

UNDERWATER EXCAVATION APPARATUS

FIELD OF INVENTION

5 This invention relates to an improved excavation apparatus, and in particular, to an improved underwater excavation apparatus. The invention also relates to a method of using such an excavation apparatus.

10 The invention also relates to an improved subsea mass flow excavation system and related method including means for orientation and placement of the system, e.g. above a cable, pipeline or structure which is typically sitting on the sea bed.

BACKGROUND TO INVENTION

15 Underwater excavation apparatus are known. WO 98/027286, also by the present Inventors comprises an underwater excavation apparatus comprising a hollow body having at least two inlets and at least one outlet, at
20 least one pair of impellers rotatably mounted in the hollow body, and means for driving the impellers, wherein the at least two inlets are substantially symmetrically disposed around an axis extending from the at least one outlet. Therein, preferably, the driving means cause the
25 impellers to be driven in contra-rotating directions, and one of the impellers is provided within one of the inlets and another of the impellers is provided within another of the inlets.

30 Excavators or mass flow excavation systems operate by directing a jet of high volume fluid under low pressure at the sea bed to displace sea bed material. The excavator is tethered from a vessel by means of a crane wire, which is used to lower and retrieve the excavator, and to maintain a given distance from the sea

bed or structure requiring excavation, such as a subsea oil or gas pipeline. In order to control the excavation, sonar detection means are used to allow the excavator operator to view the excavation in real time. Cameras and metal detection means can also be used to assist the operator.

During the excavation of a pipeline or cable the excavator is typically required to follow the direction of the pipeline. This is achieved by moving the vessel along the pipeline, using the dynamic positioning (DP) of the vessel, while the DP operator references the sonar images relayed to surface. In order to follow the line, and to view the excavation process, it is essential that the correct orientation of the excavator is maintained to ensure the sonar is correctly positioned above the line. Present art utilises tugger lines (taut lines attached to the excavator) to maintain and adjust orientation. In inclement weather, wind and tide direction may require the vessel to take a heading different from the direction of the line to be excavated, making it exceedingly difficult to keep the correct orientation of the excavator and the sonar due to the difference in ship's heading and pipeline direction. In subsea excavation apparatus using a single impeller as in US 5,607,289 reactive torque created by the impeller makes the excavation apparatus unstable in the water.

It is an object of at least one embodiment of at least one aspect of the present invention to seek to obviate or at least mitigate one or more of the aforementioned problems in the prior art.

It is a further object of at least one embodiment of at least one aspect of the present invention to seek to obviate or at least mitigate one or more problems in the prior art.

SUMMARY OF INVENTION

One or more objects of the present invention are achieved by the general solution of providing an underwater excavation apparatus comprising a means for moving the apparatus.

According to a first aspect of the present invention there is provided an underwater excavation apparatus comprising at least one means for moving the underwater excavation apparatus, the at least one moving means being provided on or adjacent to the underwater excavation apparatus.

The at least one moving means may comprise means for orienting, positioning, rotating (e.g. in use around at least one substantially vertical axis and/or at least one horizontal axis), counteracting reactive torque and/or steering the apparatus.

The/each moving means may allow for required achievement and maintenance of a desired position/orientation of the apparatus.

The moving means may be capable of moving the apparatus:

forward and/or backward;

to one side and/or to another side;

up and/or down;

rotationally around a vertically extending axis in one and/or another direction rotatably around at least one (or two perpendicular) horizontally extending axis (axes) in one and/or another direction.

The moving means may cause, in use, one or more jets of fluid, e.g. of the underwater fluid.

The moving means may comprise a plurality of moving means.

In one arrangement the moving means may comprise at least one pair of moving means, which may be

substantially symmetrically disposed on or adjacent to the apparatus, for example, a first pair of moving means may be disposed at or adjacent an upper surface of the apparatus and/or at or near adjacent ends of the apparatus. Further, or alternatively, a second pair of moving means may be disposed at or adjacent to respective opposing faces of the apparatus. The moving means may be connected/connectable to the excavation apparatus, e.g. by connection means such as brackets or arms.

The Applicant has termed the/each moving means as a "thruster".

The/each moving means may comprise at least one impeller/propeller/blade, i.e. mounted for rotation.

