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(54) **SUCTION PILE PUMP DEVICE**

(57) Assembly of a suction pile and a pump system temporary connected by convenient means to the suction space of the suction pile. Means (22, 23) are present to move the pump system interface (9) towards and away from the suction pile interface (5) while the pump system (1) is operatively attached to the suction pile, such that in a first position the interfaces (5, 9) are fluidly connected

and moved towards each other, ready for the pump system creating a fluid flow to or from the inside of the suction pile through the mutually connected interfaces (5, 9) and in a second position the interfaces are mutually spaced, mutually keeping a gap such that fluid flow exiting the suction pile through its interface (5) is not restricted to enter the pump system interface (9).

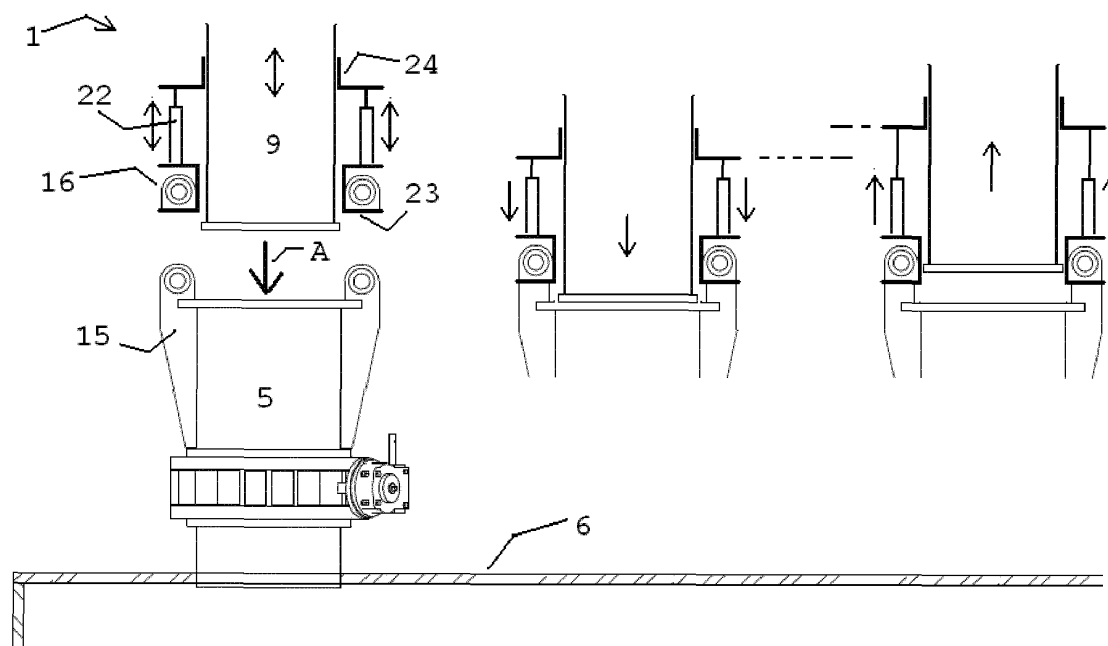


Fig. 20

Description

[0001] The invention relates to a pump device for creating a suction pressure or over pressure inside a partly in the seafloor penetrated suction pile to further penetrate or press out, respectively, the suction pile.

[0002] Suction piles and their way of installing are a.o. known from GB-B-2300661 and EP-B-0011894, which disclosures are enclosed in here by reference. Briefly, a suction pile is a thin walled steel sleeve or pipe or cylinder, which cylinder is closed at its longitudinal top end by a bulkhead or different sealing means and which cylinder is sealingly located on the subsea bottom with the open end opposite the bulkhead since this open end penetrates the subsea bottom due to the weight of the suction pile. Thus the cavity, also called suction space, delimited by the cylinder and the bulkhead is sealed by the subsea floor such that vacuum or suction can be generated by removing water from within the suction space such that a resulting force tends to force the suction pile deeper into the subsea floor. The creation of the suction can be with the aid of the pump device connected to the suction space. The applied level of the suction can be e.g. at least substantially constant, smoothly increase or decrease or else pulsate, for which there are convenient means. After use, the suction pile can easily be removed by creating an overpressure within the suction space, e.g. by pumping in (sea) water.

[0003] The use of suction piles is widespread. By way of example, a self installing marine structure, e.g. platform having a suction piles foundation is known from e.g. WO99/51821 (SIP1) or EP-A-1 101 872 (SIP2). WO 02/088.475 (SIP3) discloses a tower carrying a wind turbine at the top and suction piles as foundation.

[0004] Preferably a suction pile has one or more of: a diameter of at least 5 metres; a height of at least 5 metres; a wall thickness of at least 1 centimetre; the longitudinal axis of the suction pile and the relevant supporting leg (of the upper structure to be supported by the suction pile) are substantially in line or eccentric.

[0005] The object of the invention is versatile. In an aspect installation and/or removal (decommissioning) of the suction pile penetrating the seafloor is facilitated. In an aspect simple design of the suction pile, in particular its top bulkhead is facilitated; in an aspect storage and/or transport of one or more pump systems is facilitated; in an aspect ease of handling is facilitated. One or more of these and other aspects can be combined.

[0006] The object is obtained by a pump system designed to be temporary connected to the internal space (also called suction space) of the suction pile to generate an over pressure or under pressure within the suction space, preferably wherein the pressure difference generated relative to the surrounding water pressure (e.g. approximately 10 bar at 100 meter water depth or 100 bar at 1000 meter water depth) is at least 0.5 or 1 or 2 or 3 or 5 bar. Preferably the pump system is designed to generate within the suction space an over or under pres-

sure between 5 and 10 bar. It will be appreciated that for the under pressure (i.e. the suction), lowering of the pressure within the suction space is limited by the vacuum level (0 bar) such that at a pressure of e.g. 3 bar of the surrounding water (at a water depth of approximately 20 meter), a pump system rated for 5 bar pressure difference shall be unable to lower the pressure for more than 3 bar within the suction space (in practise the maximum attainable under pressure level will be a fraction of 1 bar above vacuum, e.g. 0.1 or 0.05 bar).

[0007] One or more of the following preferably applies to the pump system: designed to stably bear onto the suction pile top bulkhead, e.g. by comprising at least three mutually spaced supporting feet; a space frame of beams as an external protecting shell, e.g. of rectangular and/or elongate shape; at least one or two pumps, e.g. of centrifugal type; at least two pumps of different or identical type; a pump of high flow low pressure type, e.g. centrifugal pump; a pump of low flow high pressure type, e.g. membrane pump or piston pump or positive displacement pump; a means, e.g. from the lower side of the pump system downward projecting tube stud, providing the pump system interface to connect the pump to the suction space, which means preferably is provided with a seat, e.g. a flange, at its end remote from the pump system, against which the corresponding interface means at the suction pile, e.g. upward directed pipe stud, becomes seated, e.g. a corresponding seat, e.g. a flange; the pump system interface provided with a member for releasable locking engagement with the corresponding member at the suction pile interface; a quick connector to top bulkhead tube stud (a means providing the suction pile interface to connect the pump to the suction space) with preferably padlock eye system and/or spring loaded seated connection; measurement probe, e.g. echo sounder probe, designed for measurement through top bulkhead tube stud; docking cone designed to penetrate top bulkhead tube stud to align pump system for sufficient sealing; piping provided with one or more, e.g. two, 3way valves for changing the water flow direction provided by a pump, e.g. centrifugal pump, from suction to pressing without the need to reverse the pump; pin override system on latching pins; valve arrangement for reversing pump flow; vent valve arrangement in pump system (e.g. straight above interface); compact pump system size dimensions for loading four identical pump systems into one standard sea freight container, e.g. of TEU (20ft) type (shipping container of twenty foot equivalent unit, length twenty foot (6.1 meter), 8 feet (2.44 meter) wide, 9 foot 6 inch (2.90 meter) or 8 foot 6 inch (2.59 meter) or 4 foot 3 inch (1.30 meter) or a different height; convenient position of its centre of gravity, preferably approximately in the centre of the pump system, e.g. both lengthwise, widthwise and heightwise.

[0008] To the lift system to enlarge the venting capacity, preferably one or more of the following applies: means to, preferably axially, move or lift the pump system interface towards and away from the suction pile interface

while the pump system is attached to the suction pile, such that in a first position the interfaces are fluidly connected and moved towards each other and in a second position the interfaces are mutually spaced, preferably axially, preferably at least 10 or 20 millimeter, mutually keeping a gap such that fluid flow exiting the suction pile through its interface is not restricted to enter the pump system interface; said lifting means are designed to lift or move the complete pump system, e.g. by acting on the protective frame; said lifting means are designed such that if the pump system is attached to the suction pile and is lifted by a hoisting means attached to the protective frame, the suction pile suspends from the lifting means; means for rigid coupling of the pump system to the top bulkhead while simultaneously it is allowed that the suction pile interface and the pump system interface selectively mutually spaced or mutually connected; a from the pump system separate connector means or frame is provided with an element of the pump system coupling system and is attached to the pump system, e.g. protective frame by at least one movement means, preferably linear actuator, e.g. hydraulic jack, preferably regularly spaced around the pump system interface; the element of the pump system coupling system is adapted for, preferably releasable, engagement with an element of the suction pile coupling system; while the elements of the pump system coupling system and the suction pile coupling system are mutually engaged, the distance between the pump system and the suction pile can be adapted by operating the linear actuator to extend or retract; this mutual movement of the pump system interface and the suction pile interface is a linear or a tilting movement, in which latter case the connector means is preferably pivoted to the pump system. In this manner de flow through area is e.g. enlarged from 20 inch to 28 inch diameter.

[0009] To the quick connector to the top bulkhead tube stud, preferably one or more of the following applies: with means for releasable locking to the suction pile interface; with preferably a hole and/or pin, the pin preferably operated by actuator means of the pump system to move between a releasing retracted and locking extended position, preferably by lengthwise movement and/or movement perpendicular to the interface longitudinal axis; a padlock eye system; a spring loaded seated connection, e.g. a longitudinally resilient tube stud, preferably providing the tube free end (viz. e.g. fig. 13). The padlock eye system preferably comprises (viz. e.g. fig. 14-16) one or two spaced parallel plates each having a mutually registered hole, the plates preferably projecting from the pump system interface and the coupling with the suction pile is made by locating a hole in a plate of the suction pile interface in register with the pump system interface and inserting a tightly fitting pin into these two or three holes. The plates preferably extend parallel to the interface longitudinal axis.

[0010] To the measurement probe preferably one or more of the following applies: echo sounder probe; de-

signed for measurement through the top bulkhead tube stud; provided within the pump system interface, e.g. within the tube stud or the docking cone; provided in such a manner that it sends and/or receives its measurement waves, e.g. acoustic or electromagnetic, through the tube stud or docking cone; of acoustic and/or electromagnetic type.

[0011] To the docking cone preferably one or more of the following applies: designed to penetrate the suction pile interface, e.g. top bulkhead tube stud to align the pump system, or part of it, for sufficient sealing coupling of both interfaces; projects downwards and/or below the pump system; is provided by a spatial arrangement of plate like members to provide maximum flow through passage, e.g. at right angle crossing plates oriented parallel to and the cross axis co axial with the interface longitudinal axis (viz. e.g. fig. 8); co axial with pump system interface.

