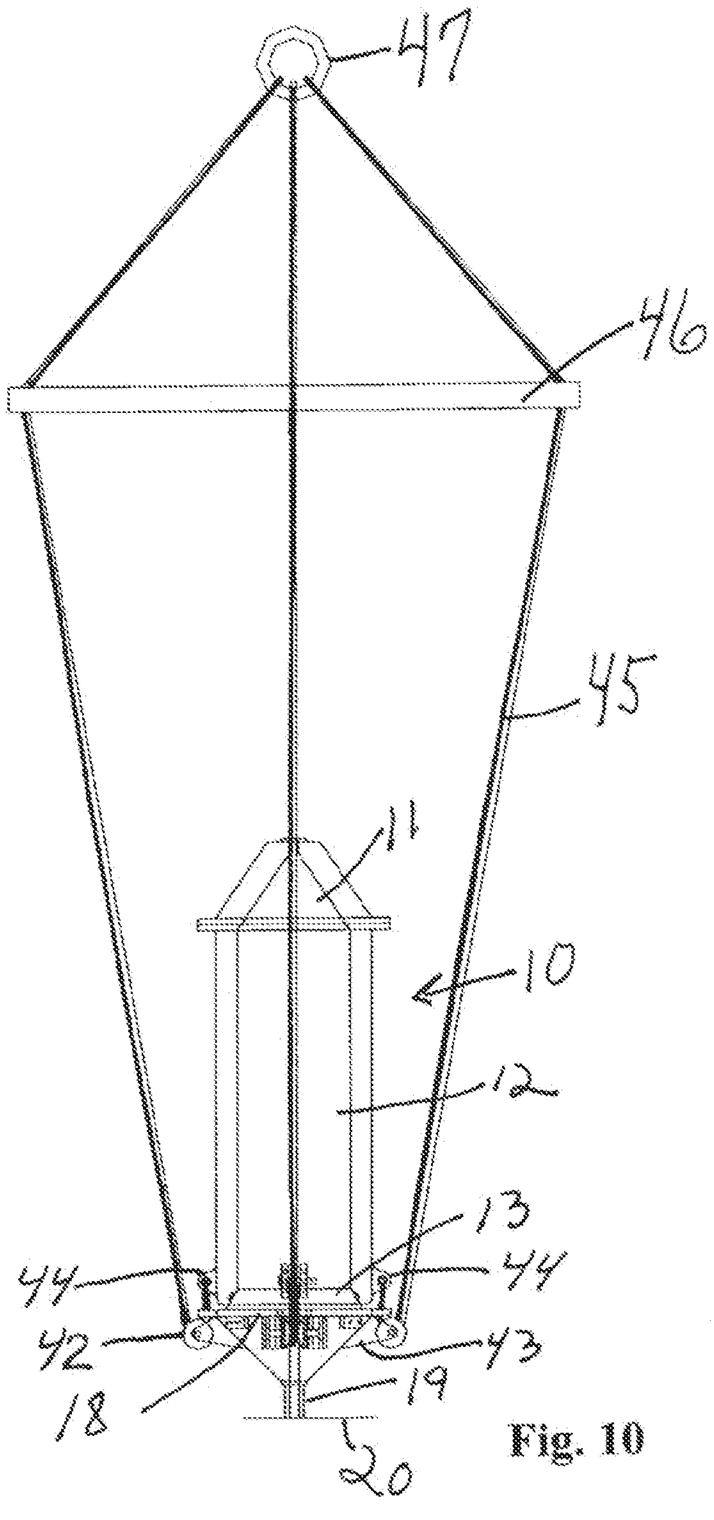


Fig. 10