The/each moving means may comprise a body having a through passage, e.g. a hollow cylindrical body.

The/each respective impeller may be mounted in the respective cylindrical body for rotation around a longitudinal axis of the through passage.

The apparatus may comprise means for driving the/each impeller.

The/each driving means may comprise an electrically or hydraulically drive means.

The/each driving means may be adapted to selectably drive the respective impeller in either direction of rotation.

Alternatively (and advantageously) the driving means may be adapted to drive the respective impeller in a single direction of rotation.

In use, the impellers of a pair of moving means may be caused to rotate in different directions so as to cause the apparatus to rotate around a substantially vertically extending axis.

In use, the impellers of a pair of moving means may be caused to rotate in the same direction so as to cause

the apparatus to move in a selected direction, e.g. forward, backward or to one side or another.

The/each moving means may comprise a nozzle and valve arrangement.

5 For example, there may be provided at least one pair of opposing nozzles and associated valves to provide for rotational movement in either direction around a substantially vertically extending axis.

10 In an advantageous arrangement there are provided two pairs of nozzles at either end of the apparatus. Suitable control of the valves provides that, in use, the apparatus can be caused to rotate and/or move, fore and aft, and/or from side to side.

15 The apparatus may comprise means for connecting or tethering and/or securing the apparatus to a vessel.

The means for connecting, tethering, and/or securing may comprise at least one eye, the/each eye being capable of receiving a cable, line or tether extending from the vessel.

20 The at least one eye may comprise at least one pair of eyes, which pair of eyes may be substantially symmetrically disposed on the apparatus, e.g. on an uppermost surface thereof at or adjacent opposing ends thereof.

25 In use, the means for connecting, tethering and/or securing may be used to roughly, approximately or "coarsely" position and/or locate the apparatus, (e.g. by movement of the vessel and/or operation of the dynamic positioning of the vessel), while the moving means may be used to more exactly, precisely or "finely" position, 30 locate and/or orientate the apparatus.

In an advantageous implementation the underwater excavation apparatus comprises a hollow body, e.g. a hollow body having at least one inlet and at least one

outlet, preferably at least one pair of impellers rotatably mounted in the hollow body and preferably further means for driving the impellers.

Advantageously, the further driving means cause the
5 impellers to be driven in contrary rotating directions, in use.

The at least one inlet may be inclined at an angle to an axis along which the at least one outlet is provided.

10 Preferably there is provided at least one pair of inlets.

Preferably the at least one pair of inlets are substantially symmetrically disposed around an axis extending from the outlet.

15 In one embodiment the underwater excavation apparatus may comprise a pair of horizontally or at least partly horizontally opposed inlets communicating with a single outlet, the outlet advantageously being disposed vertically downwards substantially midway between the two
20 inlets, in use. In this case, the excavation apparatus may, therefore, be substantially "T" shaped in profile.

In an alternative embodiment the underwater excavation apparatus may comprise a pair of inlets communicating with a single outlet, the inlets being
25 substantially symmetrically disposed around an axis extending from the outlet, the outlet being disposed vertically downwards substantially midway between the two inlets, in use. In this case, the excavation apparatus may, therefore, be substantially "Y" shaped in profile.

30 Advantageously, the outlets are each spaced/inclined substantially 45° from the axis extending from the outlet.

At least one impeller may be provided within/adjacent each inlet.

The means for driving the/each impeller(s) may include at least one drilling motor.

The at least one drilling motor may comprise a stator and a rotor rotatably mounted in the stator, the stator being provided with a rod recess and an exhaust port, the rotor being provided with a rotor channel and at least one channel for conducting motive fluid from the rotor channel to a chamber between the rotor and the stator, the rod recess being provided with a rod, which in use, forms a seal between the stator and the rotor.

Although not essential it is highly desirable that the rotor be provided with a seal or seal member for engagement with the stator.

Preferably, the seal(s) or seal member is/are made from a material selected from the group consisting of plastics material, polyethylethylketone, metal, copper alloys and stainless steel.

Advantageously, the rod is made from a material selected from the group consisting of plastics material, polyethylethylketone, metal, copper alloys and stainless steel.