[0012] To the piping with 3 way valves (viz. fig. 12), preferably one or more of the following applies: provided with one or more, e.g. two, 3way valves; provided with valves for changing or reversing the water flow direction inside a tube connected to a pump from suction to pressing without reversing the pump operation or its drive system; the tube connected to the inlet and outlet of the relevant pump, preferably through separated connections at the tube; one or both of the inlet and outlet of the pump are connected to the common tube and possibly the environment via valves, e.g. a 3way valve, preferably each inlet and outlet its own 3way valve or valve set; a 3way valve or valve set provides selective connection and sealing, respectively, between the pump inlet or outlet, on the one hand, and the environment and common tube, on the other hand; the pump is, through piping and valves, connected with its inlet and outlet to the common tube and the environment such that by merely switching the valves, selectively the outlet is connected to the environment and sealed from the common tube and simultaneously the inlet is connected to the common tube and sealed from the environment (suction), or vice versa (pressing); the pipe connected to the outlet and the common tube is separate from the pipe connected to the inlet and the common tube; a 3way valve could be replaced by a valve set, e.g. two 2way valves, one of which is located in a branch and these are simultaneously operated to selectively seal the branch and open the mains, or vice versa, in which case the branch terminates in the environment and the mains into the common tube.

[0013] To the pin override system (viz. fig. 17-18) preferably one or more of the following applies: comprises a means, e.g. handle, for manual operation by a diver or for mechanical operation by an actuator, e.g. robot arm, of an underwater vehicle (e.g. ROV), preferably the handle is designed to provide the system a rotating action from an external source; designed to simultaneously act on two spaced latching members, e.g. pins, e.g. by operating a single means, e.g. handle; designed to be operated from two sides, preferably opposite sides, of the

pump system, e.g. a handle at both sides, preferably the operation means mounted on a common axis; designed to move, e.g. displace, the actuator, preferably of linear type, e.g. a jack, preferably of hydraulic type, of the latching member or members, e.g. pins, preferably such that the member is retracted to the release position, e.g. to be away from the associated holes or eyes or different feature, e.g. edge, for locking together the interfaces of the pump system and the suction pile, such movement of the jack preferably while the jack is inoperative, e.g. due to malfunctioning; a transmission, e.g. crank type connection, to convert a rotating movement into a linear movement; a transmission between two mutually angled, e.g. perpendicular, rotating axes; at least two latching members, preferably each having an own actuator, e.g. jack; a common drive means, e.g. rotating axis, drivingly connected to two driven means, e.g. rotating axes, each associated with an own latching member.

[0014] To the vent valve arrangement (viz. fig. 7) preferably one or more of the following applies: part of or on top of or above, preferably straight above and/or co axial with, the pump system interface; the pump piping to communicate the suction or pressure from the pump to the suction pile through the interface connects to the pump system interface at a level below the vent valve arrangement and/or to the side of the pump system interface; the pump piping connects to the pump system interface at an angle to the pump system interface longitudinal axis, preferably between 70 and 110 or between 80 and 100 degrees, such as 90 degreed; the pump piping has, e.g. its end connecting to the interface, a flow through area substantially smaller, e.g. at least 25% or 50% (e.g. 6 inch piping diameter compared to 20 inch interface diameter) compared to that of the interface; the interface extends upward, e.g. parallel to the suction pile longitudinal axis; releasably seals the pump system interface to the surrounding water; the pump piping connects to the pump system interface remote from, e.g. above, the interface part (the flange feature) designed to sealingly engage the corresponding part of the suction pump interface, e.g. the flange; the pump piping connects to the pump system interface at a location between the vent valve arrangement and the flange feature; at a distance above the pump system interface a protective plate like element, oriented preferably perpendicular to the interface longitudinal axis, is located to sideways divert the upstream flow from the interface and protect pump system parts above it.

[0015] To the pump size dimensions (viz. fig. 9-11) preferably one or more of the following applies: external dimensions such that four identical pump systems can be stored into one standard sea freight container, e.g. of TEU (20ft) type, preferably such that two pump systems are located side by side, longitudinally parallel, as a pair and two such pairs are located in mutual extension such that a package is obtained with twice the width, twice the length and the same height of a single pump system (or in the alternative two pump systems are mutually stacked

and two such stacks are located side by side such that a package is obtained with twice the width, twice the height and the same length of a single pump system), which package fits lengthwise into a standard sea freight container; two pumps are located side by side at the same level; the pumps are located at the one side, the pump drives at the opposite side of the pump system interface, seen in top view; the pumps and their drives are located at a level above the level of the pump system interface; a compact piping, preferably containing at least one or two manifolds, to connect the one or two pumps to the interface and the surrounding water; piping and valving to apply suction or pressing to the interface without reversing the pump; two manifolds above each other relative to the interface longitudinal axis; a manifold associated with the pump inlet; a manifold associated with the pump outlet; a riser pipe connected to two manifolds, preferably spaced along its length; the riser pipe connects to the pump system interface, preferably at its lower end; piping at the one and opposite side of the riser pipe, seen in top view, connecting to the inlet or outlet of a relevant pump, preferably said piping connecting to a manifold; a or each manifold connecting to a pipe terminating into the surrounding water as water intake or outlet to the pump system; valving to selectively open and close a relevant pipe, e.g. to control fluid flow between a manifold and one or more of the riser pipe, a pipe terminating in the surrounding water or a pipe connecting to the pump inlet and/or outlet; a valve of open/close type or a rate control valve, the rate control valve preferably associated with the into the surrounding water terminating pipe; one or two or each manifold having four pipes connected to it, preferably one from each two pumps, one from the riser pipe and one from the into the surrounding water terminating pipe; a manifold, preferably the one associated with the pump outlet, comprises one or two curved pipes, preferably merging into a common pipe of preferably larger, e.g. at least 25%, flow through area, e.g. 4 inch diameter curved pipes merge into a 6 inch diameter common pipe; a manifold connects to a terminal of the riser pipe, e.g. the riser pipe terminates as a T-shaped pipe connecting to pipes from the pumps, preferably outlet, on the one hand and to the pipe terminating in the surrounding water, on the other hand; a manifold is symmetric, e.g. in top view; a valve is present at a level between the manifolds; a valve is present in the riser pipe at a location between the connection of the pump inlet and outlet; the piping connecting to the pump inlet and/or outlet increases in flow through area, preferably at least 20% at a location along its length between the pump inlet or outlet, respectively, and a piping branch or merger, e.g. from 3 or 4 inch diameter at the pump outlet or inlet to 4 or 6 inch diameter, respectively; a manifold, preferably associated with the pump inlet, comprises at least one or two T-pieces, e.g. mutually connected, preferably a T-piece connects to a pump inlet or outlet and to a termination into the surrounding water and/or a T-piece connects to the riser pipe and to a pump inlet or outlet;

the piping and valving is designed such that two pumps are connected to a common inlet manifold, having an inlet termination into the surrounding water, and a common outlet manifold, having an outlet termination into the surrounding water, both manifolds are connected to a common riser pipe at spaced locations along its length, between which the riser pipe has a valve, the pumps selectively suck water from the riser pipe, having its valve closed, or the inlet termination, with the riser pipe valve opened, through the inlet manifold and supply it to the outlet termination or the riser pipe, respectively, through the outlet manifold; the piping comprises two sets of two valves each (preferably the sets have not a valve in common), wherein the valves of the one set is opened at the time the valves of the other set are closed, or vice versa, preferably each valve set has of both manifolds a valve, preferably a valve associated with the riser pipe of the one manifold and a valve associated with the inlet or outlet termination of the other manifold; a pump is associated with a valve to selectively seal it from the piping, e.g. in case the pump is made inoperative.

[0016] The pump system interface and the suction pile interface have, in the operational position during suction or pressing, a longitudinal axis parallel to the one of the suction pile.

[0017] The top bulkhead of the suction pile is provided with a means, e.g. upward projecting tube stud, providing the suction pile interface to connect the pump to the suction space. Preferably this means is provided with one or more of: a valve to selectively seal the suction space; a seat, e.g. a flange, at its end remote from the top bulkhead, onto which the corresponding interface means at the pump system, e.g. downward directed pipe stud, becomes seated, e.g. a corresponding seat, e.g. a flange; a member for engagement with the corresponding member at the pump system interface, e.g. a padlock eye system, preferably oriented for penetration in a direction perpendicular to the suction pile longitudinal axis. The padlock eye system preferably comprises a plate having a hole. Preferably the plate extends parallel to the interface longitudinal axis and/or the hole is oriented for inserting a pin perpendicular to the suction pile longitudinal axis.

[0018] It is noted that the invention is directed to suction piles for foundations, in other words designed to carry the weight of an upper structure, e.g. wind turbine or platform, placed on top, to avoid that such upper structure sinks into the subsea bottom. Thus a foundation suction pile bears loads from the associated upper structure which tend to force the suction pile further into the ground. A foundation suction pile is by the nature of its loading different from a suction pile for anchoring, which anchoring suction pile must withstand pulling forces from the anchored object which tries to leave its desired location by trying to pull the anchoring suction pile out of the subsea bottom. The invention is also directed to suction piles for anchoring.

[0019] Preferably one or more of the following applies:

the diameter of the suction pile is constant over its height (the height is the direction from the top bulkhead towards the opposite open end, which is the direction parallel to the suction pile longitudinal axis); from the top bulkhead the cylinder walls of the suction pile extend parallel; the open end of the suction pile, designed to be located on the sea floor first is completely open, in other words, its aperture is merely bordered by the cylinder walls; the water depth is such that the suction pile is completely below the water surface when its lower end contacts the sea floor, in other words when its lower end has not penetrated the sea floor yet; with the penetration of the suction pile into the sea floor completed, the top bulkhead is spaced from the sea floor.

[0020] The suction pile is also preferably provided with known as such valves and/or hatches adjacent or at its top bulkhead for selectively allowing water and air to enter or exit the suction space through the top side of the suction pile.

[0021] The invention is directed, in an embodiment, to a pump system operatively connected temporary to a suction pile as a marine structure or part of it, the suction pile preferably provided by an open bottom and closed top, advantageously cylindrical, elongate shell providing a suction compartment or suction space, said closed top having an externally facing upper face and an opposite, toward the suction space facing lower face and preferably provided with one or more valves selectively allowing fluid communication between the suction space and the environment.

[0022] The invention is further illustrated by way of non-limiting, presently preferred embodiments providing the best way of carrying out the invention and illustrated in the drawing, which shows in:

Fig. 1 a top view of a suction pile;

Fig. 2 a sectional side view according to the fig. 1 line A-A of the suction pile and a pump system on top of it;

Fig. 3 a pump system in perspective view;

Fig. 4-6 a front, top and side view of the pump system of fig. 3;

Fig. 7-8 a view according to line B-B in fig. 5 and D-D in fig. 6;

Fig. 9 of the fig. 3 pump system the piping and pumps in perspective exploded view;

Fig. 10 the fig. 9 piping from the opposite direction;

Fig. 11a-b a side and front view of the fig. 9 piping;

Fig. 12 a perspective view of an alternative piping;

Fig. 13 an exploded side view of a resilient flange coupling;

Fig. 14 an exploded side view of a pin locked flange coupling;

Fig. 15 an photographic image of a part of the fig. 14 coupling;

Fig. 16 a perspective view of a part of the fig. 14 coupling;

Fig. 17 a view according to line A-A in fig. 4;

Fig. 18 a perspective view of the fig. 17 mechanism;
 Fig. 19 a perspective view of an alternative to the
 Fig. 14 embodiment; and
 Fig. 20 a side view of the Fig. 19 embodiment.

[0023] Fig. 1-2 show the suction pile interface 5, the cylindrical wall 7, the pump system 1, the pump system interface 9, the seafloor 11, the soil plug 12 within the suction space, the top bulkhead 6, the longitudinal axis 14, the open lower side 8.

[0024] Fig. 3-18 show particulars of the pump system, particularly the above discussed features: a quick connector to mutually lock the pump system and suction pile interfaces releasably; measurement probe design; docking cone design; piping for changing the water flow direction without reversing the pump; pin override system on latching pins; vent valve arrangement in pump system; compact pump system size dimensions.