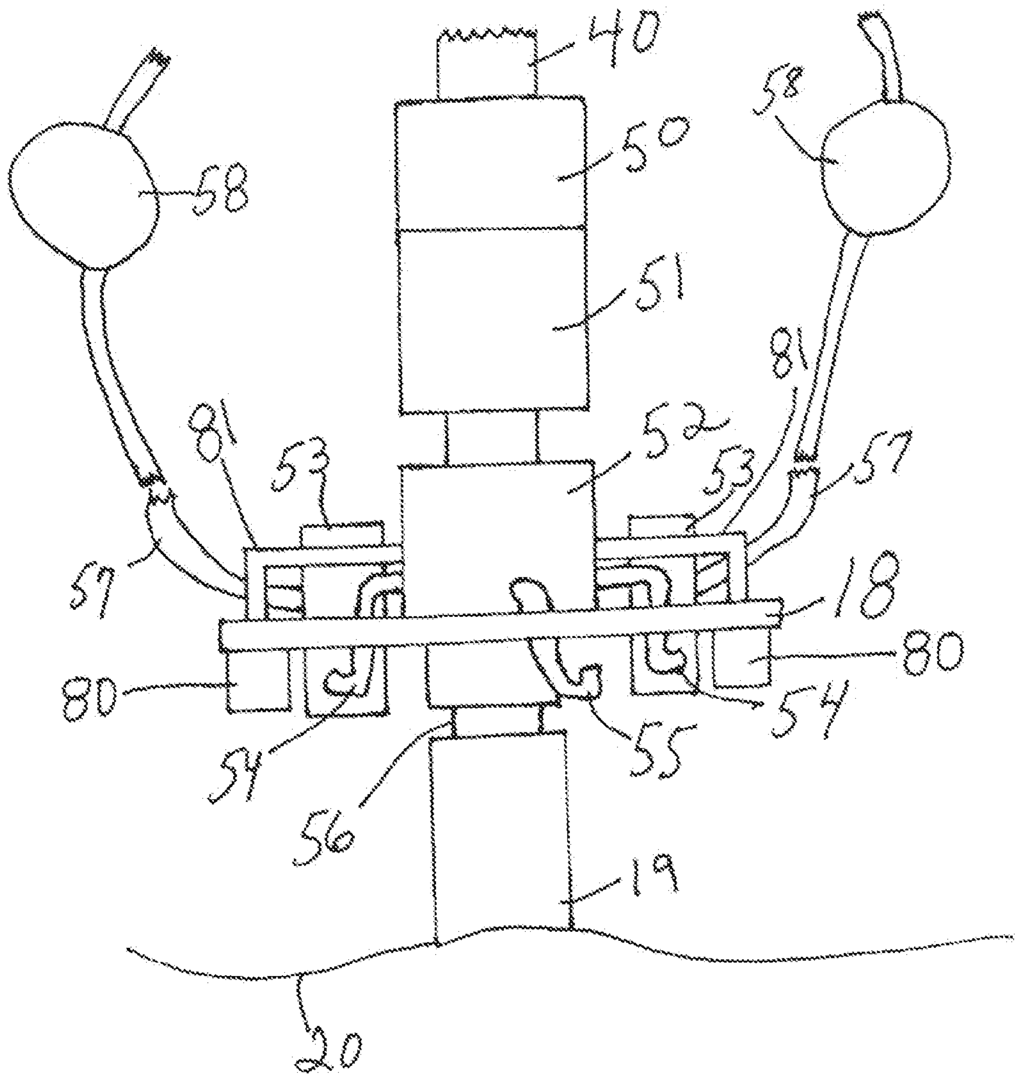


Fig. 11

