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(54) **Underwater core sampling apparatus**

(57) A core sampling apparatus comprising core sampling means (10, 8) suitable for being driven in an underwater bed to take a sample thereof. The apparatus comprises a turret (1) for supporting the core sampling means (8, 10), the turret comprising in turn a substantially flat base (1a) for being rested on the underwater bed, and guide means (1c) extending perpendicularly from the base (1a), for slidingly supporting the sampling means (10, 8), the apparatus also comprising drive means (7, 5) supported by the turret (1) for controlling the sliding of the sampling means (8, 10) along the guide means (1c).

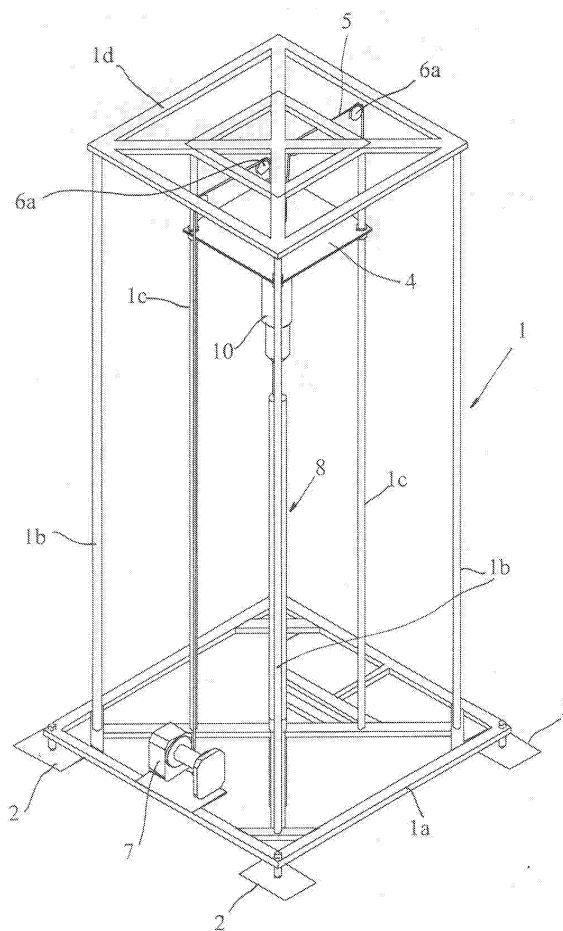


Fig. 1

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Description

[0001] The present invention relates to the field of the samplings of subsoil material for the purpose of analyzing the chemical and/or physical properties thereof. More particularly, the object of the invention is an underwater core sampling apparatus which can be used in the above mentioned field.

[0002] Investigation of the sediments which make up an underwater bed enables a considerable amount of data to be obtained regarding the environmental effects of human activity on the ecosystem, namely the marine ecosystem. These data are extremely important in particular for the increasingly frequent operations of environmental reclamation of marine and coastal areas involved in long-term pollution phenomena, areas which in most cases show seriously contaminated sediments. In fact, the need for a rapid removal of the pollutants from the aquatic environment by means of reclamation technologies requires prior quality and/or quantity characterization of the materials to be removed, from a chemical, physical and biological standpoint.

[0003] Characterization of underwater beds is also essential for evaluating the environmental impact and effects on the aquatic ecosystems of interventions and operations such as routine or non-scheduled harbor dredging, the building of harbor infrastructures (wharfs, jetties, basins etc.), the laying of cables and pipes, monitoring of protected marine areas or sites subjected to environmental risks.

[0004] Intensive research is therefore underway into technologies which simplify the work of sampling of underwater sediments and fulfill the need to work in an underwater environment with a lightweight and versatile apparatus which is also, as far as possible, autonomous from the back-up boat.

[0005] More specifically, this research is aimed at identifying specific apparatus for underwater core sampling or samplings *in situ* of underwater beds, able to minimize the physical alteration and contaminations of the samples, and which can be used with small sea crafts, such as boats up to 15 meters or small floating structures, so as to be used in any marine sedimentary deposit, from the coastal zone to the limit of the continental shelf, in river, lake and lagoon areas.

[0006] The present invention achieves the objects mentioned above thanks to the apparatus whose essential features are defined by the first of the annexed claims.

[0007] The features and advantages of the core sampling apparatus according to the present invention will be made clearer by the following description of one of its embodiments, given by way of a non-limiting example with reference to the accompanying drawings, wherein:

- figure 1 is an axonometric view of the apparatus according to the invention, represented schematically and with parts omitted for the sake of clarity;

- figure 2 is a top plan view of the apparatus of figure 1;
- figures 3 and 4 are cross-section views of the apparatus taken respectively along lines III-III and IV-IV of figure 2;
- figures 5 to 7 show three subsequent steps of a core sampling procedure with the apparatus of the previous figures, the apparatus being shown in cross-section as in figure 3; and
- figures 8 and 9 are enlarged views of a probe head of the apparatus, respectively in the working steps of figure 6 and figure 7.