[0025] Fig. 3 illustrates the protective external space frame 24 and the four supporting feet 25. At the top, the frame 24 is provided with attachments 28 (e.g. eyes) for a hoisting device to hoist the pump system 1 and also the suction pile suspending from the pump system when the interfaces 5, 9 are mutually coupled. The pump 3 and its drive at opposite sides of the interface 5, 9 is most clearly illustrated in fig. 7 and 9.

[0026] The protective element at a distance above the pump system interface, as part of the vent valve arrangement, is most clearly illustrated in fig. 6, 7 and 9.

[0027] The cone 27 is the lower part of fig. 8, also illustrated in fig. 4, 6 and 7.

[0028] The connection of the riser pipe to the side of the interface is best illustrated in fig. 7.

[0029] The fig. 9-11 piping has six valves. Fig. 11a-b illustrate the valve associated with the riser pipe, the two manifolds above and below it. The arrows in fig. 10 illustrate flow directions.

[0030] In fig. 12 two 3way valves 2, the centrifugal pump 3 and the two pipe terminals 4 connecting to the interface 9 (not shown) are illustrated, with the connecting piping. The 3way valves are simultaneously switched such that the one connects to associated piping to the surrounding water and the other connects the associated piping to the interface 9 such that in this manner the inlet or the outlet of the pump is connected to the interface 9 and thus the pump operates as suction or pressure source, respectively, to the interface 9.

[0031] Fig. 13 shows the suction pile interface 5 and the pump system interface, the terminate end 9 of which latter is floatingly suspended due to the bellows 10 and springs 13, such that a spring loaded coupling can be made such that the interfaces are merely mutually sealed by gravitational force (the weight of the pump system).

[0032] Fig. 14 shows to the right hand side the locked state. This embodiment can be designed such that the complete suction pile can suspend from the mutually locked interfaces 5, 9, in different words the suction pile can suspend from the protective frame. The arrow illus-

trates the displacement of the pump system interface 9 towards the suction pile interface 5.

[0033] Fig. 15-17 show of the padlock eye system the two parallel plates 16 associated with the pump system interface, fig. 15 also shows the retracted pin 17 and fig. 17 the extended pin 17 to mutually lock the registered holes of the three plates 15, 16.

[0034] Fig. 17 shows in phantom the location of the plate 15 associated with the suction pile interface, plate 15 being part of the padlock eye system and sandwiched between the plates of the pump system interface if the interfaces are mutually locked. Also shown is the hydraulic jack 18 as the actuator to retract and extend the pin 17.

[0035] The turn handle 19, transmission 20 between rotating axes, and crank 21 to convert rotation into translation are shown in fig. 18.

[0036] Fig. 19 and 20 show an embodiment for rigid coupling of the pump system 1 to the top bulkhead 6 while simultaneously it is allowed that the pipes 5 and 9 are selectively mutually spaced (e.g. for purposes of venting fluid from inside the suction pile to the environment) or mutually connected. A connector frame 23 is provided with the plates 16 of the padlock eye system. The connector frame 23 is attached to the protective frame 24 by four hydraulic jacks 22 (three visible in fig. 19) regularly spaced around the interface 9. At the time the plates 15 and 16 are mutually fixed by the pins 17, the distance between the pipes 5 and 9 can be adapted by operating the hydraulic jacks to extend or retract.

[0037] Fig. 20 illustrates most to the left the phase during which the pump system 1 is lowered (illustrated by arrow A) onto the top bulkhead 6, hydraulic jacks 22 retracted, plates 15, 16 mutually registered and spaced. In the mid coupling of the pump system 1 with the top bulkhead 6 is completed since the pins 17 mutually fix the plates 15, 16. Since the hydraulic jacks 22 are retracted, pipe 9 connects to pipe 5. Most to the right the hydraulic jacks 22 are extended, lifting frame 24 and thus pipe 9 relative to connector frame 23, such that pipes 5, 9 mutually keep a gap such that fluid flow exiting the suction pile by pipe 5 is not restricted to enter pipe 9.

[0038] The fig. 19 embodiment allows to suspend the suction pile from the protective frame 24.

[0039] An alternative to fig. 19 is to provide the jacks 22 at a longitudinal end with the plates 16 and locate the jacks 22 such that the plates 16 can be registered with the plates 15. In this manner the connector frame 23 can be left out. In another alternative the frame 23 is pivoted to the pump system 1 at the one side of the interface 9, yielding a tilting movement of the pump system 1 relative to the suction pile.

[0040] The invention is not limited to the above described and in the drawings illustrated embodiments.

[0041] The drawing, the specification and claims contain many features in combination. The skilled person will consider these also individually and combine them to further embodiments. Features of different in here disclosed embodiments can in different manners be com-

bined and different aspects of some features are regarded mutually exchangeable. All described or in the drawing disclosed features provide as such or in arbitrary combination the subject matter of the invention, also independent from their arrangement in the claims or their referral.

[0042] The invention relates to a pump system designed to be temporary connected to the suction space of a suction pile, present under water, to generate an over pressure or under pressure within the suction space; and/or to an assembly of a pump system temporary connected by convenient means to the suction space of a suction pile, wherein preferably the pump system bears onto the top of the upward extending suction pile.

[0043] The invention also relates to a method of manipulating, e.g. installing, a suction pile, e.g. at an offshore location partly penetrating the sea bottom, comprising one or more of the following steps: connecting a pump system to the suction pile, preferably such that a rigid coupling between the coupling parts is obtained; operating the pump system to create inside the suction pile a pressure difference with the water around the suction pile.

Claims

1. Assembly of a suction pile and a pump system temporary connected by convenient means to the suction space of the suction pile, preferably wherein the pump system bears onto the top of the upward extending suction pile.
2. Assembly according to claim 1, having means (22, 23) to move the pump system interface (9) towards and away from the suction pile interface (5) while the pump system (1) is operatively attached to the suction pile, such that in a first position the interfaces (5, 9) are fluidly connected and moved towards each other, ready for the pump system creating a fluid flow to or from the inside of the suction pile through the mutually connected interfaces (5, 9) and in a second position the interfaces are mutually spaced, preferably at least 10 or 20 millimeter, mutually keeping a gap such that fluid flow exiting the suction pile through its interface (5) is not restricted to enter the pump system interface (9).
3. Assembly according to claim 1 or 2, said lifting means (22, 23) are designed to move the complete pump system (1) by acting on the protective frame (24) and are designed such that if the pump system is attached to the suction pile and is lifted by a hoisting means attached (28) to the protective frame, the suction pile suspends from the lifting means (22, 23).
4. Assembly according to any of claims 1-3, having means (15, 16, 17) for rigid coupling of the pump

system to the top bulkhead while the design is such that while the coupling means (15, 16, 17) are engaged simultaneously it is allowed that the suction pile interface and the pump system interface are selectively mutually spaced or mutually connected, preferably in that the coupling means are attached to movement means (22) for relative movement of the interfaces (5, 9).

5. Assembly according to any of claims 1-4, wherein a from the pump system separate connector means or frame (23) is provided with an element (16) of the pump system coupling system and is attached to the pump system, e.g. protective frame (24) by at least one movement means (22) and the element (16) of the pump system coupling system is in releasable engagement with an element (15) of the suction pile coupling system.
6. Assembly according to claim 5, the connector means (23) is pivoted to the pump system (1) such that the movement means (22) provide a tilting movement of the pump system interface (9).
7. Assembly according to any of claims 1-6, between suction pile and pump system a quick connector is operative comprising a pin (17) operated by actuator means (18) of the pump system to move between a releasing retracted and locking extended position.
8. Assembly according to any of claims 1-7, the pump system comprising a measurement probe designed for measurement through the top bulkhead tube stud (5).
9. Assembly according to any of claims 1-8, the pump system comprising a docking cone designed to penetrate the suction pile interface (5) and it projects downwards and below the pump system and is co axial with pump system interface (9).
10. Assembly according to any of claims 1-9, the pump system comprises two, 3way valves for changing or reversing the water flow direction inside a tube connected to a pump from suction to pressing without reversing the pump operation or its drive system.
11. Assembly according to any of claims 1-10, the pump system comprises a means, e.g. handle, for manual operation by a diver or for mechanical operation by an actuator, e.g. robot arm, of an underwater vehicle (e.g. ROV), designed to act on a latching member (17), e.g. pin, by displacing the actuator (18) of the latching member such that the latching member (17) is retracted to the release position.
12. Assembly according to any of claims 1-11, the pump system comprises a vent valve arrangement being

part of the pump system interface (9) and the pump piping to communicate the suction or pressure from the pump to the suction pile through the interface (5, 9) connects to the pump system interface (9) at a level below the vent valve arrangement and at a distance above the pump system interface (9) a protective plate like element, oriented perpendicular to the interface (9) longitudinal axis, is located to sideways divert the upstream flow from the interface (9) and protect pump system parts above it.

13. Assembly according to any of claims 1-12, the pump system comprises two pumps (3) located side by side at the same level and the pumps (3) are located at the one side, the pump drives at the opposite side of the pump system interface (9), seen in top view and the pumps (3) and their drives are located at a level above the level of the pump system interface (9).
14. Assembly according to any of claims 1-13, the pump system comprises piping (26) connecting the pump (3) to the pump system interface (9), the piping (26) comprising a manifold having four pipes connected to it, one from each two pumps, one from the riser pipe and one from the into the surrounding water terminating pipe and the manifold comprises one or two curved pipes merging into a common pipe.
15. Assembly according to any of claims 1-14, the pump system comprises piping (26) comprising two manifolds which are symmetric in top view and a valve is present at a level between the manifolds.