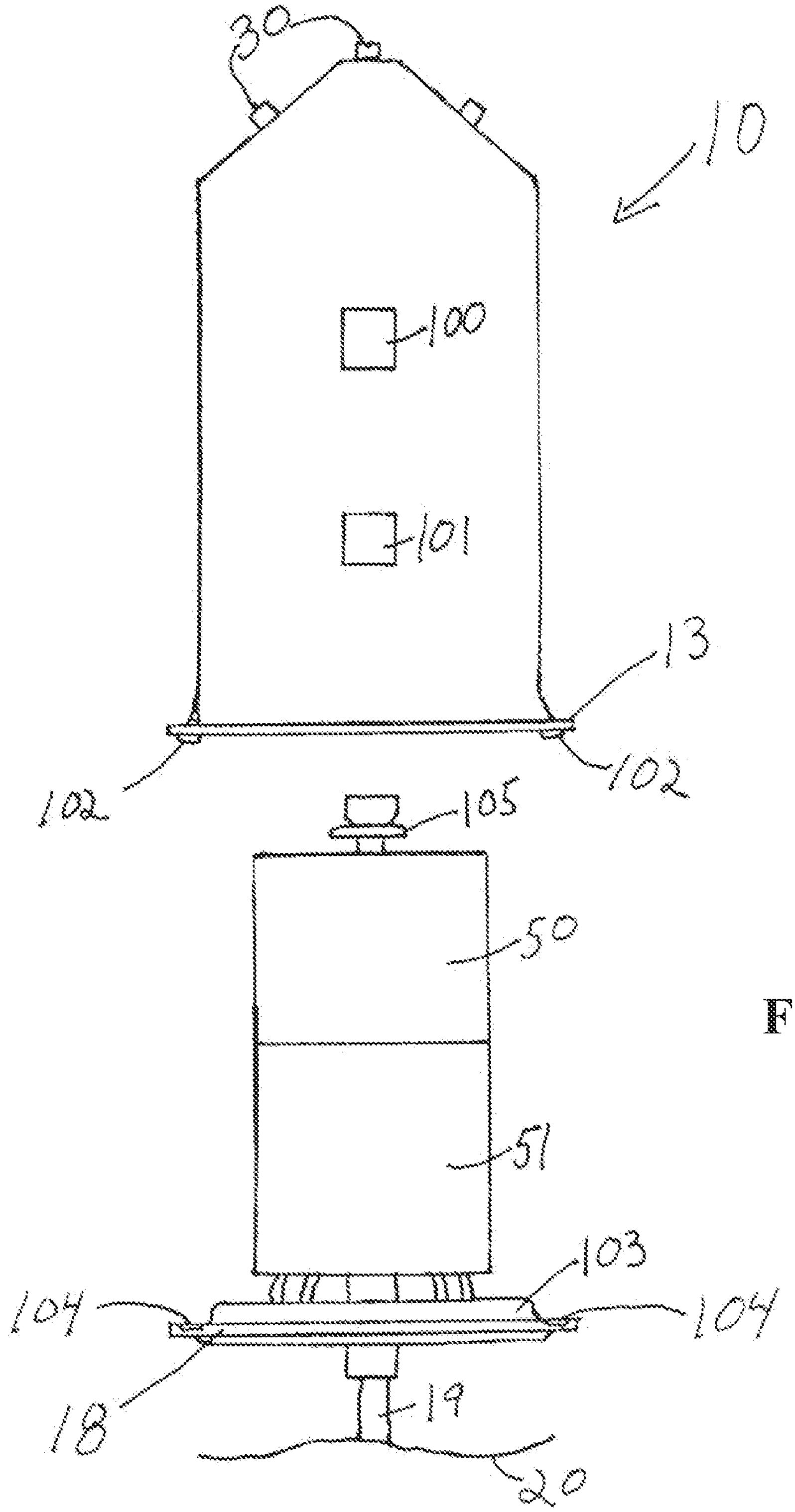


Fig. 12

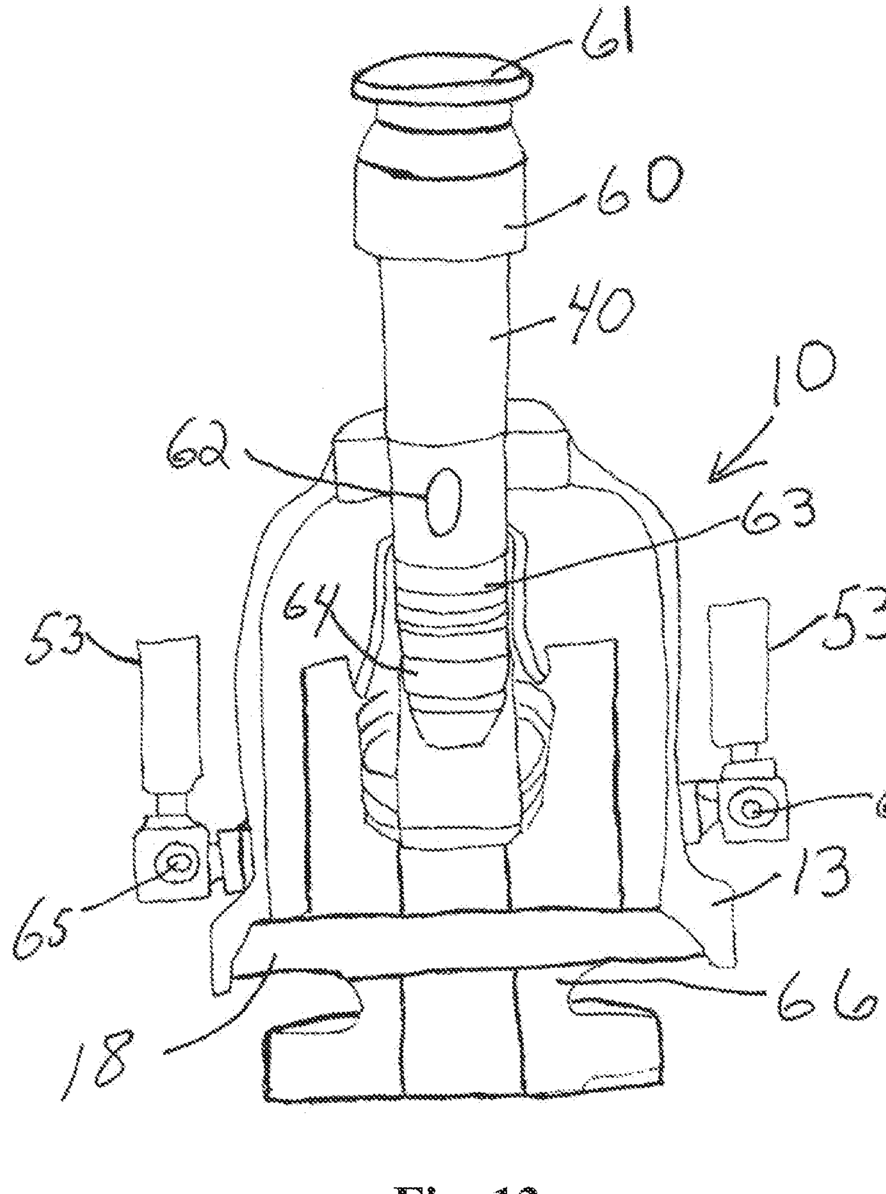