Preferably, the stator is provided with two rod recesses which are disposed opposite one another, and two exhaust ports which are disposed opposite one another, each of the rod recesses being provided with a respective rod, the rotor having two seals which are disposed opposite one another.

The drilling motor may advantageously comprise two drilling motors arranged with their respective rotors connected together each motor comprising a stator and a rotor rotatably mounted in the stator, the stator being provided with a rod recess and an exhaust port, the rotor being provided with a rod recess and an exhaust port, the rotor being provided with a rotor channel and at least

one channel for conducting motive fluid from the rotor channel to a chamber between the rotor and the stator, the rod recess being provided with a rod, which, in use, forms a seal between the stator and the rotor.

5 Preferably, the drilling motors are connected in parallel, although the drilling motors could be connected in series if desired.

Advantageously, the drilling motors are arranged so that, in use, one drilling motor operates out of phase with the other. Thus, in a preferred embodiment each
10 drilling motor has two chambers and the chambers in the first drilling motors are 90° out of phase with the chambers in the second drilling motor. Similarly, in an embodiment in which each drilling motor has four
15 chambers, the chambers in the first drilling motor would preferably be 45° out of phase with the chambers on the second drilling motor. This arrangement helps to ensure smooth power output and inhibits stalling.

Alternatively, the at least one drilling motor may
20 be a "Moineau" motor, hydraulic motor or a suitably adapted electric motor.

The impellers may be driven by means of a gearbox or by exploitation of the opposing reactive torque on a drive body of the motor.

25 When the reactive torque upon the motor body is utilised, at least one impeller may be connected to an output shaft of the motor, while at least one other impeller may be connected to the motor body.

Alternatively the impellers may be driven by a pair
30 of motors operating in opposite directions. In such case the motors and impellers may be balanced and may be run at equal speed.

The underwater excavation apparatus may further comprise an agitator device having mechanical disturbance means and fluid flow disturbance means.

5 The underwater excavation apparatus may, in use, be suspended from a surface vessel or mounted upon a sled of the type currently known for use in subsea excavation operations.

10 Preferably the underwater apparatus may comprise a hollow body having a pair of inlets communicating with an outlet, at least one pair of impellers rotatably mounted in the hollow body and means for driving the impellers, the inlets being substantially symmetrically disposed around an axis extending from the outlet, wherein the inlets are not horizontally opposed to one another.

15 According to a second aspect of the present invention there is provided a method of underwater excavation comprising:

providing an excavation apparatus according to the first aspect of the present invention;

20 excavating an underwater area using the apparatus.

BRIEF DESCRIPTION OF DRAWINGS

25 Embodiments of the present invention will now be described by way of example only, and with reference to the accompanying drawings, which are:

Figure 1 a front cross-sectional view of a first excavation apparatus according to the prior art;

30 **Figure 2** a front cross-sectional view of a second excavation apparatus according to the prior art;

Figures 3(a) to (c) front, side and top views of a first embodiment of an

excavation apparatus according to the present invention;

Figure 4 a front view of a second embodiment of an excavation apparatus according to the present invention;

Figures 5(a) to (c) front, side and top views of a third embodiment of an excavation apparatus according to the present invention; and

Figure 6 a top view of a fourth embodiment of an excavation apparatus according to the present invention.

DETAILED DESCRIPTION OF DRAWINGS

Referring to Figure 1, there is shown a first embodiment of an underwater excavation apparatus 300a according to the prior art. The apparatus 300a comprises a hollow body 370a formed from a pair of horizontally opposed inlet ducts 371a and an outlet duct 373a, a drive motor 310a and a pair of impellers 335a, 340a.

The apparatus 300a is further provided with deflection baffles 302a within the hollow body 370a, suspension brackets 306a to enable the apparatus 300a to be suspended from a surface vessel, guide vanes 386a, to regulate the flow of fluid past the impellers 335a, 340a, and safety grids 385a to seek to prevent the ingress of solid matter which may damage the impellers 335a, 340a. In this first prior art excavator, the drive motor 310a is provided along an axis common to the horizontally opposed inlet ducts 371a and impellers 335a, 340a. An output shaft 330a of the motor 310a is connected to a first impeller 335a while the second impeller 340a is attached

to a shaft 342a connected via a swivel 325a to an outer housing of the drive motor 310a.