[0008] Referring to the above figures, the apparatus according to the invention comprises a turret 1 with a network structure in stainless steel, comprising in turn: a base 1a, generally quadrilateral; four external uprights 1b which rise up perpendicularly from the base 1a in proximity of respective angles thereof; four internal uprights 1c, which also extend perpendicularly to the base 1a from points on the diagonals thereof, said points being all at the same distance from the centre, and closer to said centre than the external uprights 1b; and a flat covering frame 1d which joins the upper ends of the uprights 1b, 1c, closing the turret at the top in a parallel arrangement to the base 1a.

[0009] The base 1a has, at the four angles, respective adjustable feet 2, for allowing the apparatus to rest on the sea bed, or any other underwater bed wherein sampling of the material to be analyzed is to take place. Each of the feet 2 is controlled by an oil-pressure linear actuator (not shown), in order to enable independent variation of the extension of the four feet from the base 1a of the turret 1. A hook-like or ring-like member 3, not shown in figure 1, projects from the top covering frame 1d for allowing the turret 1 to engage with external lifting/transport means of, as will be cleared further on.

[0010] The internal uprights 1c of the turret 1 act as guides for the sliding of a quadrilateral plate 4, slidably connected to said uprights at the four angles, and consequently able to translate from the top frame 1d towards the base 1a, and vice versa, remaining parallel to both. The movement of the plate 4 is controlled by a drive system with a wire 5 and deviation pulleys 6a, 6b, linked to a winch 7 with oil-pressure operation, fixedly mounted on the base 1a along one side thereof.

[0011] More specifically, the wire 5 unwinds from the winch 7 to a set of pulleys 6a supported below the top frame 1d, and also around a pulley 6b placed on the upper face of the sliding plate 4. A wire-winding pulley is finally provided at the other end of the wire 5, that is to say the end opposite to that connected to the winch 7. This wire-winding pulley is arranged over the base 1 on the side opposite to the winch 7, and cannot be seen in the drawings because it is concealed by the schematization of an oil-pressure unit 9, to be described in greater detail shortly.

[0012] A vibrating hammer 10, represented schemat-

ically in the drawings, is attached to the lower face of the plate 4, that is to say the face opposite that with the pulley 6b. The hammer 10, in turn with oil-pressure operation, is of a known type if considered as such - employing the technology known as "vibracoring" in the field of drilling and sampling - and therefore will not be described in detail.

[0013] The hammer 10 thrusts a sampling probe, generally denoted at 8 and comprising a linear core barrel 11, with tubular structure and length corresponding substantially to the maximum length of the sample of material which can be taken. The barrel 11 projects downwards in a central position for passing through the base 1a by inserting slidingly in a hole 1e formed to the purpose in a suitable position.

[0014] As can be seen clearly in particular in figures 8 and 9, a tubular head 12 with a cutting edge 12a is screwed coaxially at the free end of the barrel 11. Inside the head 12, having for the purpose a structure which can be broken down into two parts, a sleeve 13 is engaged, with diameter smaller than that of the head 12 so as to define in co-operation therewith a toroidal gap 14.

[0015] The sleeve 13 acts as a support for one end of a tubular sheath 15 for lining the core (that is to say, the sample with a substantially cylindrical shape) of material to be taken. The sheath 15, made of a material such as white nylon, slightly stretchable in a radial direction but substantially non-stretchable in an axial direction, is fitted around the sleeve 13, in the gap 14, in order to be free to unfold axially inside the barrel 11.

[0016] Inside the sleeve 13, near the cutting edge 12a of the head 12, a check valve 16 is arranged, formed by a convex diaphragm made of an elastically flexible material. The diaphragm is notched radially in such a way as to open towards the interior of the barrel 11 (figure 8), allowing the passage of the sampling material therein, and to close elastically in such a way as to block the entrance of the barrel (figure 9), preventing release of the aforesaid material.

[0017] Finally, video cameras 18 and lighting devices 17 can be seen in figures 2 to 4, supported by the turret 1 on the base 1a and on the top frame 1d, to allow remote vision of the sampling zone and consequently of the core sampling operations, from a back-up boat or from land.