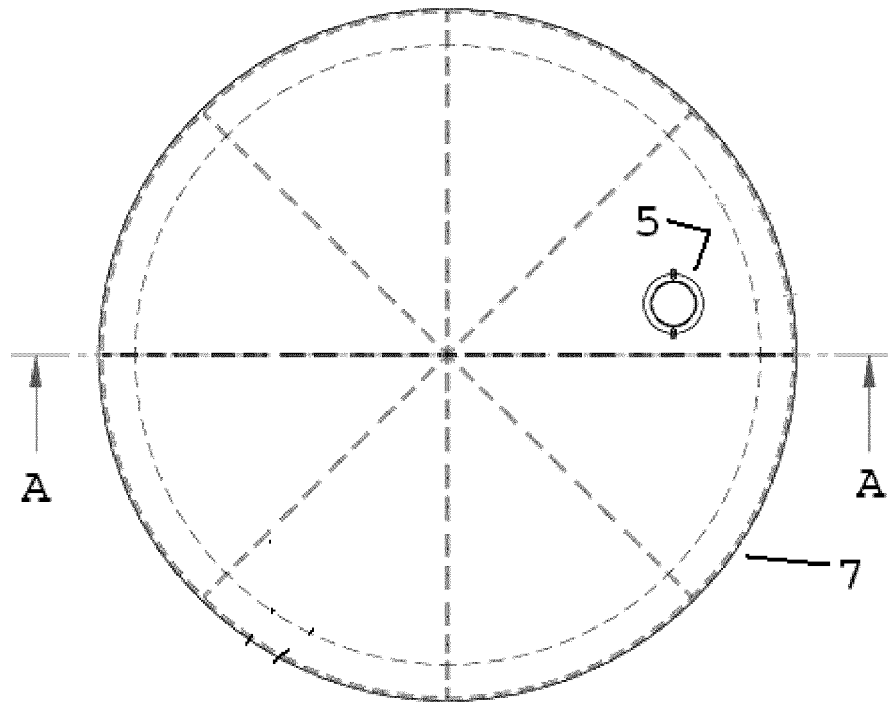


Fig. 1

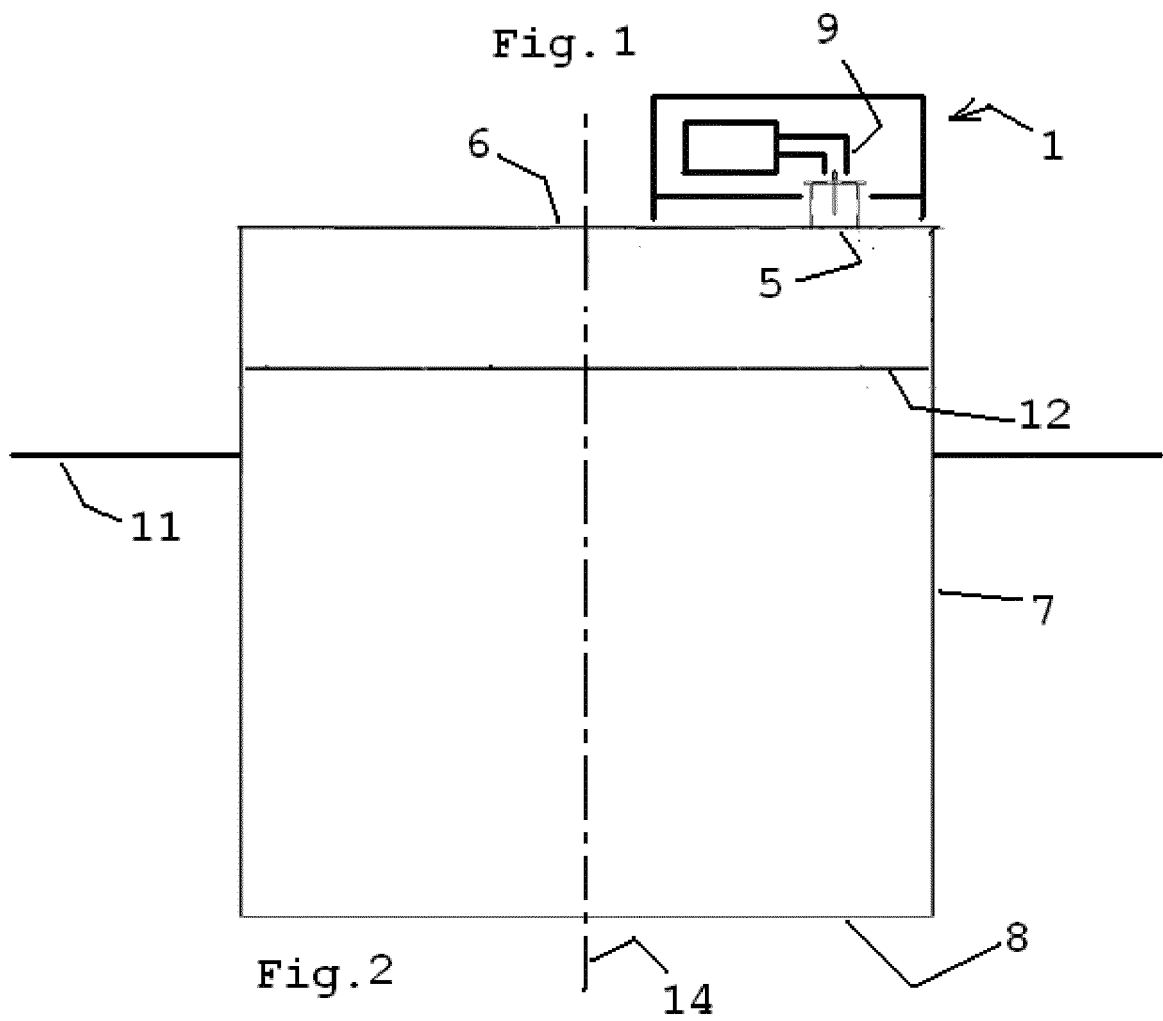


Fig. 2

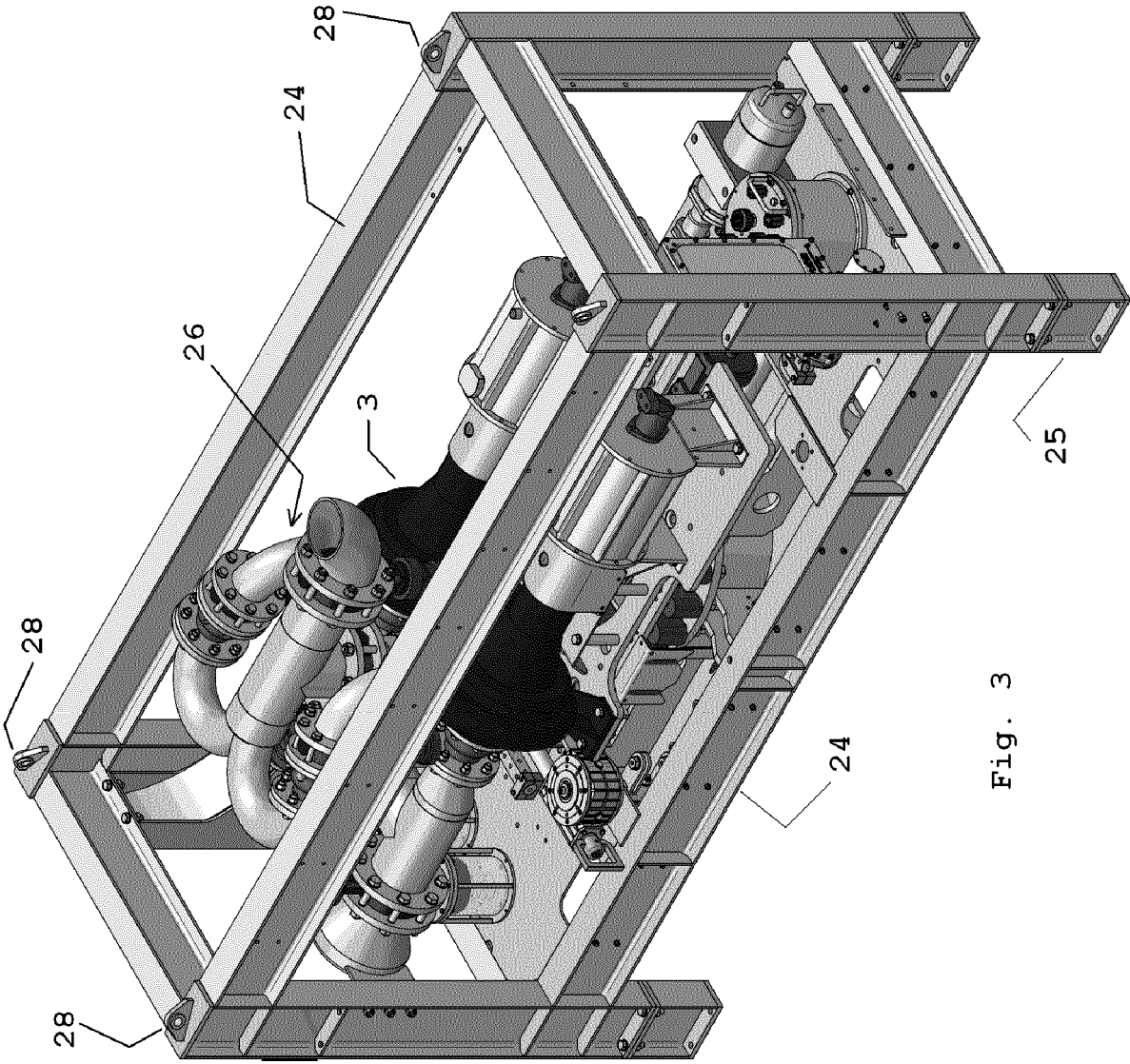


Fig. 3