Fig. 13

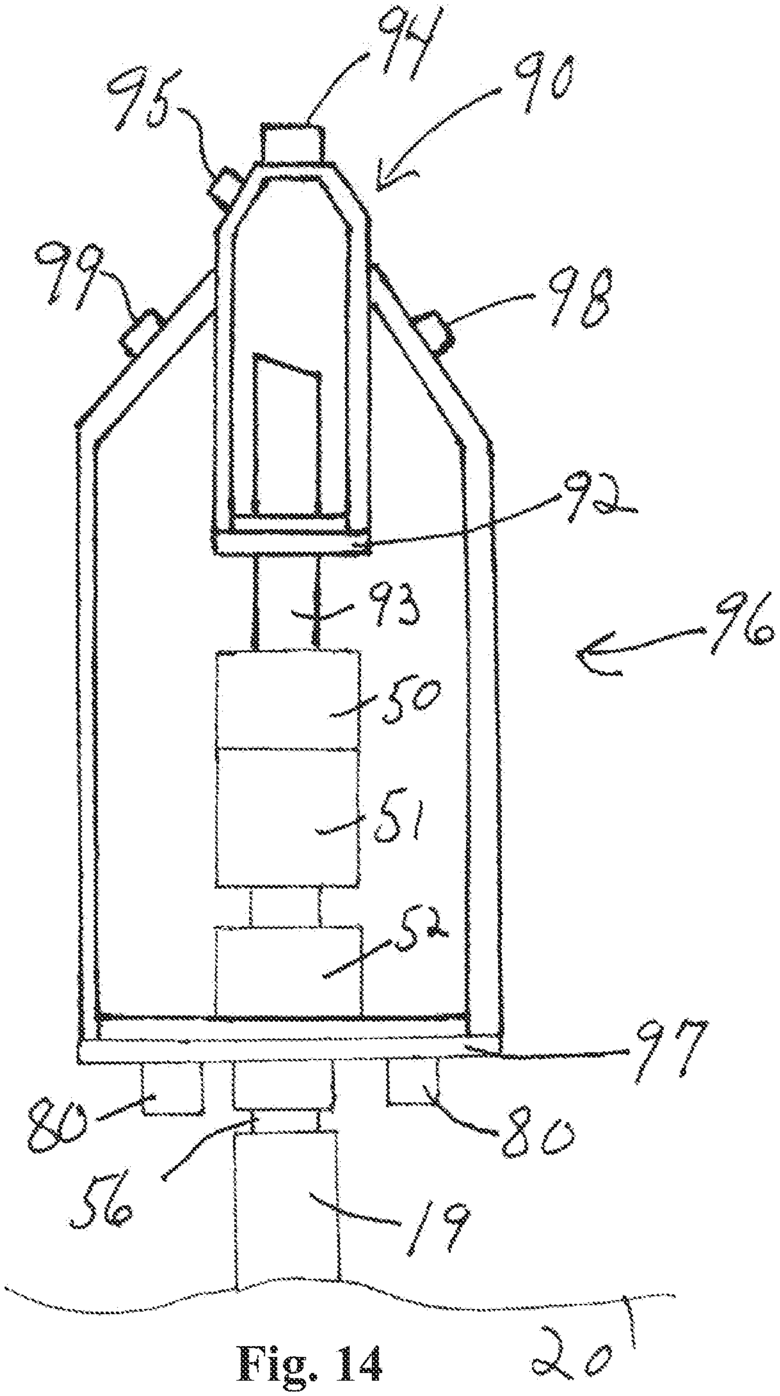