[0018] The lighting devices 17 and the video cameras 18, as well as the oil-pressure unit 9, are electrically powered and controlled by means of a cable system, not shown, which connects the apparatus to the back-up boat or to land. Similar connection cabling is also provided for the surface transmission of the video signal emitted by the video cameras 18.

[0019] Representation is also omitted of the oil-pressure circuits which connect the unit 9 to the vibrating hammer 10, to the winch 7 and to the actuators of the feet 2, moreover having features, as such, which are obvious to a person skilled in the art.

[0020] Referring now in particular to figures 5 to 9, the core sampling operations with the apparatus according to the present invention are carried out in the following manner. Assuming that a back-up boat is employed, the boat with the apparatus on board is positioned at the point of the seabed wherein the sampling has to be carried out. A DGPS antenna can be used for accurate positioning, dialoguing with a PC provided with appropriate navigation software.

[0021] The turret, initially without the probe 8, is equipped with the same. The cutting head 12 with the sheath-holder sleeve 13 and the check valve 16 is set up separately, arranging the sheath 15. The sheath, cut to size beforehand according to the length of the core which is to be sampled, is folded for the greater part of its extent in such a way to become axially compressed around the sleeve 13. An O-ring seal is placed around the sheath at the base of the sleeve, for improved tightness of the connection.

[0022] If the sheath is in the shape of a tubular portion open at both ends, the end intended to remain inside the barrel 11 is closed by a knot. A number of punctures are also carried out in the sheath near the closed end for assisting the passage of the water during subsequent descent of the apparatus, so as to avoid untimely unfolding of the sheath. The head 12 can finally be screwed to the barrel 11.

[0023] Having attached the probe 8 to the hammer 10, with the plate 4 in the position of maximum elevation and therefore with the barrel 11 completely withdrawn inside the turret 1, the apparatus is lowered underwater, hooked via the member 3 by suitable lifting means. The video cameras 18 make it possible to check that the point of resting on the seabed does not have evident obstacles. The turret 1 finally touches the seabed as in figure 5.

[0024] By means of the oil-pressure control system the linear actuators which control the position of the feet 2 are operated in such a way as to align the turret in a vertical direction. For this purpose a spirit level (not shown) may advantageously be arranged on the turret in the visual field of the camera 18 on the base 1a. The spirit level will give the operator on board the back-up boat the necessary control feedback. In fact, the feet 2 will be maneuvered until the spirit level shows that the turret is perfectly vertical.

[0025] Again by means of the oil-pressure control system, the hammer 10 is operated and thrusts the penetration of the probe 8 in the sediment to be sampled. The consequent descent through gravity of the plate 4 is accompanied by release of the wire 5 from the winch 7. To the penetration of the probe, assisted by the cutting head 12, there responds the filling of the barrel 11, and more specifically of the sheath 15, by the sediment (figure 8). Relative sliding between sediment and probe causes, in addition to the opening of the valve 16, axial unfolding of the sheath 15 from the sleeve 13. The verticality of penetration and therefore the stratigraphic ac-

curacy of the sampling will be guaranteed by the positioning of the turret 1, regulated as described above.

[0026] When penetration is complete (figure 6), or in any case has reached the required depth, operation of the winch 7 causes raising of the plate 4 via the wire 5 and, consequently, extraction of the probe 8 from the sediment. The check valve 16 closes, preventing release of the material (figure 9). Once extraction has been completed, with the probe 8 which is once again fully withdrawn into the turret 1, the lifting means on board the boat bring the apparatus back to the surface (figure 7).

[0027] After detaching the probe 8 from the hammer 10, the head 2 is unscrewed and the core removed, exerting a traction on the end part of the sheath 15 and carefully placing it inside an appropriate rigid support to avoid bends of the core with consequent physical alterations of the sampled material. The core can then be sectioned and placed in refrigerated sorting boxes so as to be delivered for the analyses.

[0028] The apparatus according to the invention fully achieves the above mentioned objects. It allows unadulterated sampling of the various stratigraphic levels of the sediment, thanks to the system for positioning and stabilizing the turret on the surface of the seabed. The turret remains connected to the boat, allowing high bathymetries of use yet ensuring regular sampling of the core in a continuous manner and without sudden movements. These results are of fundamental importance because the regulations and the procedures of analysis of the sediments sampled require that the quality of the sampling of material be not affected in any way: polluting substances of anthropic or natural origin, are found in marine sediments in a form dissolved in, or associated to, other substances, and any kind of remixing of the levels at different depths and of different grain size fractions must be avoided in the sampling operations.

[0029] Another advantage of the apparatus according to the invention comes from the fact that, despite the high power required for driving the penetration of the probe 8, during the same penetration the thermal conditions of the sediments traversed remain unchanged, which does not happen e.g. with core samplers of the rotary type. In this way also the non-alteration of the volatile compounds in the sample is always guaranteed.