In use, motive fluid is supplied to the motor 310a via fluid inlet 308a which in turn causes the output shaft 330a and impeller 335a to rotate. Reactive torque from this rotation causes the outer housing of the drive motor 310a to rotate in a direction opposite to that of the output shaft 330a. This in turn results in the rotation of the second impeller 340a. The impellers 335a, 340a are configured such that, despite rotating in opposite directions, they each provide an equal flowrate of water into the hollow body 370a. Water drawn into the hollow body 370a thus is directed via the deflection baffles 302a through the outlet duct 373a and towards the sea bed 400a.

The shaft 342a and swivel 325a may, in an alternative embodiment, be replaced by a second motor which directly drives the impeller 340a, as described with reference to Figure 2.

The excavation device 300a may be suspended, for example, from the bow or stern of a surface vessel, or through a moonpool of a dedicated subsea operations vessel.

The excavation apparatus 300a may further be provided with an agitator device (not shown) having mechanical disturbance means and fluid flow disturbance means.

In an advantageous version the motor 310a comprises a drilling motor, such as that disclosed in WO 95/19488, the content of which is incorporated herein by reference.

The drilling motor 310a may comprise a first motor and a second motor, substantially the same as that disclosed in EP 1 007 796 B1.

Referring now to Figure 2, there is shown a second prior art underwater excavation apparatus 300b. like parts of the apparatus 300a are identified by numerals used to identify parts of the apparatus 300a of Figure 1, except subscripted with "b" rather than "a".

The apparatus 300b differs from the apparatus 300a in that the shaft 342a and swivel 325a are replaced by a second motor 310'b and a T-coupling 326b. Thus, in this embodiment the impellers 335b, 340b are driven by respective motors 310b, 310'b. In use, motive fluid is supplied to motors 310b, 310'b via fluid inlet 308b and T-coupling 326b.

Referring to Figures 3(a) to 3(c), there is shown an underwater excavation apparatus, generally designated 300c, according to a first embodiment of the present invention. The apparatus 300c is similar to the apparatus 300a or 300b in many respects, like parts being denoted by like numerals, except suffixed "c".

As can be seen from Figure 3(a), the apparatus 300c includes a sonar head 400c. The apparatus 300c also comprises at least one means 405c for moving the underwater excavation apparatus, the at least one moving means 405c being provided on or adjacent to the underwater excavation apparatus 300c.

The at least one moving means 405c comprises means for orientating, positioning, rotating (e.g. in use, around at least one substantially vertical axis, and at least one substantially horizontal axis), counteracting reactive torque and/or steering the apparatus 300c.

The moving means 405c is capable of moving the apparatus 300c:

- forward and/or backward;
- to one side and/or to another side;
- up and/or down;

rotationally around a vertically extending axis in one and/or another direction rotatably around at least one (or two perpendicular) horizontally extending axis (axes) in one and/or another direction.

5 The/each moving means 405c allows for required achievement and maintenance of a desired position/orientation of the apparatus.

The moving means causes, in use, one or more jets of fluid, e.g. of the underwater fluid.

10 The moving means 405c comprises a plurality of moving means 405c, connected to the apparatus 400c by connection means 406c, such as brackets, arms or the like.

In this arrangement the moving means 405c comprises
15 a pair of moving means 405c, which are substantially symmetrically disposed on or adjacent to the apparatus 405c. The pair of moving means 405c are disposed at or adjacent an upper surface of the apparatus 300c, and at or near adjacent ends of the apparatus 300c. The
20 apparatus 300c further comprises a further pair of moving means 405c placed on a respective sides of the apparatus 300c.

The Applicant has termed the/each moving means 405c as a "thruster".

25 The/each moving means 405c comprises an impeller/propeller/blade 410c. The/each moving means 405c also comprises a body 415c having a through passage, e.g. a hollow cylindrical body. The/each respective impeller 410c is mounted in the respective cylindrical
30 body 415c for rotation around a longitudinal axis of the through passage.