Fig. 14

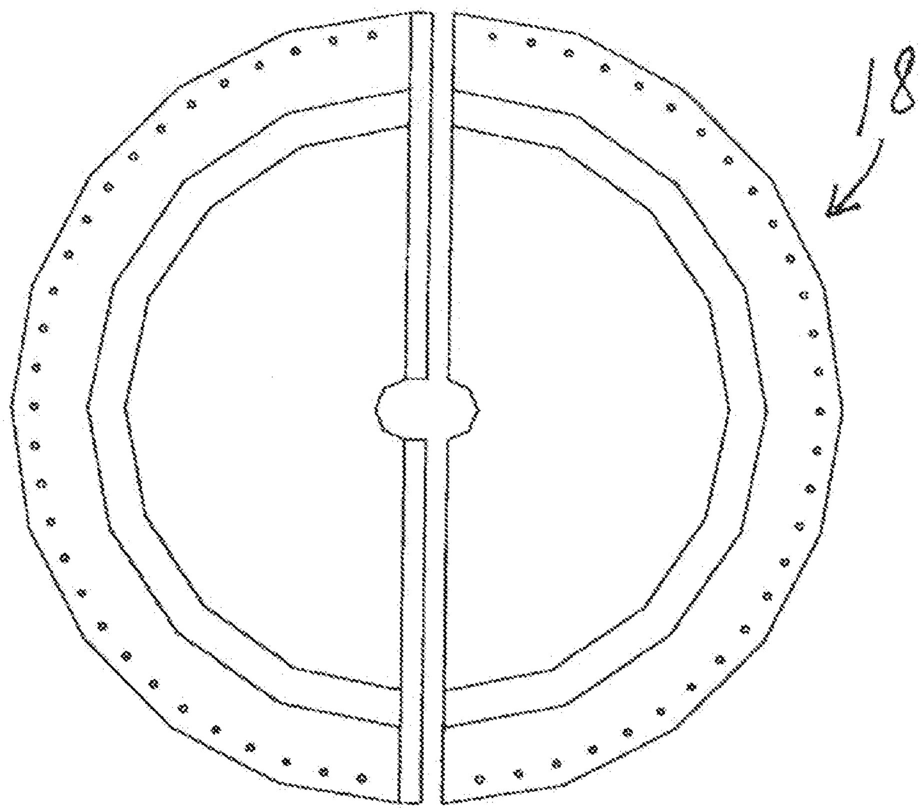