[0030] The underwater video cameras 18 and relative lighting devices 17 allow direct control of the operations from a control panel installed on board the back-up boat used. This increases the level of safety of the sampling operations, allows video filming of the same by way of visual documentation and immediate detection of anomalies during the operations of driving the core sampler and during subsequent recovery of the core.

[0031] The sheath covering system allows the material taken from the seabed to be immobilized, avoiding detrimental mixing caused by the circulation of fine sediment and above all of the interstitial water of the higher or lower levels. A PVC covering is present inside the

barrel 11 to avoid direct contact of the sampled material with the metal of the apparatus. However, unlike what may occur in the prior art, the covering is not worn out and destroyed for each sampling but instead, thanks to the insulation guaranteed by the sheath, it can be re-used, thus considerably lowering operation costs and avoiding the production of large amounts of waste plastic material.

[0032] The sheath 15 for covering the core allows intact reproduction of the stratigraphy and also facilitates transport of the same core, which can be easily analyzed and studied at a later date, once taken onshore. In this it can be avoided that the operations of dividing and removal of the various segments to be analyzed are carried out on board the boat, where subsequent sampling of other cores would be hindered. These operations can take place in a laboratory, where staff have available all the appropriate utilities such as unsalted and uncontaminated running water, refrigeration means, chemical solvents and miscellaneous equipment, which improve the overall quality of sampling. The analysis staff (minimum of 2-3 people) do not therefore have necessarily to go aboard, avoiding all the logistic and economic consequences which this entails, above all in terms of safety of the environment and of workers.

[0033] Obviously, analyses may also be performed immediately after bringing the material to the surface, such as measuring the pH value, the Redox potential or the concentration of volatile substances. For this purpose the material of which the sheath is made allows needles to be driven in, and small incisions to be made for the use of specific instruments, without jeopardizing the intactness of the core which in any case remains completely wrapped in the sheath.

[0034] Mention should also be made of the easy handling of the entire apparatus, unlike the systems used to date, due to the constructional simplicity and consequent very small size of the same. The apparatus can easily be installed on board small boats, in this way avoiding all the problems linked to the use of large sea crafts. This entails firstly a considerable economic saving for handling and possible hire of boats with high tonnage, and secondly improved safety conditions of sailing, with considerably lower interference with marine traffic, above all when working in port areas (as in most cases).

[0035] The easy handling leads to considerable ease of positioning of the apparatus, with consequent saving in energy and financial resources, and labor costs. There may be less need for official authorizations, and for finding suitable boats not always available in every port or coastal area. Interruption of the core sampling operations and a rapid return to the port in case of sudden and fast onset of adverse weather conditions are also guaranteed. The apparatus can then also be used in difficult working situations, such as for example near port entrances, in industrial port areas with particularly high traffic, and in areas with current and swell condi-

tions which are unfavorable to sampling operations.

[0036] The apparatus according to the invention allows cores with diameter up to 90 mm to be taken, reaching bathymetries to a depth of 100 meters and penetration to 6 meters according to the powers applied and, naturally, the type of sediment found, with totally satisfactory results in terms of non-disturbability of the samples and stratigraphic reconstruction, and a good percentage of recovery in relation to the penetration carried out. Problems of use on sandy beds do not occur, not even where there is gravel and pebbles with a diameter of a few centimeters, or on sediments with a high percentage of organic material such as shell or vegetal residues.

[0037] The sheath core sampling system of the embodiment illustrated, although advantageous on the basis of what is described above, does not constitute in itself and *per se* an essential feature of the invention, which lies more generically in the configuration of the apparatus with support turret to be rested on the bed, and core sampling means which slide in relation to the turret. The turret can moreover change in relation to the preferred embodiment, as regards construction, dimensions, materials and accessories, though assuring a working similar to the exemplified embodiment. Although advantageous, the vibrating hammer may be replaced by different systems for driving the core sampling means. Namely, a rotary drill mast can be used, to be mounted directly in a sliding manner on the inner uprights 1c, thus replacing the whole assembly of plate 4 and hammer 10. In this case, in order to avoid the rotation of the probe that could damage the integrity of the sample, the same probe will be connected to the drill mast so as to be free to rotate with respect thereto, e.g. by inserting the probe coaxially within a pipe integral to the mast, while the mutual axial sliding between the pipe and the probe is prevented.

[0038] Other variants and/or changes may be made to the underwater core sampling apparatus according to the present invention without thereby departing from the scope of protection of the invention itself, as defined in the annexed claims.

