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Method and device for moving rocks and sediments under water

The present invention relates to a method of the kind described in the preamble of claim 1.
The invention further relates to a device according to the preamble of claim 3 for
conducting said method.

Background

For work at subsea oil and gas installations or in connections with such installations, e.g. maintenance work, there is often a need to move rocks and particulate material that partly covers the bodies that are to be repaired. It can be pipelines, valve housings and the like.

In a similar way a need may occur to remove sediments in connection with new installations on the sea bottom, or for removal of collected drill cuttings at platforms or the like.

Similar needs may also occur in connection with subsea work, like harbour works or work at barrage or quay structures.

Previously known technology

The most common way to remove sediments in connection with subsea work, is by utilizing large "fans", large and heavy suction devices with a high power consumption and specially designed excavators. Disadvantages are that they require a lot of power and/ or other resources, they require large surface vessels, have a limited versatility, are as good as stationary, or they are not at all suited for deep waters.

NO patent No. 302.043 describes a dredge designed for subsea operations, especially to remove or move drill cuttings, comprising a motor, a pump device and an ejector, where the motor is designed to run the pump which in its turn provides a stream of water to the ejector, which is positioned in a tubing through which the cuttings or the like is supposed to be transported. The apparatus is designed to rest on the sea bottom and to receive energy from the surface, while the inlet end of the tubing is supposed to be moveable e.g. with the aid of a remote controlled mini submarine, a so called ROV.



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This apparatus is not suited to move sediments with relatively large rocks, mainly because the pipeline has an effective loss of diameter due to the ejector's design and position. Further it has a geographically very limited work range as it is designed to rest at the sea bottom, even though the pipeline is designed to be somewhat moveable.

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Japanese patent applications Nos. 043 25 799 A and 043 25 800 A describes an ejector pump system where the ejector is positioned mainly outside the pipeline so that the ejector does not reduce the effective diameter of the pipeline. From the abstract of these patent applications it is not possible to see what kind of utilizations these systems are meant for. Neither are there any indications of dimensions or power requirements for these systems.

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Objects

It is an object with the present invention to provide a method for transportation of rocks and sediments under water, especially at deep waters.

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It is a particular objective to provide a method for transportation of rocks with a typical maximum diameter of 250 - 500 mm.

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It is a further object to provide an apparatus for performing said method, which apparatus should be versatile in its use, especially in the way that it should be easy to move around down at the sea bottom.

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It is a still further object to provide such an apparatus that is easy to control, and which does not require more energy than what may be supplied from the surface, e.g. through a conventional electric cable.

The invention

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These and other objects are achieved by the method according to the invention as defined by claim 1. Preferred embodiments of the invention are disclosed by the dependent claims 2-5.

The mentioned objects are also achieved by a device as defined by claim 6. Preferred embodiments of the device are disclosed by the dependent claims directed to the device.

Below a more detailed description of a device according to the invention is given with reference to the accompanying drawings, where:

Figure 1 is a schematic drawing of a first embodiment of the invention,

Figure 2 is a schematic drawing of a second embodiment of the invention.

Figure 3 is a simplified schematic drawing of a third embodiment of the invention,

10 Figures 4a-c shows details of a device according to the invention according to any one of the embodiments shown in figures 1-3.

Figure 1 shows a device 1 designed to move on the sea bottom S with the aid of belts 2 powered from the surface through a cable 3. The device comprises a tubing 5, preferably
15 with a flexible section 8, said tubing having an inlet end 6 and an outlet end 7. To the tubing an ejector nozzle 11 is attached, said nozzle being supplied with water from a pump 12 powered by an hydraulic unit 13. All of said equipment are supported by a chassis F which again is supported by the belts 2. It is preferred that the tubing 5, when it includes a flexible section 8, further comprises a manipulator 9 which is able to move the tubing
20 within certain degrees of freedom. In figure 1 the manipulator 9 consists of a multi-link arm controlled by means of an hydraulic unit 16. The device is adapted to transport sediments 14 including rocks of a size up to the diameter of the tubing 5 from one site to another, by the pressure gradient in the tubing set up by the ejector nozzle 11, providing a "vacuum from left to right in the drawing.