The apparatus 300c also comprises means for driving the/each impeller (not shown). The/each driving means

typically comprises an electrically or hydraulically drive means (not shown). Such is controllable from surface, e.g. via an umbilical. The driving means can be adapted to drive the respective impeller 410c in either
5 direction of rotation. Alternatively (and advantageously- e.g. due to simplicity) the driving means can be adapted to drive the respective impeller 410c in a single direction of rotation.

In use, the impellers 410c of a pair of moving means
10 can be caused to rotate in different direction so as to cause the apparatus 300c to rotate around a substantially vertically extending axis.

In use, the impellers 410c of a pair of moving means 405c can be caused to rotate in the same direction so as
15 to cause the apparatus to move in a selected direction, e.g. forward, backward or to one side or another.

The apparatus 300c comprises means for connecting or tethering and/or securing the apparatus 300c to a vessel.

In use, the means for connecting, tethering, and/or
20 securing typically comprises at least one eye, the/each eye being capable of receiving a cable, line or tether extending from the vessel. The at least one eye can comprise at least one pair of eyes, which pair of eyes are substantially symmetrically disposed on the apparatus
25 300c, e.g. on an uppermost surface thereof at or adjacent opposing ends thereof.

The means for connecting, tethering and/or securing can be used to roughly, approximately or "coarsely" position and/or locate the apparatus 300c, while the
30 moving means can be used to more exactly, precisely or "finely" position, locate and/or orientate the apparatus 300c.

In use, orientation can be achieved and maintained by exerting thrust on the apparatus 310c or "excavator"

from a jet, or jets, of fluid generated by the moving or thrusting means 405c attached to the excavator. The thruster means can be an electrically or hydraulically driven propeller rotating within a tubular housing, whereby the propeller tips are in close proximity to the tubular housing. An open propeller may be used but is less efficient. With rotation of the propeller, fluid is moved through the housing and reactive thrust is exerted upon the housing and to the excavator, thus causing the excavator to move. A single thruster is sufficient to maintain orientation if it is capable of reverse operation, i.e. reverse operation of the electric or hydraulic motor will cause the propeller to rotate in the opposite direction, directing the jet of fluid (and thus thrust) in the opposite direction.

For efficient burial it is also important to keep the fluid flow emanating from the excavator beside and/or over the line. Lateral positioning of the excavator is normally achieved by movement of the vessel. However, with the use of two thrusters the operator can control the excavator's lateral position relative to the line. To achieve this the operator may:

(1) Adjust azimuthal control to achieve the desired orientation;

(a) using a single thruster or

(b) two thrusters acting in opposing directions.

(2) Thereafter adjust lateral position using the two thrusters together.

Rather than manually fixing orientation, it is preferable to derive a control signal from circuitry with reference to a compass located on the excavator, and thus automate azimuthal control and positioning of the sonar

or metal detection apparatus above the subsea cable or pipeline.

The use of the above arrangement enables the excavator to be used from vessels with lower grade dynamic positioning, e.g. DP I, as opposed to DP II or greater, where the number indicates the quality of the positioning equipment used.

Referring now to Figure 4, there is shown a side view of a second embodiment of an excavation apparatus, generally designated 300d, according to the present invention.

The apparatus 300d differs from the apparatus 300c in providing a pair of moving means 405d on either end of the apparatus 400d, and an additional pair of moving means 405'd facing outwards, so as to provide for side to side movement.

Referring now to Figures 5(a) to 5(c), there is shown a third embodiment of an excavation apparatus, generally designated 300e, according to the present invention.

The apparatus 300e differs from the apparatus 300b in that an additional pair of moving means 405e are provided on top of the apparatus 300e. Therefore, in the apparatus 300e there is provided two moving means at either end. One of the two at either end having a impeller that rotates in one direction, and the other of the two at the other end of the impeller that rotates in a contrary direction.

Referring now to Figure 6, there is shown a fourth embodiment of an excavation apparatus, generally designated 300f, according to the present invention.

In this embodiment the/each moving means 405f comprises a nozzle and valve arrangement. For example, there can be provided at least one pair of opposing

nozzles 405f and associated valves 455f to provide for rotational movement in either direction around a substantially vertically extending axis.