Claims

1. A core sampling apparatus comprising core sampling means (10, 8) suitable for being thrust in an underwater bed to take a sample thereof, the apparatus being **characterized in that** it comprises a turret (1) for supporting said core sampling means (8, 10), the turret (1) comprising in turn a substantially flat base (1a) for being rested on said bed, and guide means (1c) extending perpendicularly from said base (1a), for slidably supporting said sampling means (10, 8), the apparatus also comprising drive means (7, 5) supported by said turret (1) for controlling the sliding of said core sampling means

(8, 10) along said guide means (1c).

2. The apparatus according to claim 1, wherein said turret (1) consists of a network structure with a quadrilateral base comprising a plurality of external uprights (1b) which rise up perpendicularly from said base (1a), and a top frame (1d) joining the upper ends of said uprights (1c) and defining hooking means (3) of the turret by external handling means, said guide means (1c) comprising a plurality of internal uprights (1c) extending between said base (1a) and said top frame (1d), said core sampling means (10, 8) being slidably engaged with said internal uprights (1c) so as to be movable in a reciprocating way from said top frame (1d) to said base (1a).
3. The apparatus according to claim 2, wherein said core sampling means (10, 8) are supported by a support plate (4) slidable on said inner uprights (1c) between said base (1a) and said top frame (1d) while remaining parallel to both, said control means (5, 7) comprising an actuation system with wire (5) and drive pulleys (6a, 6b), driving said plate (4) and linked to a winch (7) mounted on said base (1a).
4. The apparatus according to claim 3, wherein said wire (5) is unwound from said winch (7) to a set of pulleys (6a) arranged below said top frame (1d), and to a pulley (6b) placed on the upper face of said plate (4), a winding pulley being finally provided on said base (1a) at the opposite side in relation to said winch (7).
5. The apparatus according to any of the claims 2 to 4, wherein said core sampling means (8, 10) comprise vibration and percussion thrust means (10) connected to the lower face of said plate (4), and a sampling probe (8) extending from said thrust means (10) perpendicularly in relation to said base (1a) and towards it.
6. The apparatus according to claim 2, wherein said core sampling means comprise rotary drill mast thrust means, sliding on said inner uprights (1c) between said top frame (1d) and said base (1a), and a sampling probe extending from said drill mast perpendicularly in relation to said base (1a) and towards it, said probe being connected to the mast freely with respect to rotation, while the mutual axial sliding is prevented.
7. The apparatus according to claim 5 or 6, wherein said sampling probe (8) comprises a linear barrel (11) with a tubular structure, passing through said base (1a) by inserting slidably in a hole (1e) formed therein, and a head (12) with a cutting edge (12a) releasably connected to a free end of said barrel

(11).