Fig. 15

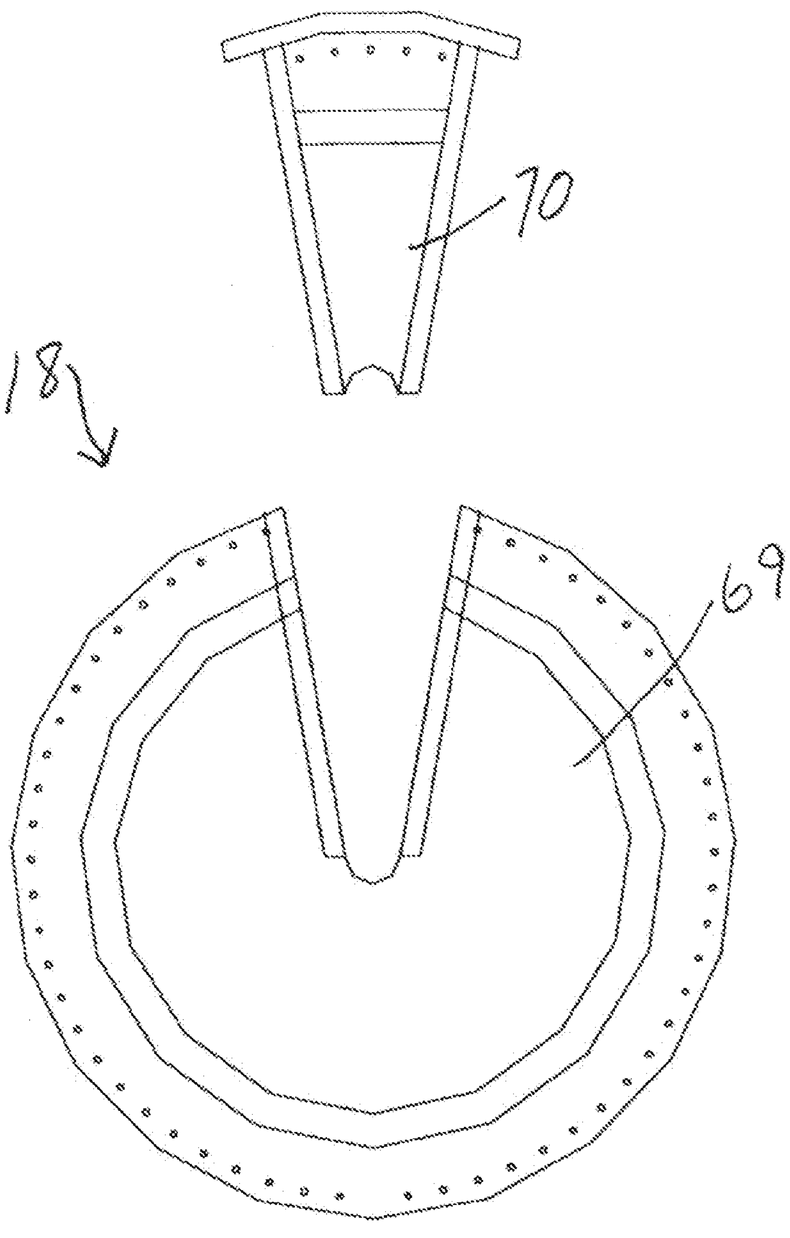