5 In an advantageous arrangement there are provided two pairs of nozzles 450f at either end of the apparatus 300f. Suitable control of the valves 455f provides that, in use, the apparatus 300f can be caused to rotate and/or move, fore and aft, and/or from side to side.

10 The moving or thruster means 405f can therefore be provided by a vector thrust mechanism, with a central power source, such as a mixed flow or centrifugal pump, pumping fluid into a manifold with a plurality of outlet nozzles.

15 Control valves can be used to open and close each nozzle. In this embodiment an opposing pair of controlled nozzles can replace a reversible propeller arrangement.

The pump and nozzle arrangement shown can be mounted on the top of the excavator.

20 It will be appreciated that the embodiments of the present invention hereinbefore described are given by way of example only, and are not meant to be limiting to the scope of the invention in any way.

25 For example, although the disclosed embodiments are generally "T" shaped, other housing shapes may be envisaged. For example, "Y" shaped as disclosed in EP 1 007 796 B1.

30 It may be envisaged that the moving means (thrusters) may be provided on or mounted, e.g. detachably attachably, to a frame, which frame may be detachably attachable to the excavator apparatus. This may facilitate retro-fitting of thrusters to existing excavator apparatus. The frame may also facilitate provision of a power pack, e.g. attached to surface by an electrical umbilical cable, the power pack powering the

impellers/thrusters. This may be advantageous in "deep water"

5 It will also be appreciated that the various moving means of the various disclosed embodiments may be combined so as to provide for greater control, or a greater number of degrees of freedom of movement of the apparatus.

CLAIMS

1. An underwater excavation apparatus comprising at least one means for moving the underwater excavation apparatus, the at least one moving means being provided on or adjacent to the underwater excavation apparatus.

2. An underwater excavation apparatus as claimed in claim 1, wherein the at least one moving means comprise means for orienting, positioning, rotating - such as, in use, around at least one substantially vertical axis and/or at least one horizontal axis, counteracting reactive torque and/or steering the apparatus.

3. An underwater excavation apparatus as claimed in either of claims 1 or 2, wherein the/each moving means allows for required achievement and maintenance of a desired position/orientation of the apparatus.

4. An underwater excavation apparatus as claimed in any preceding claim, wherein the moving means is capable of moving the apparatus:

forward and/or backward;

to one side and/or to another side;

up and/or down;

rotationally around a vertically extending axis in one and/or another direction rotatably around at least one/two perpendicular horizontally extending axis/axes in one and/or another direction.

5. An underwater excavation apparatus as claimed in any preceding claim, wherein the moving means causes, in use, one or more jets of fluid, such as of the underwater fluid.

6. An underwater excavation apparatus as claimed in any preceding claim, wherein the moving means comprise a plurality of moving means.

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7. An underwater excavation apparatus as claimed in any preceding claim, wherein the moving means comprise at least one pair of moving means, which are substantially symmetrically disposed on or adjacent to the apparatus.

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8. An underwater excavation apparatus as claimed in claim 7, wherein a first pair of moving means are disposed at or adjacent an upper surface of the apparatus and/or at or near adjacent ends of the apparatus.

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9. An underwater excavation apparatus as claimed in either of claims 7 or 8, wherein a pair/second pair of moving means are disposed at or adjacent to respective opposing faces of the apparatus.

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10. An underwater excavation apparatus as claimed in any preceding claim, wherein the moving means are connected/connectable to the excavation apparatus, such as by connection means such as brackets or arms.

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11. An underwater excavation apparatus as claimed in any preceding claim, wherein the/each moving means comprises at least one impeller/propeller/blade mounted for rotation.

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12. An underwater excavation apparatus as claimed in claim 11, wherein the/each moving means comprise a body having a through passage, such as a hollow cylindrical body.

13. An underwater excavation apparatus as claimed in claim 12, wherein the/each respective impeller is mounted in the respective cylindrical body for rotation around a longitudinal axis of the through passage.

14. An underwater excavation apparatus as claimed in any of claims 11 to 13, wherein the apparatus comprises means for driving the/each impeller.

15. An underwater excavation apparatus as claimed in claim 14, wherein the/each driving means comprises an electrically or hydraulically drive means.