8. The apparatus according to claim 7, wherein said head (12) has a dismountable structure and houses coaxially a sleeve (13) for supporting one end of a tubular sheath (15) for covering the core sampling material by unfolding axially inside said barrel (11). 5
9. The apparatus according to claim 8, wherein inside said sleeve (13), near the cutting edge (12a) of said head (12), a check valve (16) is arranged, said valve (16) being formed by a convex diaphragm made of an elastically flexible material, notched radially in such a way as to open towards the inside of said barrel (11). 10
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10. The apparatus according to claim 8 or 9, wherein said tubular sheath (15) is made of a textile material which is slightly stretchable in the radial direction and substantially non-stretchable in the axial direction. 20
11. The apparatus according to any of the previous claims, wherein said base (1a) of said turret (1) has a plurality of support feet (2), projecting downwards for resting on the underwater bed, the extension of said feet (2) being controllable by actuator means so as to align said turret (1) in a vertical direction. 25
12. The apparatus according to any of the previous claims, wherein said turret (1) supports at least one video camera (18) and lighting means (17) for allowing remote vision of the sampling zone. 30
13. The apparatus according to claim 12, wherein a spirit level is placed on said turret (1), in the field of vision of one of said video cameras (18), usable to control the vertical arrangement of said turret (1). 35
14. The apparatus according to claim 12 or 13, wherein said control means (7), said core sampling means (10, 8) and said actuator means of said feet (2) are operated via an oil-pressure system comprising an oil-pressure control unit (9) and relative circuits supported by said turret (1). 40
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15. The apparatus according to claim 14, wherein said video cameras (18), said lighting means (17) and said oil-pressure unit (9) are electrically powered and controlled via a cabling system which connects the apparatus to a back-up boat or to land, connection cabling also being provided for the surface transmission of the video signal emitted by said video cameras (18). 50
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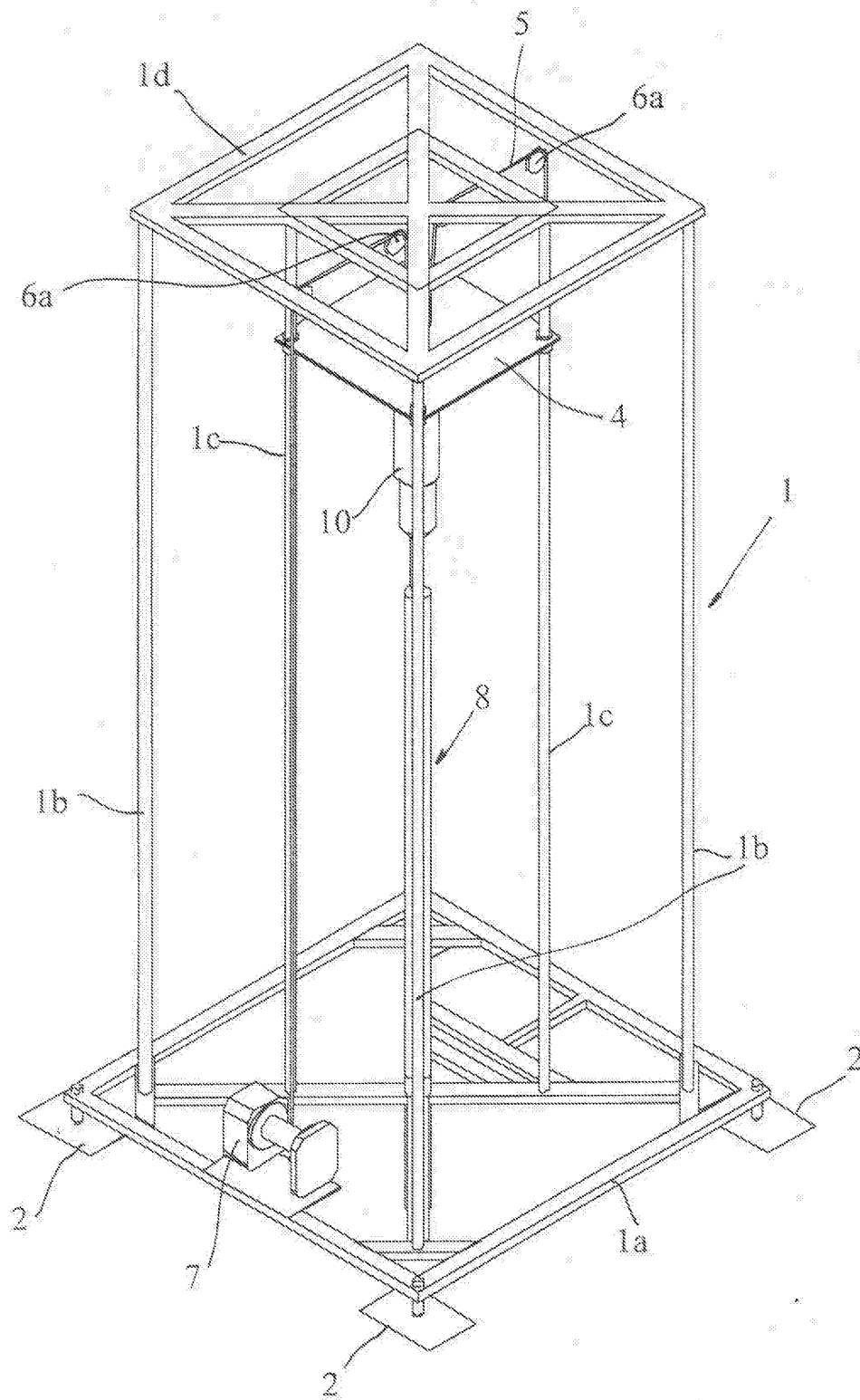