Fig. 16

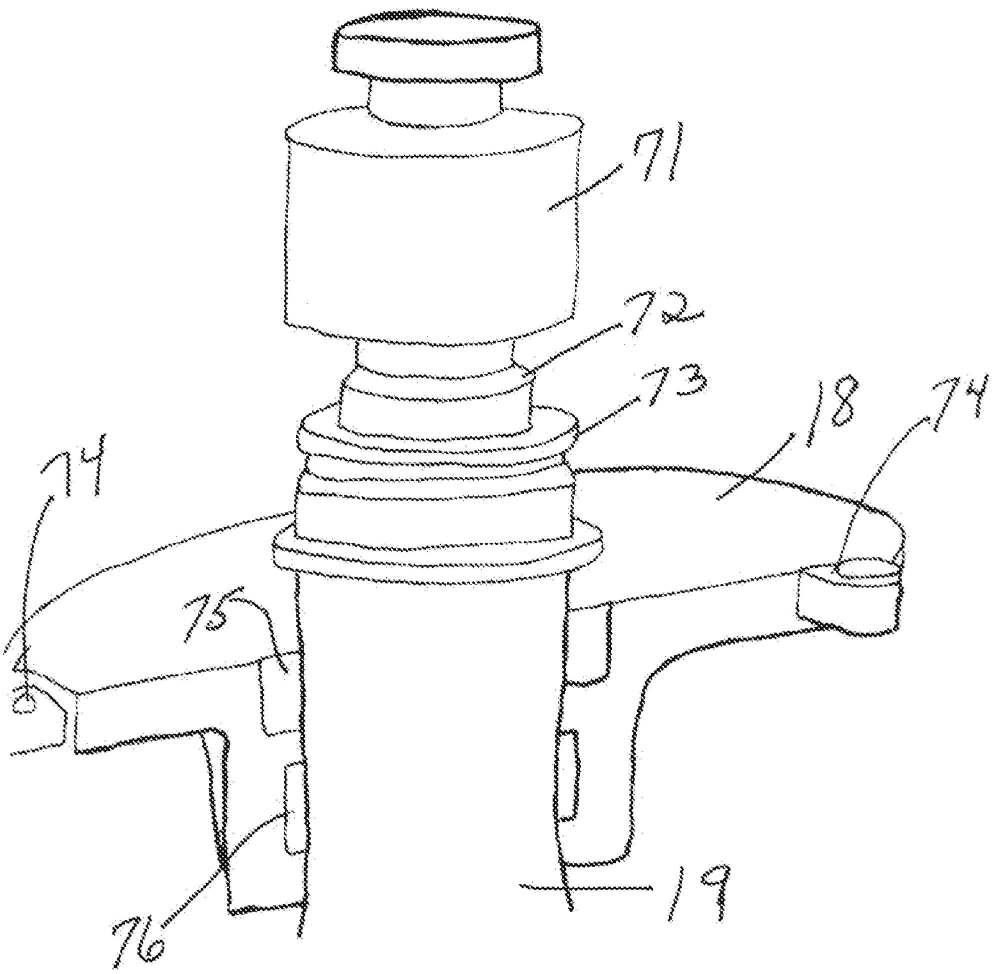


Fig. 17