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Figure 2 shows an alternative embodiment of the invention. By this embodiment there is no power to the wheels or belts, as the device is supported by freely moving wheels 2' capable of being turned in several directions and preferably in any direction. The drawing shows 2 wheels while it is understood that at least two other wheels are hidden behind
30 these two. Most typically the device in this embodiment has 4 wheels, but it may also have e.g. 3 or 5 wheels. As an alternative to freely moving wheels, freely moving belts may be utilized.

By the device according to figure 2, the manipulator 9' consists of a remotely operated vehicle (ROV) controlling the tubing 5 and, if the sea-bottom so allows, the ROV may pull the entire device 1 in a desired direction. It is to be understood that the freely moving wheels 2' need not have the shown shape, they may have any form suited for subsea transportation.

Figure 3 shows a further embodiment of the device according to the invention, an embodiment that may be seen as a variation of the embodiment of figure 2. Figure 3 is simplified and does not show all the features of figure 2. The central aspect of this embodiment lies in the details indicated by the reference numeral 2'', which may be denoted "water cushions" (cf. air cushions of a hovercraft), which may cause the device to float just above the sea level. The so-called water cushions are supplied with water from a powerful water pump, for instance the pump that feeds the ejector nozzle 11. In the drawing this is shown schematically in the form of a particular supply conduit 18 from the pump 12. Movement of tubing 5 and possibly of the entire device 1 may as shown in figure 2, be effectuated by means of a pulling force from an ROV through the tubing 5.

Figure 4 shows details at the inlet end 6. The figure 4a shows that the outer part (mouth piece) of the inlet end 6 comprises telescopic units 21 may be pulled or pushed out.

Figure 4b further shows that the mouth piece may comprise an annulus "lance" 21 which is hollow and which is able to flush water through a plurality of openings 22 inwards as well as outwards relative to the mouth piece, so that the inlet end as such becomes shielded and not so easily will become packed when the mouth piece is pressed into the sediments. The water is fed to the lance through conduit 23 which may communicate with e.g. the water pump 12 or another suitable water pump.

At the inlet mouth piece 10 of the tubing 5 there may also be provided a nozzle (not shown) for backflushing of rocks etc. that might get stuck in the mouth piece.

Further it is preferred that the inlet mouth piece 10 is rounded and that the cross-section of the tubing is constant, and that any bend on the tubing 5 has sufficiently large radius to ensure that rocks will not get stuck. It is further preferred that the outlet end 7 of the

tubing is shaped as a diffusor, as this reduces the frictional loss through the tubing.

The device according to the invention may be manufactured mainly in a plastic material with a density close to that of water, so that it is easy to support.

Calculation example

In the following example of utilization there is an assumption of one or two water pumps each powered by a motor of 75 kW. It is assumed that the tubing has an internal diameter of 300 mm. In the case of two pumps there is also conducted calculations for a 500 mm tubing. Further data are given in the table below.

Motor power (axle-)	kW	75	150	150
Power efficiency	%	80	80	80
Internal diameter	mm	300	300	500
Length (inlet – outlet)	m	15	15	12
Speed prior to mixing chamber	m/s	5.8	7.4	5.9
Required speed	m/s	4.4	4.4	5.7
Motive power (lifting height)	m	2.5	4.2	1.8
of which inlet loss is	m	0.3	0.6	0.4
frictional loss is	m	1.4	2.3	0.7
outlet loss is	m	0.7	1.3	0.7
Ca. capacity transport rocks	tons/hour	70	120	100

Practical example

A commission conducted shows that the invention works in practice. During the summer of 1999, 1500 m³ ($d_{\max}$ = ca. 150 mm) of rocks were moved with the aid of a corresponding ejector mechanism, carried by a remotely operated vehicle, ROV. The commission was conducted in Tengsfjorden, by an oil pipe at a depth of 540 m below sea level. For powering the water pumps, two hydraulic engines with a total effect of approx. 24 kW were used. The tubing was 10 m long and had an internal diameter of 250 mm.

During 26 effective work hours 1500 m³ of rocks were moved, which corresponds to a capacity of 60 tons/ hour. Only a minimal wearage was observed on the tubing in PE plastic. Later, several successful tasks have been performed with this technology.