Fig. 1

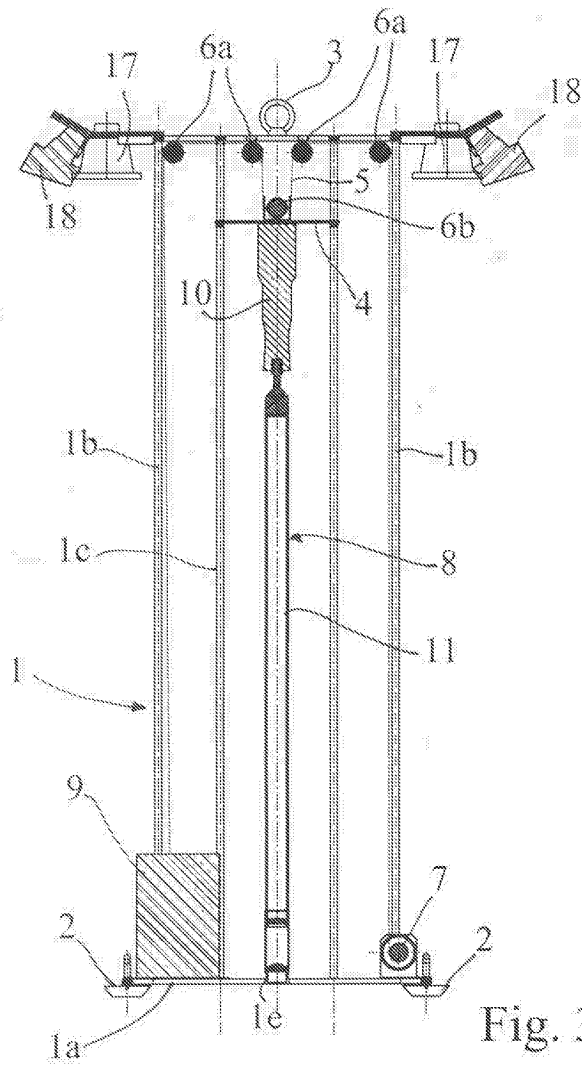


Fig. 3

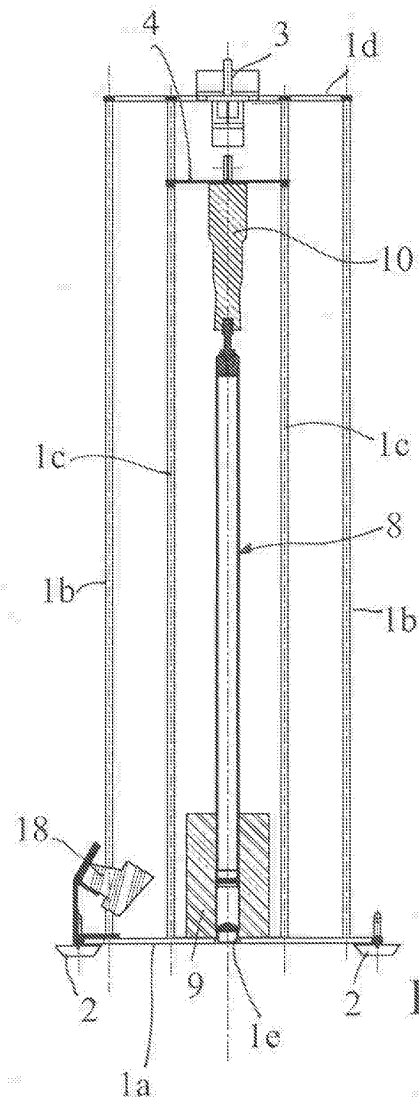


Fig. 4

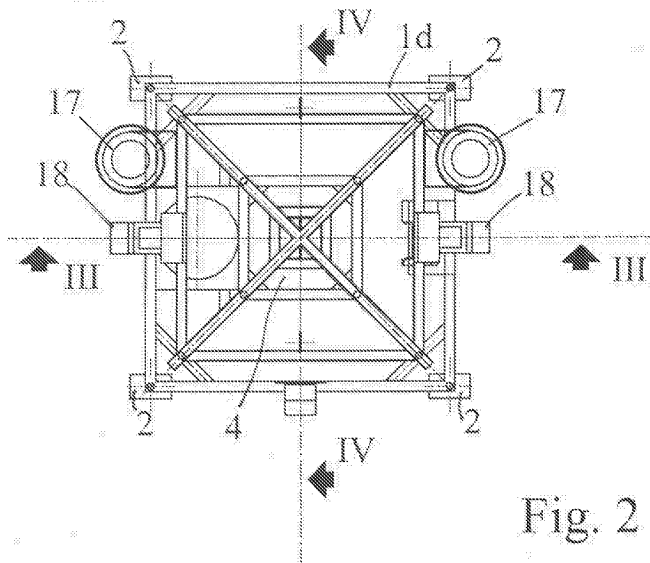