16. An underwater excavation apparatus as claimed in either of claims 14 or 15, wherein the/each driving means is adapted to selectably drive the respective impeller in either direction of rotation.

17. An underwater excavation apparatus as claimed in either of claims 14 or 15, wherein the driving means is adapted to drive the respective impeller in a single direction of rotation.

18. An underwater excavation apparatus as claimed in any of claims 11 to 17, wherein, in use, the impellers of a pair of moving means are caused to rotate in different directions so as to cause the apparatus to rotate around a substantially vertically extending axis.

19. An underwater excavation apparatus as claimed in any of claims 11 to 18, wherein, in use, the impellers of a pair of moving means are caused to rotate in the same direction so as to cause the apparatus to move in a

selected direction, such as forward, backward or to one side or another.

20. An underwater excavation apparatus as claimed in any preceding claim, wherein the/each moving means comprises a nozzle and valve arrangement.

21. An underwater excavation apparatus as claimed in claim 20, wherein there are provided at least one pair of opposing nozzles and associated valves to provide for rotational movement in either direction around a substantially vertically extending axis.

22. An underwater excavation apparatus as claimed in either of claims 20 or 21, wherein there are provided two pairs of nozzles at either end of the apparatus, control of the valves providing that, in use, the apparatus can be caused to rotate and/or move, fore and aft, and/or from side to side.

23. An underwater excavation apparatus as claimed in any preceding claim, wherein the apparatus comprises means for connecting or tethering and/or securing the apparatus to a vessel.

24. An underwater excavation apparatus as claimed in claim 23, wherein the means for connecting, tethering, and/or securing comprises at least one eye, the/each eye being capable of receiving a cable, line or tether extending from the vessel.

25. An underwater excavation apparatus as claimed in claim 24, wherein the at least one eye comprises at least one pair of eyes, which pair of eyes are substantially

symmetrically disposed on the apparatus, such as on an uppermost surface thereof at or adjacent opposing ends thereof.

5 26. An underwater excavation apparatus as claimed in any
of claims 23 to 25, wherein, in use, the means for
connecting, tethering and/or securing can be used to
roughly, approximately or coarsely position and/or locate
the apparatus, while the moving means can be used to more
10 exactly, precisely or finely position, locate and/or
orientate the apparatus.

27. An underwater excavation apparatus as claimed in any
preceding claim, wherein the underwater excavation
15 apparatus comprises a hollow body, such as a hollow body
having at least one inlet and at least one outlet, at
least one pair of impellers rotatably mounted in the
hollow body and further means for driving the impellers.

20 28. An underwater excavation apparatus as claimed in
claim 27, wherein the further driving means cause the
impellers to be driven in contrary rotating direction, in
use.

25 29. An underwater excavation apparatus as claimed in
either of claims 27 or 28, wherein the at least one inlet
is inclined at an angle to an axis along which the at
least one outlet is provided.

30 30. An underwater excavation apparatus as claimed in any
of claims 27 to 29, wherein there is provided at least
one pair of inlets.

31. An underwater excavation apparatus as claimed in claim 30, wherein the at least one pair of inlets are substantially symmetrically disposed around an axis extending from the outlet.

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32. An underwater excavation apparatus as claimed in any of claims 27 to 31, wherein the underwater excavation apparatus comprises a pair of horizontally, or at least partly horizontally, opposed inlets communicating with a single outlet, the outlet being disposed vertically downwards substantially midway between the two inlets, in use.

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33. An underwater excavation apparatus as claimed in any of claims 27 to 31, wherein the underwater excavation apparatus comprises a pair of inlets communicating with a single outlet, the inlets being substantially symmetrically disposed around an axis extending from the outlet, the outlet being disposed vertically downwards substantially midway between the two inlets, in use.

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34. An underwater excavation apparatus as claimed in claim 33, wherein the outlets are each spaced/inclined substantially 45° from the axis extending from the outlet.

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35. An underwater excavation apparatus as claimed in any of claims 27 to 34, wherein at least one impeller(s) is provided within/adjacent each inlet.

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36. An underwater excavation apparatus as claimed in any of claims 27 to 35, wherein the further means for driving the/each impeller(s) includes at least one drilling motor.