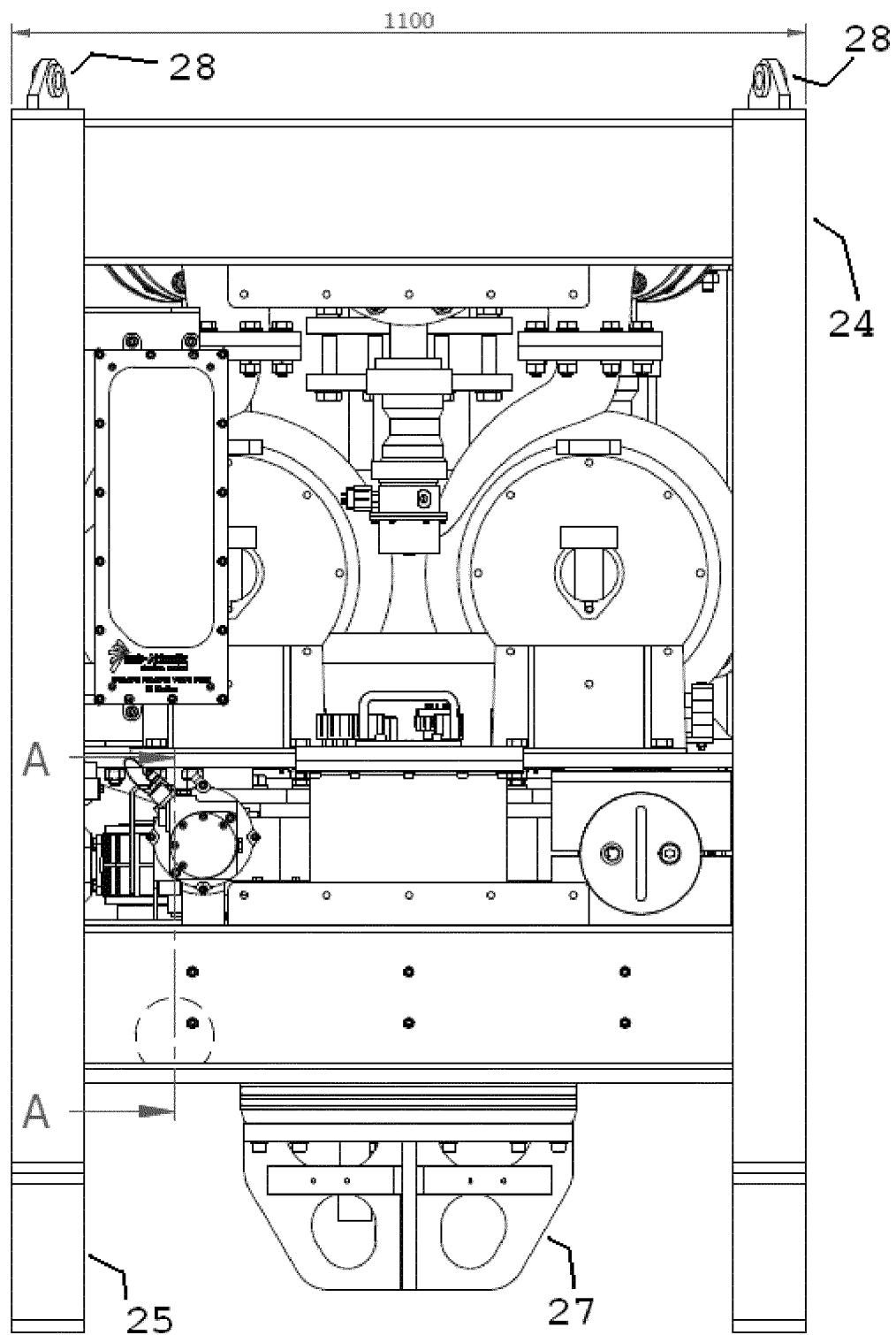


Fig. 4

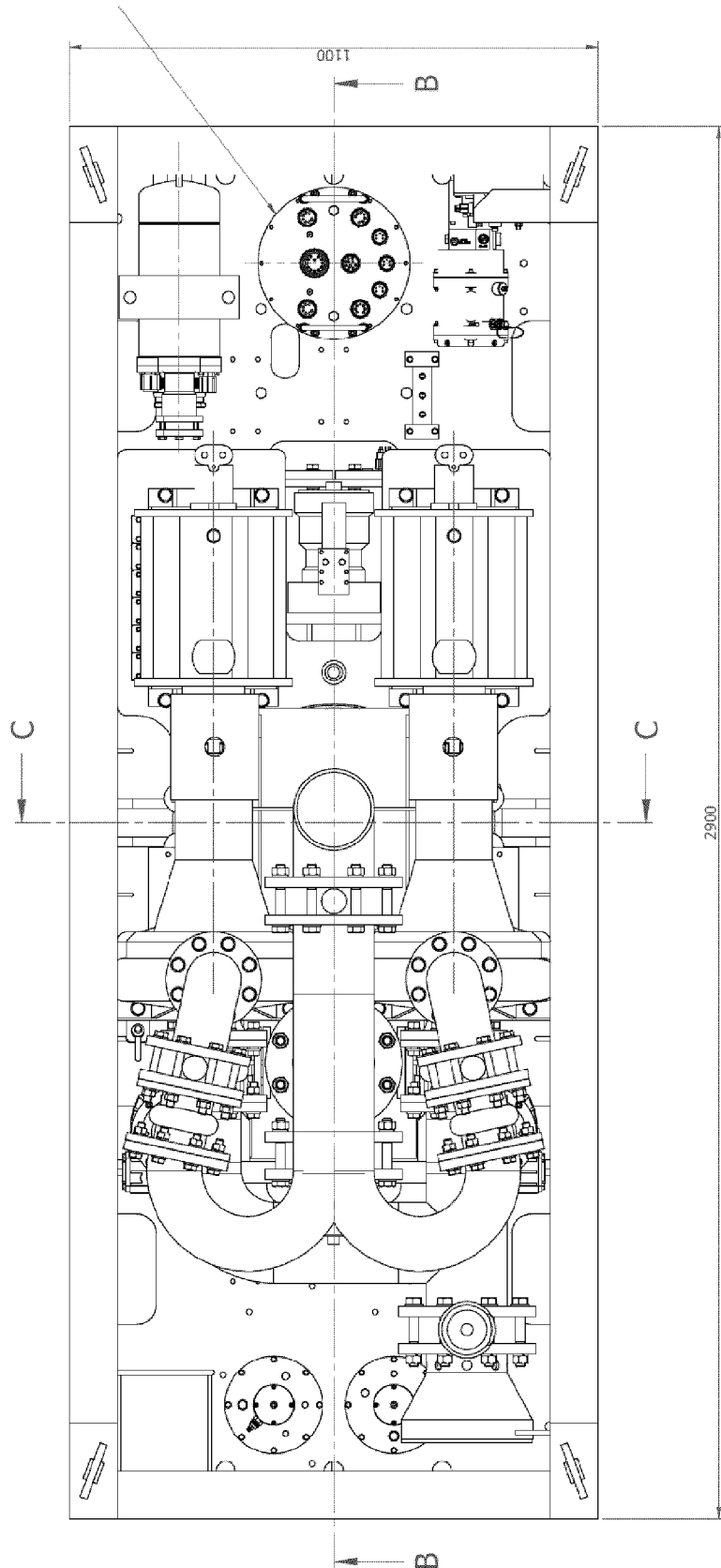


Fig. 5

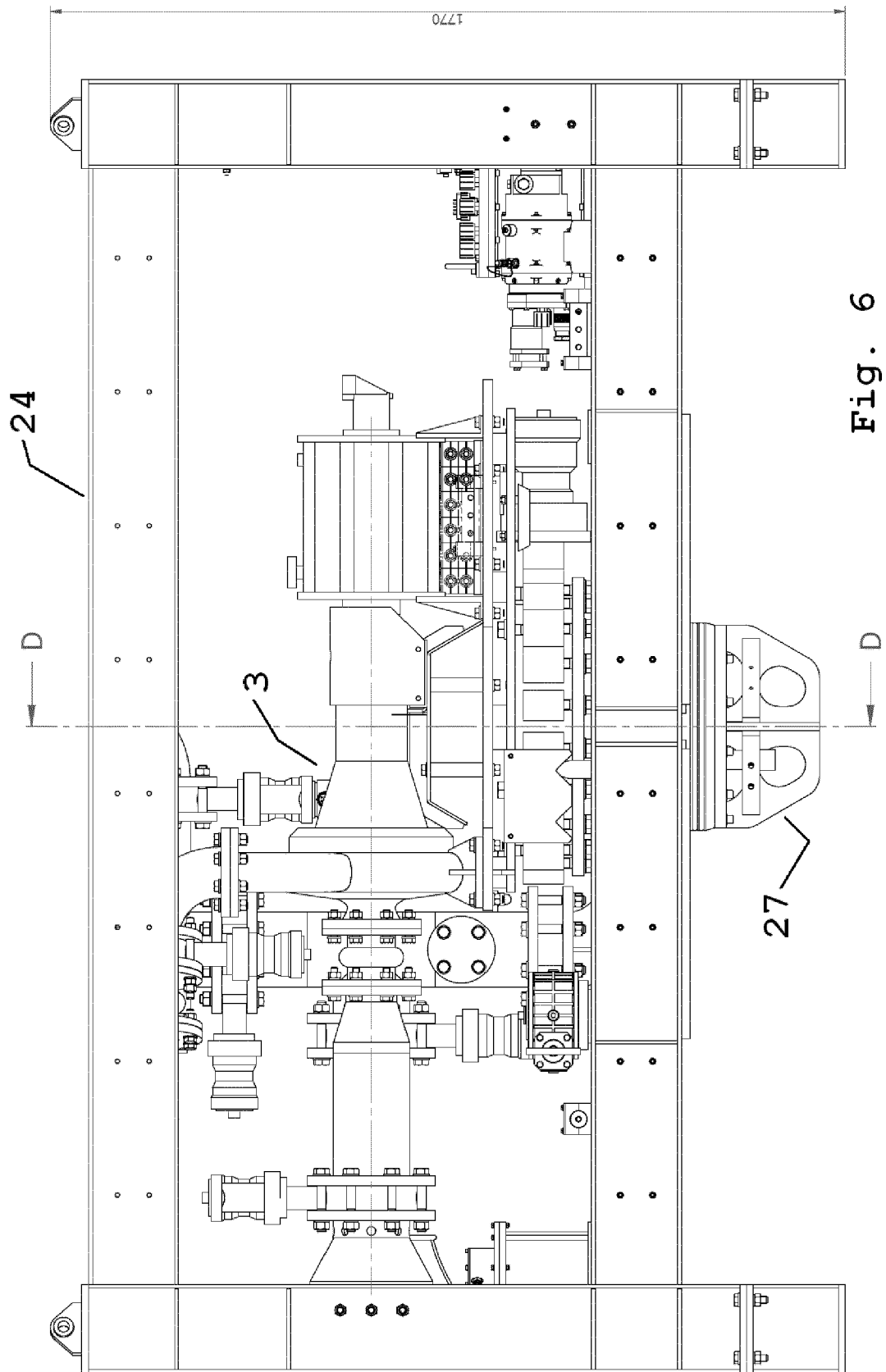
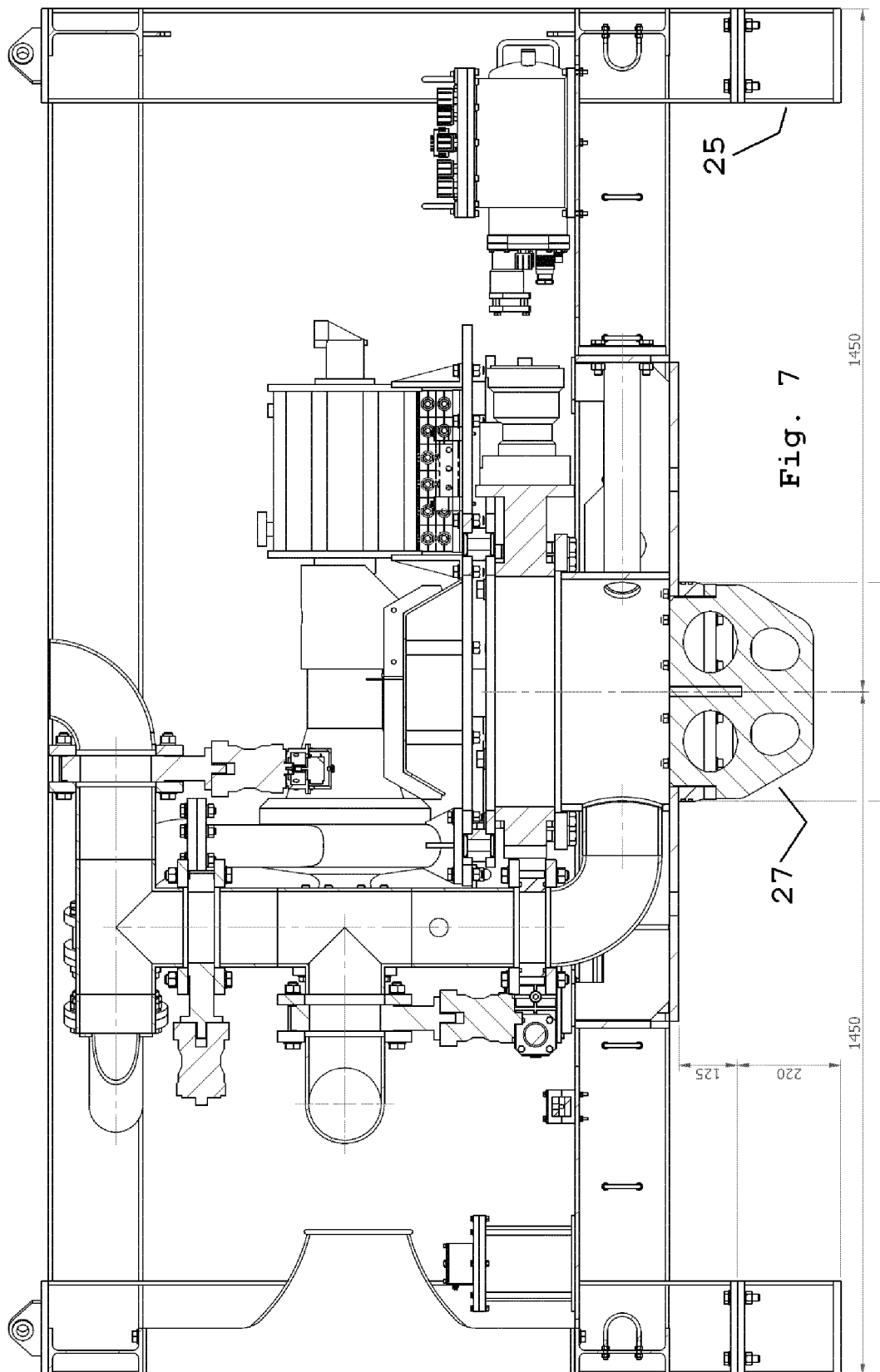