5 In March 2000 the present invention was utilized at the Draugen field, at a depth of 300 m. The commission was carried out from the boat Seaway Kingfisher. 5 m length of a pipeline was uncovered during 40 minutes before the commission had to be interrupted. This corresponds to 20 m³ mass or 45 tons/ hour. Considering that the rocks were moved from a region where frequent re-locations of the device was required, the result was very
10 satisfying. A 75 kW pump and a tubing of 15 m with an internal diameter of 300 mm was utilized.

The drawings and the examples are merely illustrations of the invention, which is only limited by the subsequent claims.

Claims

1. Method for moving subsea rocks and sediments, also at significant depths, e.g. in connection with removal of protective rocks around subsea installations, where maintenance is to be conducted, utilizing a rigid or at least partly flexible tubing through which a pressure gradient is produced by arranging an ejector nozzle externally in relation to said tubing and feeding water from a water pump to said nozzle,
characterized in placing the tubing, the ejector and the pump on a chassis designed to move on the sea bottom, supplying the required power through one or more cables from the surface and preferably remotely controlling the tubing with a manipulator adapted to the purpose.
2. Method as claimed in claim 1,
characterized in providing the chassis with belts or wheels and move it along the sea bottom with power to the belts and/ or the wheels respectively.
3. Method as claimed in claim 1,
characterized in that the manipulator is an hydraulically controlled multi-link arm.
4. Method as claimed in claim 1,
characterized in providing the chassis with belts or wheels that are able to turn freely in several directions and using an ROV as the manipulator and that the ROV is utilized for moving the chassis as well as for controlling the tubing.
5. Method as claimed in claim 1,
characterized in furnishing the chassis with "water cushions" that are fed with water from one or several water pumps enabling the chassis to float above the sea bottom using an ROV as the manipulator, and that the ROV is utilized for moving the chassis as well as for controlling the tubing
6. Device for moving subsea rocks and sediments, also at significant depths, e.g. in connection with removal of protective rocks around subsea installations, where

maintenance is to be conducted,

characterized in that the device comprises a rigid or at least partly flexible tubing (5) through which the masses (14) may be transported with the aid of a pressure gradient produced by an ejector nozzle (11) arranged externally in relation to said tubing (5) said
5 nozzle being fed with water from a water pump (12), a chassis (F) adapted to be transported along the (sea) bottom and that all required power is arranged to be supplied through cable (3) from the surface, and that the tubing (5) preferably is arranged to be remotely controlled by a manipulator (9, 9').

10 7. Device as claimed in claim 6.

characterized in that the manipulator (9, 9') is an hydraulically controlled multi-link arm (9).

8. Device as claimed in claim 6 or 7,

15 **characterized in** that the chassis (F) is supported by belts (2) or by wheels (2') and is arranged to be transported along the sea bottom by power to the belts (2) and/ or the wheels (2') respectively.

9. Device as claimed in claim 6,

20 **characterized in** that the manipulator (9, 9') is an ROV (9') that is controlled principally independently of the device (1) as such.

10. Device as claimed in claim 9,

25 **characterized in** that the chassis (F) is supported by freely turning belts (2) or wheels (2') that possibly may be turned in any direction, and is arranged to be transported along the bottom with the aid of a pull force exerted by the ROV (9') through the tubing (5).

11. Device as claimed in claim 9,

30 **characterized in** that the chassis (F) is provided with "water cushions" (2") facing the sea bottom fed with water from the pump (12) or by specially adapted pumps (not shown), so that the chassis (F) may partly float above the bottom (S) and is arranged to be transported along the bottom with the aid of a pull force exerted by the ROV (9') through the tubing (5).

12. Device as claimed in claim 6,
characterized in that the tubing (5) at its inlet end (6) is telescopically extendable.
13. Device as claimed in claim 6,
5 **characterized in** that the inlet end (6) of the tubing (5) comprises means (21) for penetration and pressurized water flushing (22) designed to disintegrate compact or hardened sediments in order to improve the suction capacity of the device.
14. Device as claimed in claim 6,
10 **characterized in** that close by the inlet mouth piece (10) there is arranged a nozzle (not shown) for backwards flushing of rocks etc. that might get stuck in the mouth piece.
15. Device as claimed in claim 6,
15 **characterized in** that the inlet mouth piece (10) is rounded and that the cross-section of the tubing (5) is constant, and that any bend of the tubing (5) has sufficiently large radius to ensure that rocks can not get stuck therein and that the outlet end (7) is shaped as a diffuser (to minimize the friction loss through the tubing).