Fig. 2

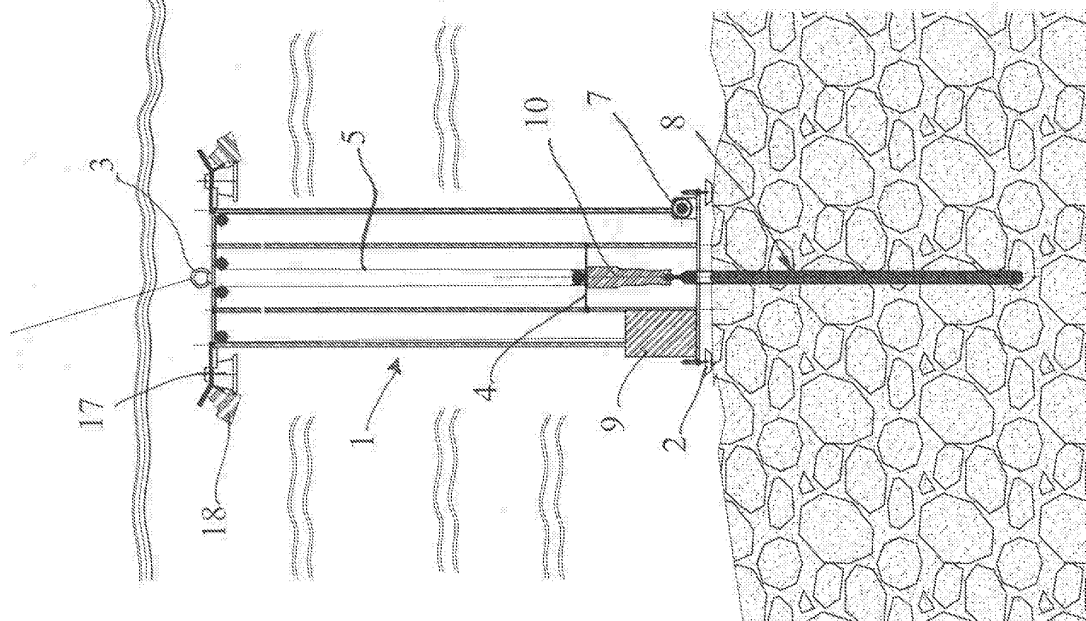


Fig. 6

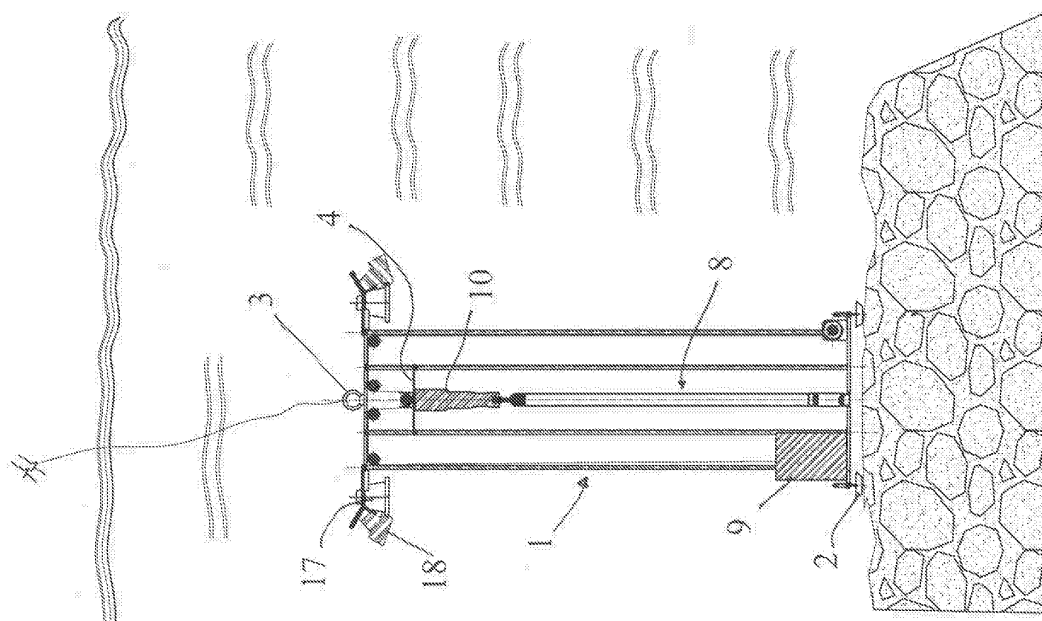


Fig. 5

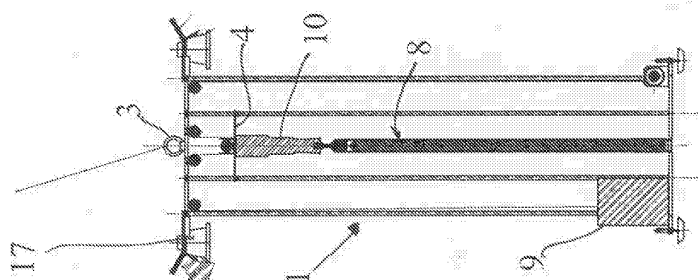


Fig. 7