Fig. 6



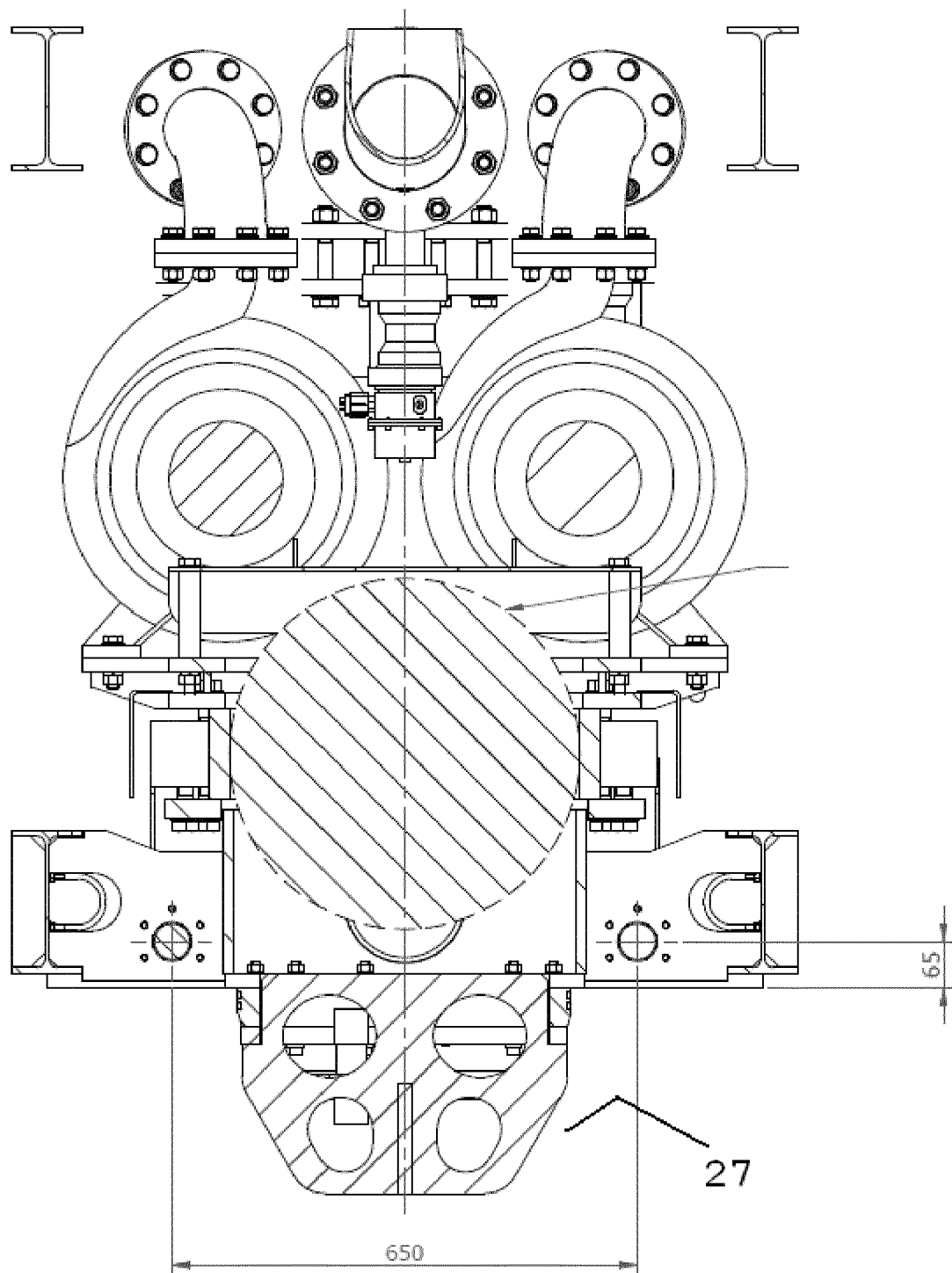


Fig. 8

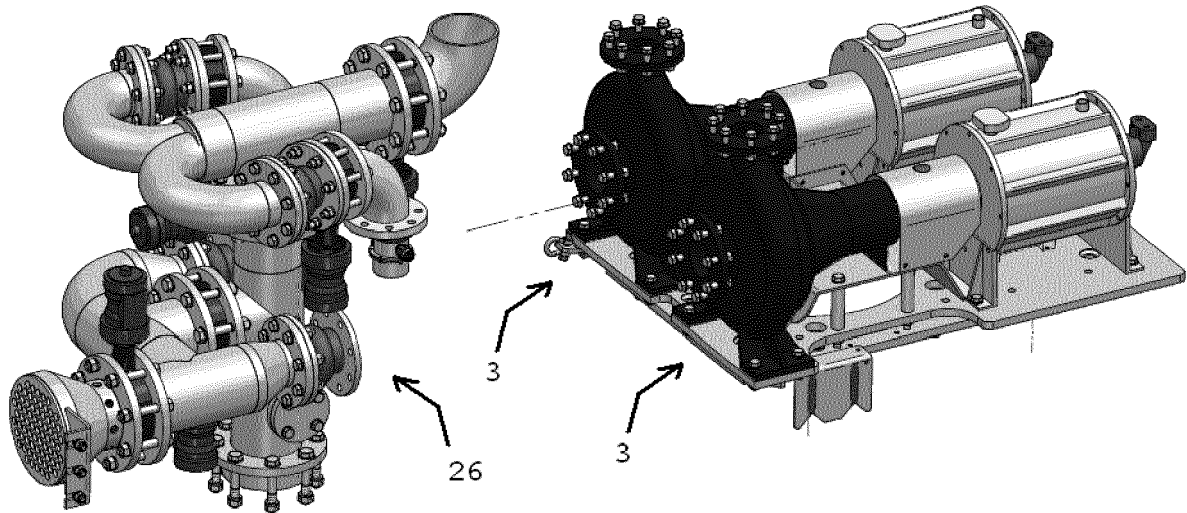


Fig. 9

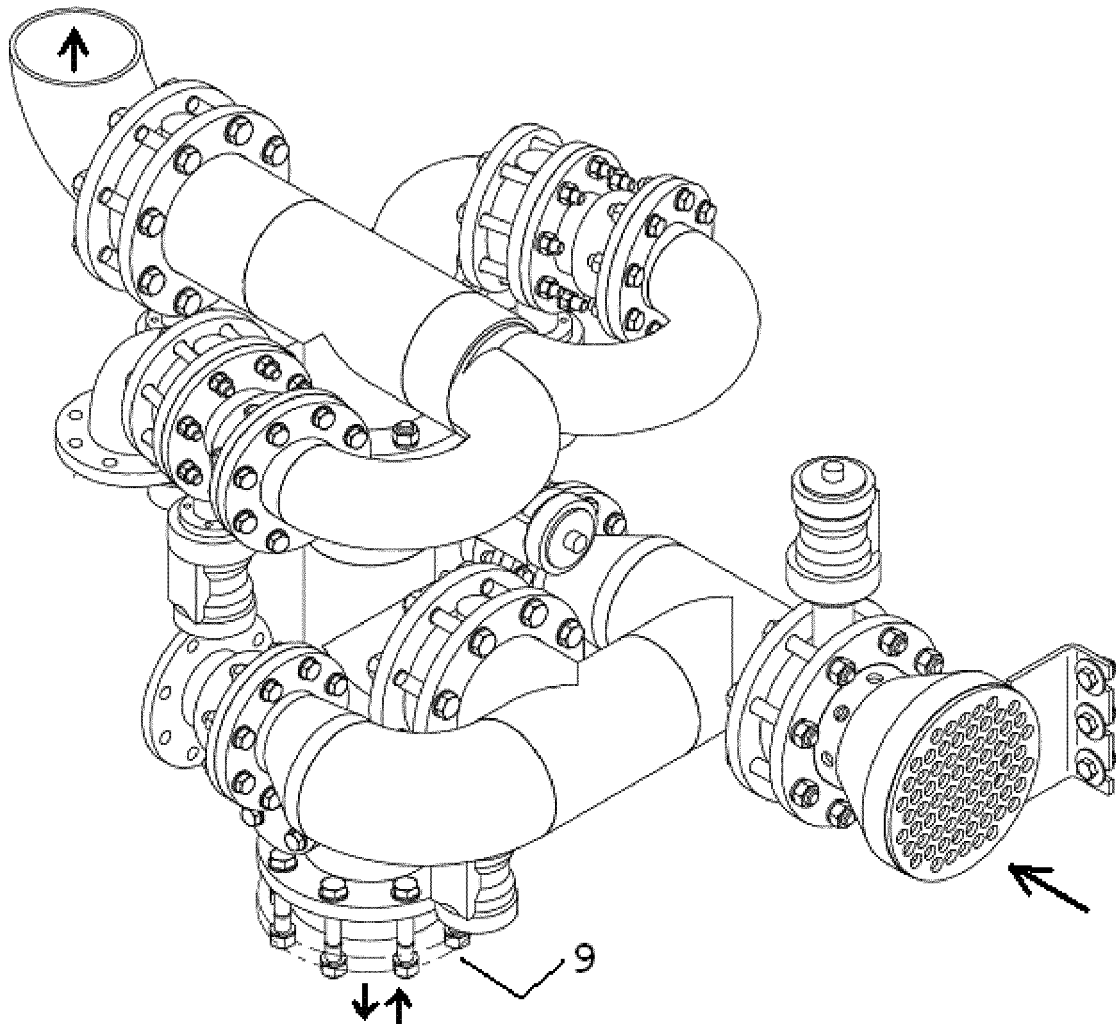


Fig. 10

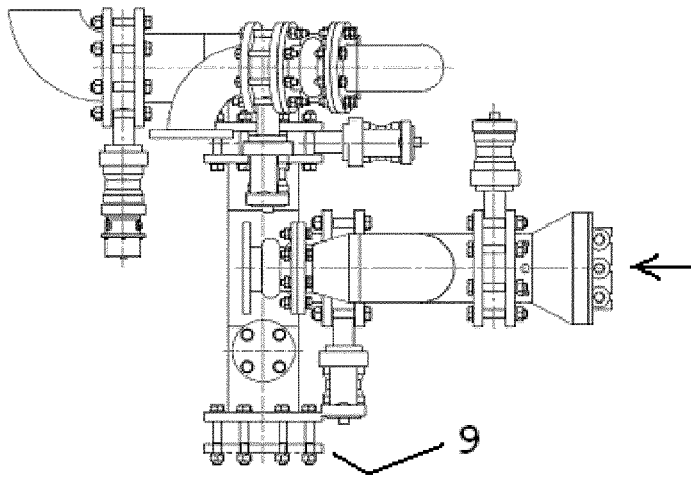


Fig. 11a

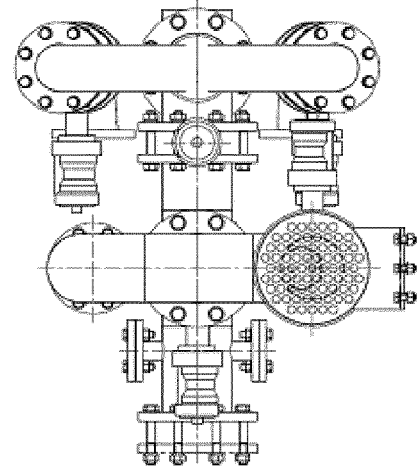


Fig. 11b