37. An underwater excavation apparatus as claimed in claim 36, wherein the at least one drilling motor comprises a stator and a rotor rotatably mounted in the stator, the stator being provided with a rod recess and an exhaust port, the rotor being provided with a rotor channel and at least one channel for conducting motive fluid from the rotor channel to a chamber between the rotor and the stator, the rod recess being provided with a rod, which in use, forms a seal between the stator and the rotor.

38. An underwater excavation apparatus as claimed in claim 37, wherein the rotor is provided with a seal or seal member for engagement with the stator.

39. An underwater excavation apparatus as claimed in claim 38, wherein the seal(s) or seal member is/are made from a material selected from the group consisting of plastics material, polyethylethylketone, metal, copper alloys and stainless steel.

40. An underwater excavation apparatus as claimed in any of claims 37 to 39, wherein the rod is made from a material selected from the group consisting of plastics material, polyethylethylketone, metal, copper alloys and stainless steel.

41. An underwater excavation apparatus as claimed in any of claims 37 to 40, wherein the stator is provided with two rod recesses which are disposed opposite one another, and two exhaust ports which are disposed opposite one another, each of the rod recesses being provided with a

respective rod, the rotor having two seals which are disposed opposite one another.

5 42. An underwater excavation apparatus as claimed in any of claims 36 to 41, wherein the drilling motor comprises two drilling motors arranged with their respective rotors connected together each motor comprising a stator and a rotor rotatably mounted in the stator, the stator being provided with a rod recess and an exhaust port, the rotor
10 being provided with a rod recess and an exhaust port, the rotor being provided with a rotor channel and at least one channel for conducting motive fluid from the rotor channel to a chamber between the rotor and the stator, the rod recess being provided with a rod, which, in use,
15 forms a seal between the stator and the rotor.

43. An underwater excavation apparatus as claimed in claim 42, wherein the drilling motors are connected in parallel.

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44. An underwater excavation apparatus as claimed in either of claims 42 or 43, wherein the drilling motors are arranged so that, in use, one drilling motor operates out of phase with the other.

25

45. An underwater excavation apparatus as claimed in claim 44, wherein each drilling motor has two chambers and the chambers in the first drilling motor are 90° out of phase with the chambers in the second drilling motor,
30 or each drilling motor has four chambers, and the chambers in the first drilling motor are 45° out of phase with the chambers in the second drilling motor.

46. An underwater excavation apparatus as claimed in claim 36, wherein the at least one drilling motor is a Moineau, hydraulic or electric motor.

5 47. An underwater excavation apparatus as claimed in any of claims 27 to 46, wherein the impellers are driven by means of a gearbox or by exploitation of the opposing reactive torque on a drive body of the motor.

10 48. An underwater excavation apparatus as claimed in claim 47, wherein when the reactive torque upon the motor body is utilised, at least one impeller is connected to an output shaft of said motor, while at least one other impeller is connected to the motor body.

15 49. An underwater excavation apparatus as claimed in claim 47, wherein the impellers are driven by a pair of motors operating in opposite directions, said motors and impellers optionally being balanced and running at equal
20 speed.

50. An underwater excavation apparatus as claimed in any preceding claim, wherein the underwater excavation apparatus further comprises an agitator device having
25 mechanical disturbance means and fluid flow disturbance means.

51. An underwater excavation apparatus as claimed in any preceding claim, wherein the underwater excavation
30 apparatus, in use, is suspendable from a surface vessel or mountable upon a sled.

52. An underwater excavation apparatus as claimed in any preceding claim, wherein the underwater apparatus

comprises a hollow body having a pair of inlets communicating with an outlet, at least one pair of impellers rotatably mounted in the hollow body and means for driving the impellers, the inlets being substantially
5 symmetrically disposed around an axis extending from the outlet, wherein the inlets are not horizontally opposed to one another.

53. An underwater excavation apparatus comprising a
10 means for moving the apparatus.

54. A method of underwater excavation comprising:
providing an excavation apparatus according to any
of claims 1 to 52 or claim 53;
15 excavating an underwater area using the apparatus.

55. An excavation apparatus as hereinbefore described with reference to the accompanying drawings.

20 56. A method of underwater excavation as hereinbefore described with reference to the accompanying drawings.