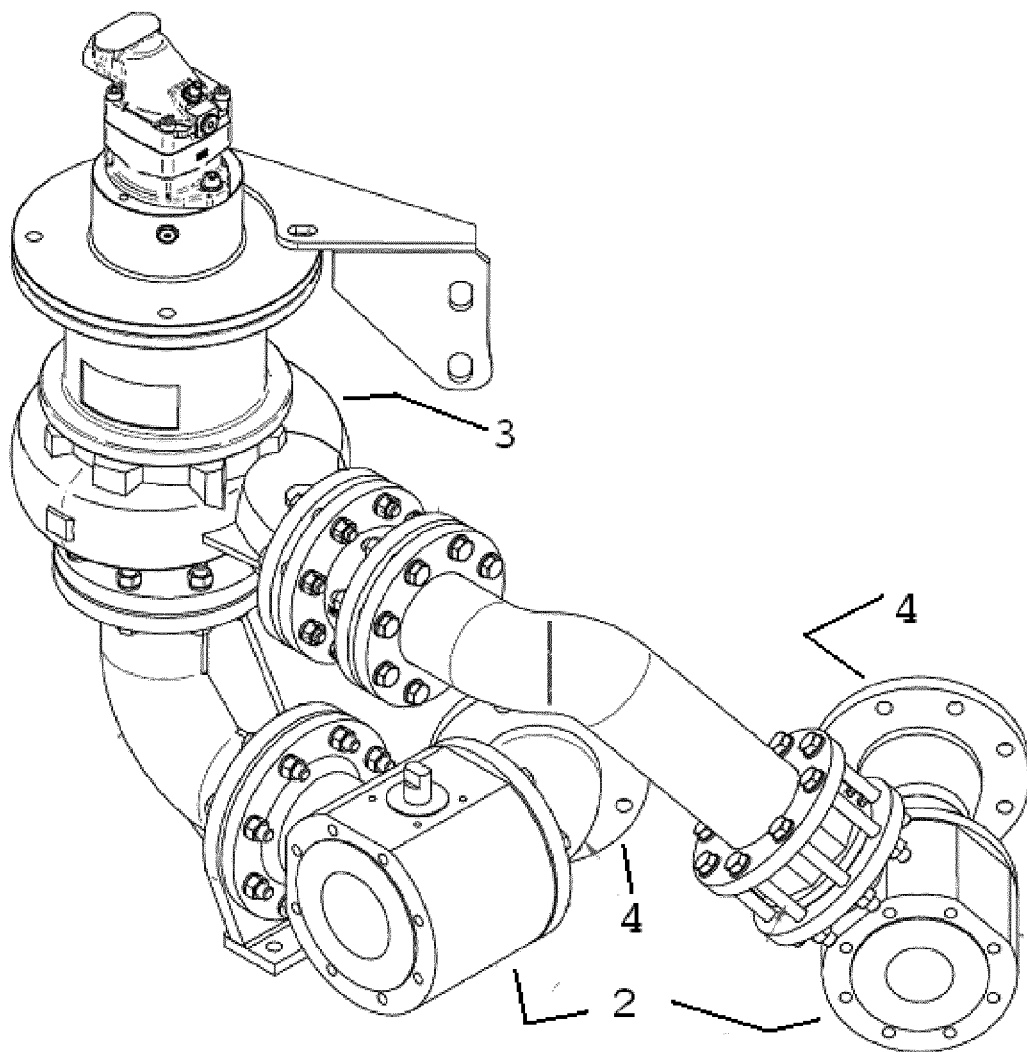


Fig. 12

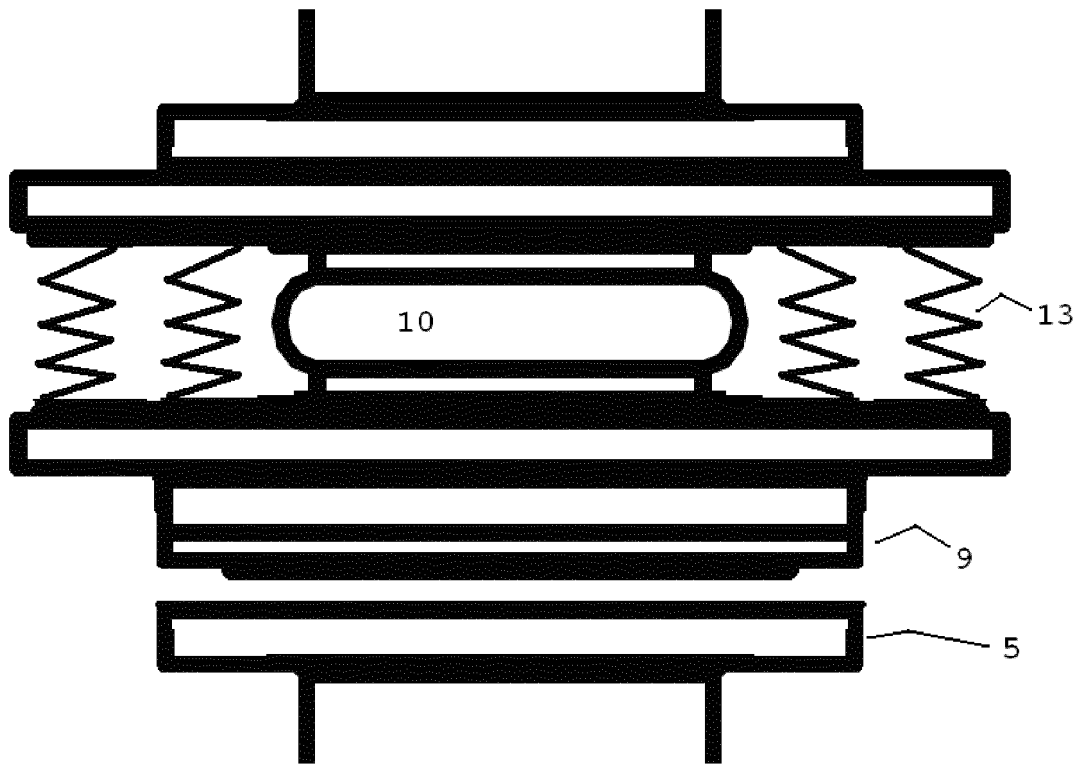


Fig. 13

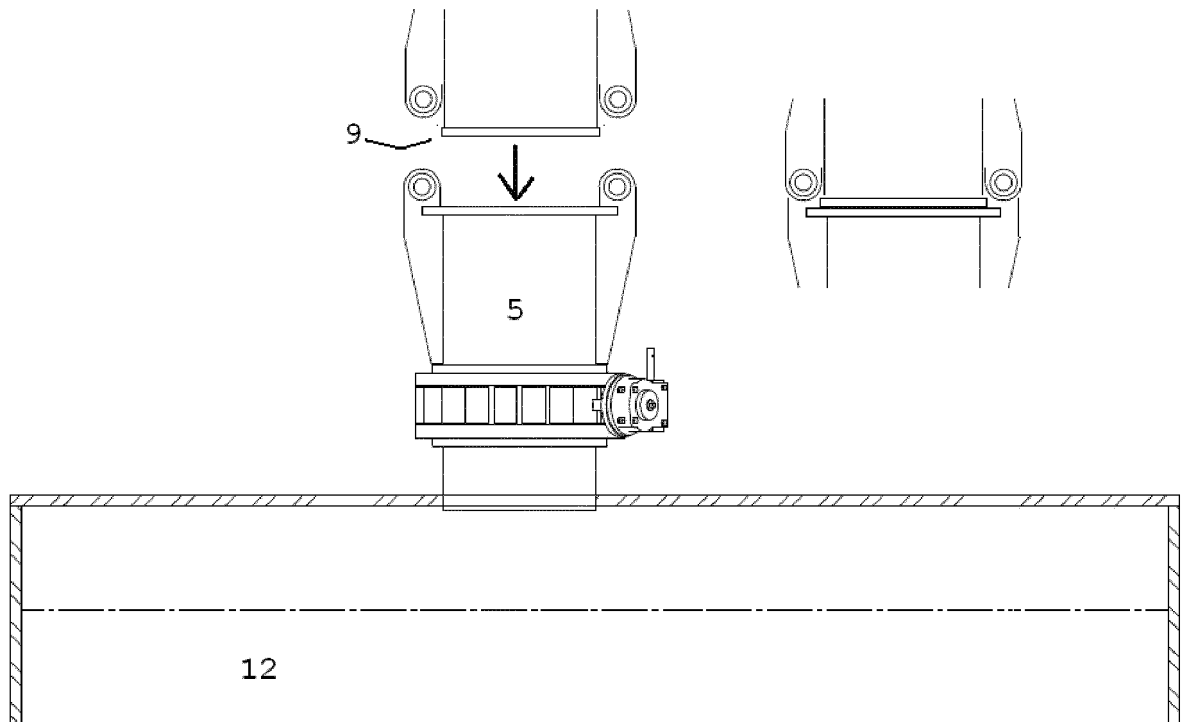


Fig. 14

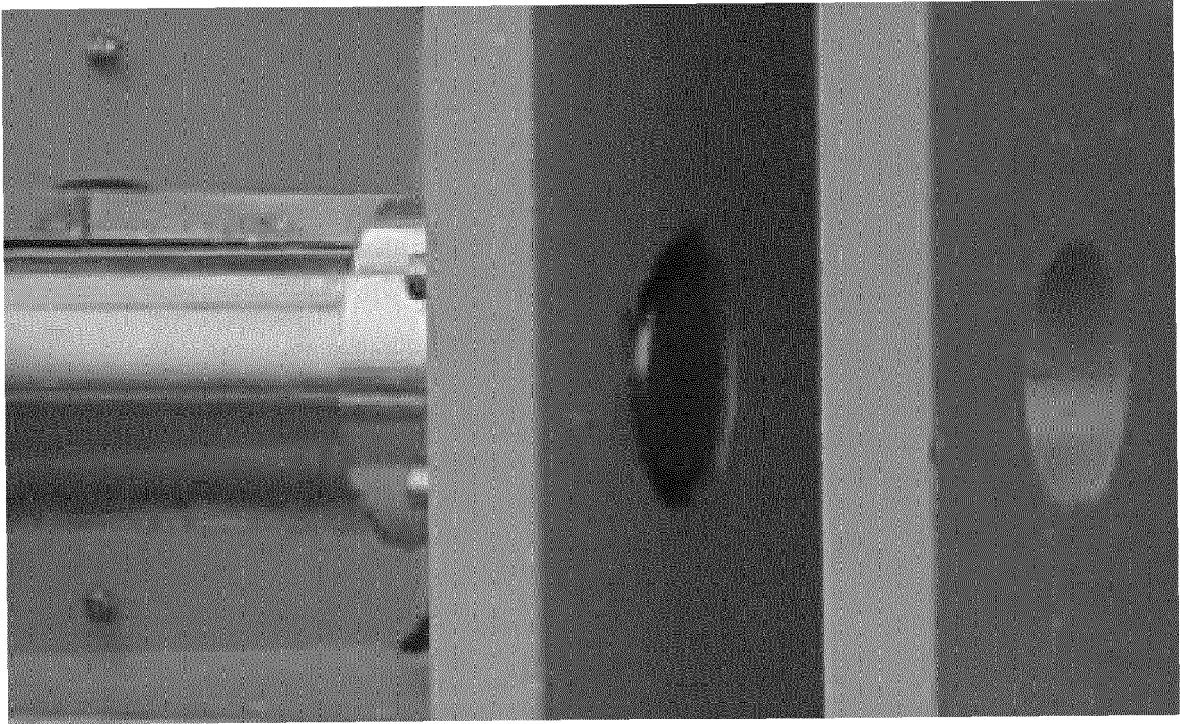


Fig. 15

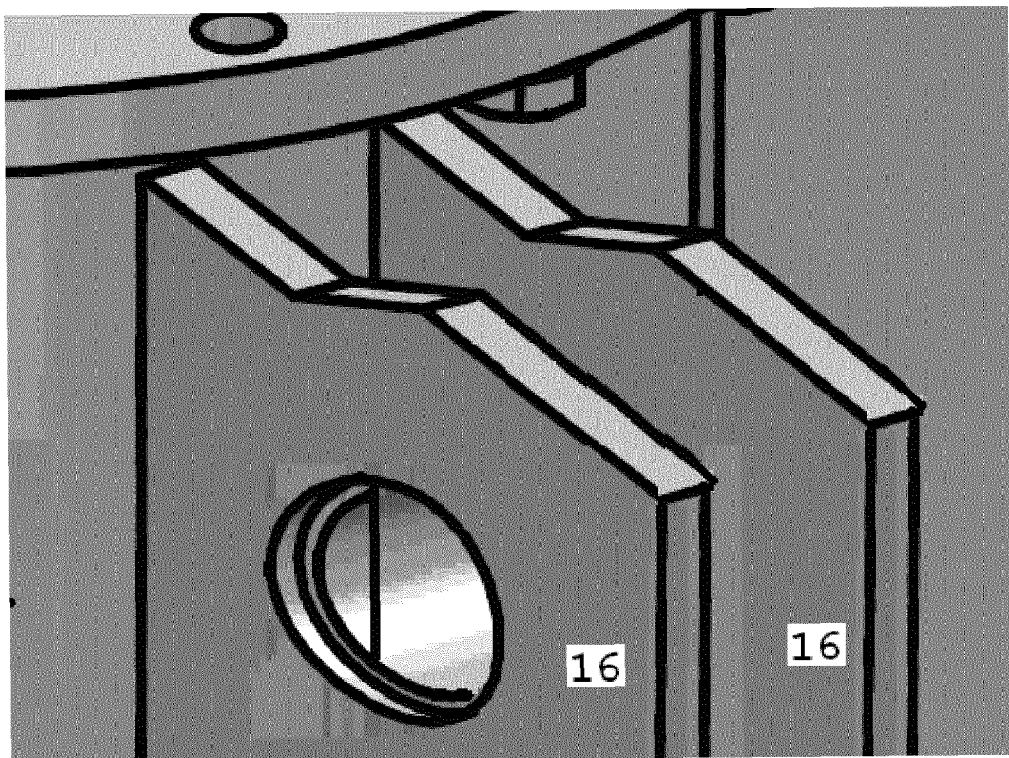


Fig. 16

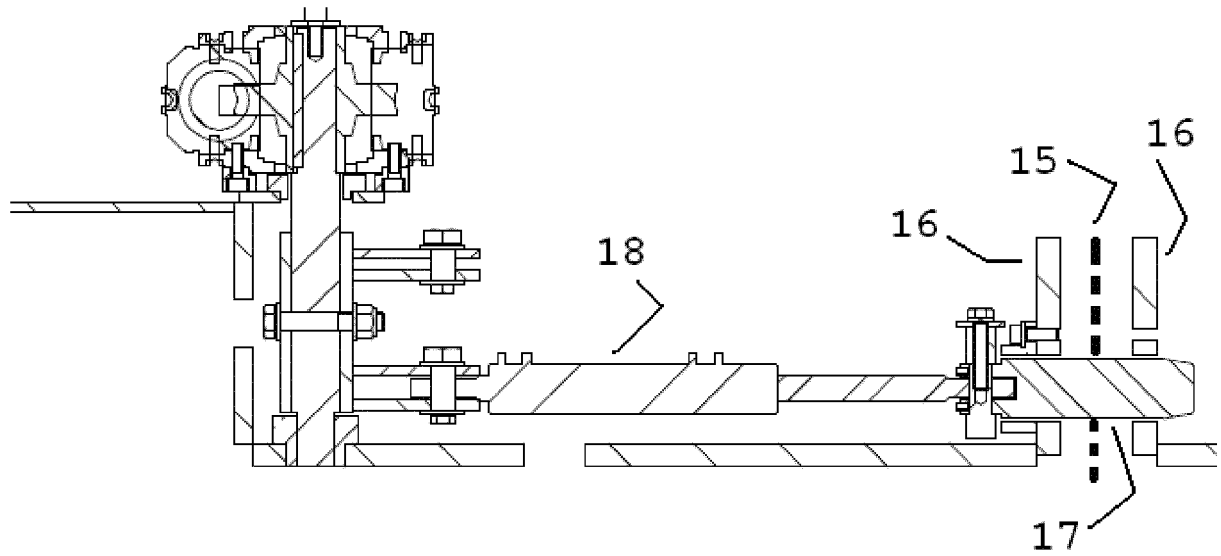


Fig. 17

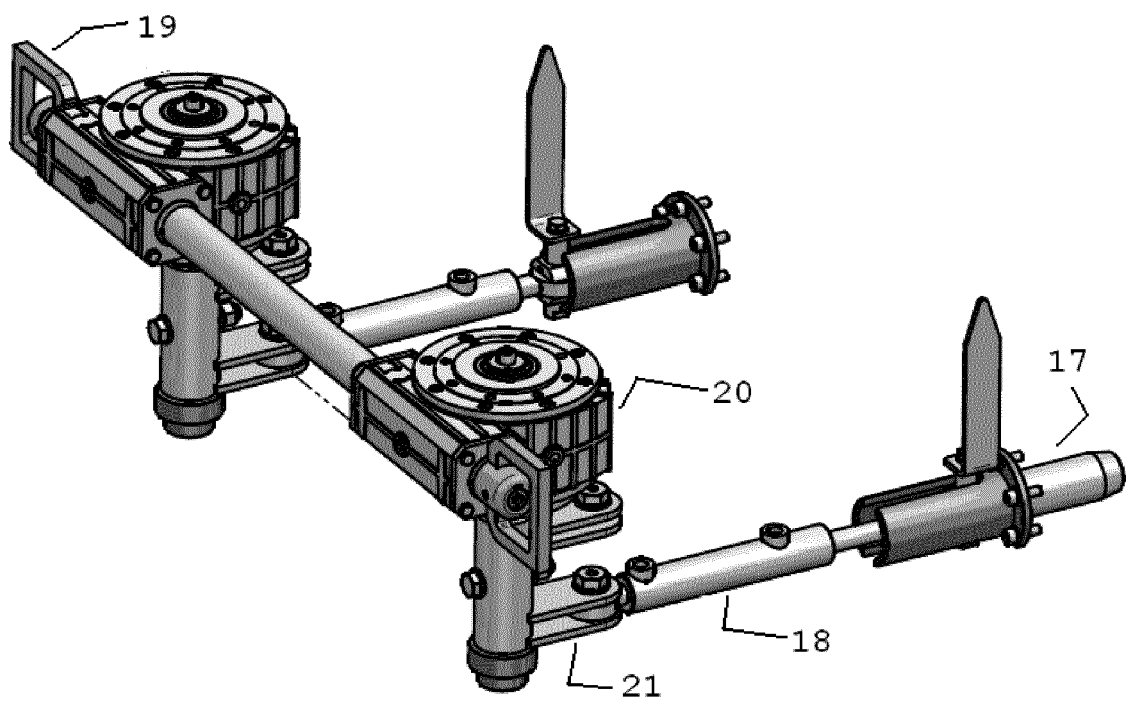


Fig. 18

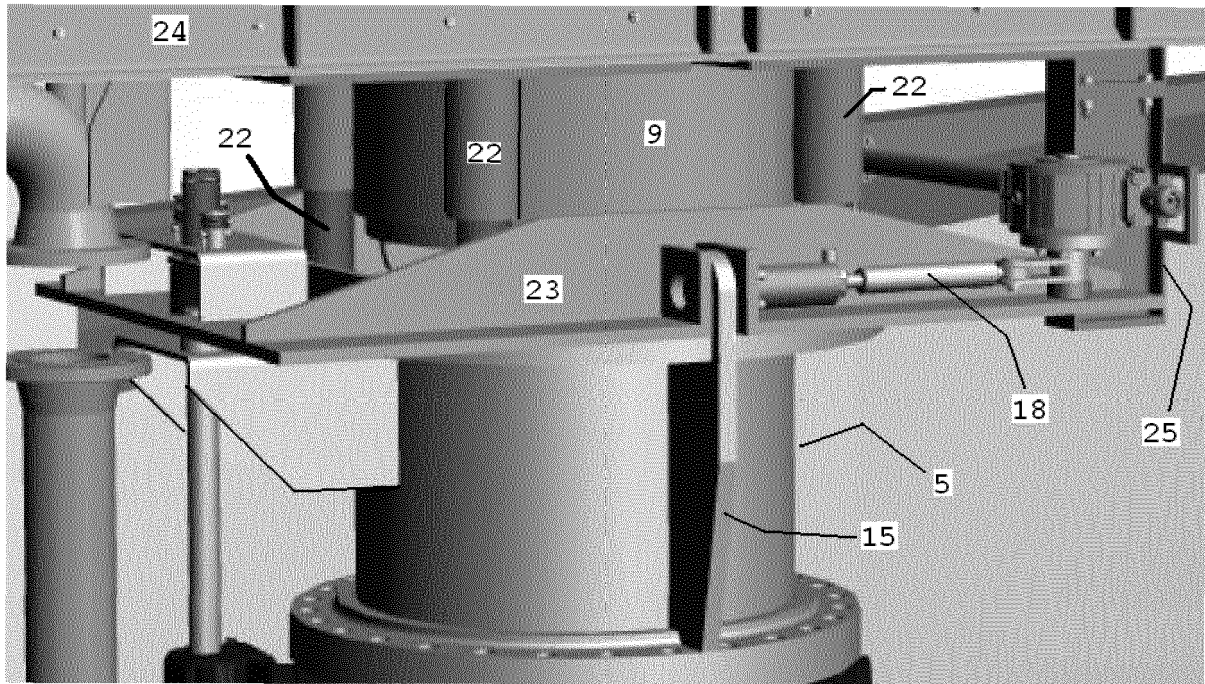


Fig. 19

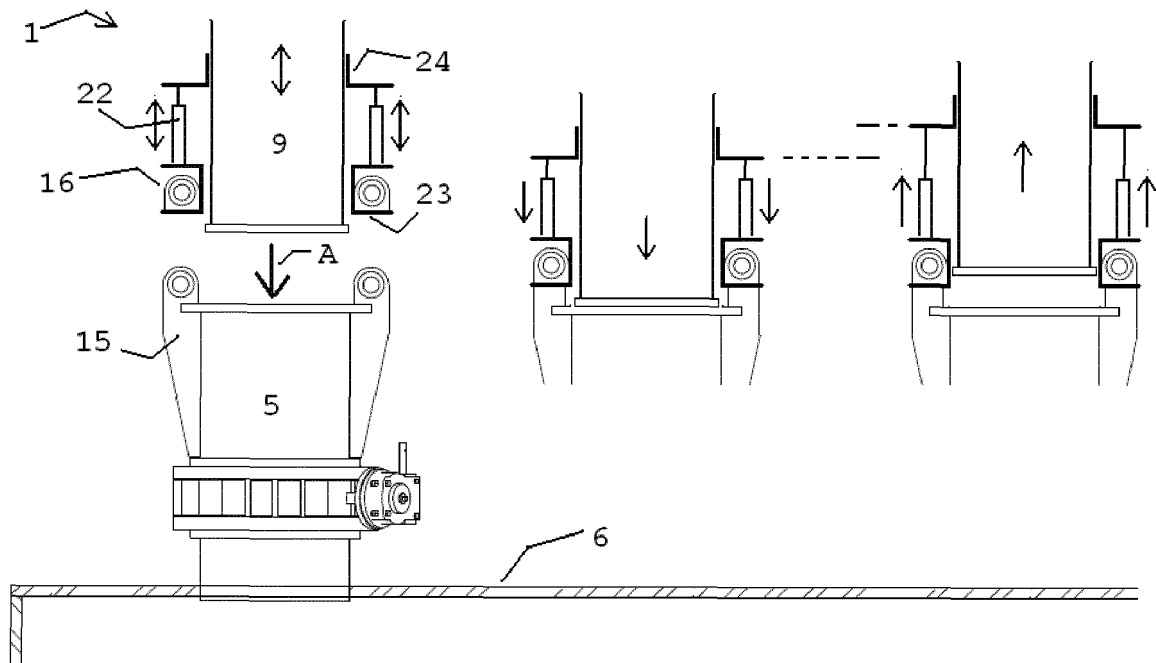


Fig. 20

REFERENCES CITED IN THE DESCRIPTION

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