

REMOTELY OPERATED VEHICLE ASSEMBLY

FIELD OF THE INVENTION

[0001] This invention relates to a remotely operated vehicle assembly for use in subsea applications, and more particularly to an improved connection between a remotely operated vehicle and an umbilical.

BACKGROUND OF THE INVENTION

[0002] Remotely operated vehicles (ROV) are common in deepwater industries such as offshore hydrocarbon extraction. ROVs are unmanned, highly maneuverable and controlled by a person aboard a vessel, ship, platform, mobile offshore drilling unit (MODU), etc. An umbilical is used to connect electrical power, hydraulic power, and/or fiber optic connections between a surface vessel and an ROV. ROVs are typically equipped with various equipment such as manipulator arms, video cameras, sonar and lights, etc. Additional equipment can be added to expand the vehicle's capabilities.

[0003] Since the umbilical contains elements such as an electric power line and/or a fiber optic cable assembly, known remotely operated vehicles have a rigid, unadjustable interconnection with the umbilical. This means that during deployment and movement of the ROV, torsional stresses are generated at the interface of the remotely operated vehicle and the umbilical. Such stresses can shorten the life of the assembly, and also increase the need for maintenance. Also, the operator is

1 limited in the range of motion of the ROV to reduce or avoid such stresses.
2 Moreover, known ROV's have fixed thrusters, so to turn right, a left fore/aft thruster
3 thrusts ahead, while a right fore/aft thruster thrusts reverse. The thrusters are
4 reversed to turn left. This means that known ROVs requires a large space to turn
5 around i.e, they have a relatively large turning radius. Such turning can generate
6 turbulence. Such turbulence can cause visibility issues near the seabed.

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8 [0004] It would be desirable to provide a remotely operated vehicle connected to an
9 umbilical with reduced stress between the umbilical and the ROV and which has a
10 reduced turning radius.

11 12 SUMMARY OF THE INVENTION

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14 [0005] A remotely operated vehicle assembly is adapted to be connected to an
15 offshore platform having a remotely operated vehicle and an umbilical connected to
16 the remotely operated vehicle, and adapted to be connected to the offshore platform.
17 The remotely operated vehicle is rotatable with respect to the umbilical.

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19 [0006] From the foregoing disclosure and the following more detailed description of
20 various embodiments it will be apparent to those skilled in the art that the present
21 invention provides a significant advance in the technology of remotely operated
22 vehicles. Particularly significant in this regard is the potential the invention affords
23 for providing a high quality connection between the remotely operated vehicle and
24 the umbilical. Additional features and advantages of various embodiments will be
25 better understood in view of the detailed description provided below.

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2 BRIEF DESCRIPTION OF THE DRAWINGS

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4 [0007] Fig. 1 is a view of the remotely operated vehicle connected to an umbilical
5 which is in turn attached to a MODU in accordance with one embodiment.

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7 [0008] Fig. 2 is an isometric view of the remotely operated vehicle in Fig.1.

8

9 [0009] Fig.3 is a cross section view taken through the remotely operated vehicle of
10 Fig. 2.

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12 [0010] Fig. 4 shows several views of the remotely operated vehicle of Fig. 3

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14 [0011] Fig. 5 is a close up view of the interconnection between the umbilical and the
15 remotely operated vehicle of Fig. 2.

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17 [0012] It should be understood that the appended drawings are not necessarily to
18 scale, presenting a somewhat simplified representation of various features illustrative
19 of the basic principles of the invention. The specific design features of the remotely
20 operated vehicle as disclosed here, including, for example, the slew ring assembly,
21 will be determined in part by the particular intended application and use environment.
22 Certain features of the illustrated embodiments have been enlarged or distorted
23 relative to others to help provide clear understanding. In particular, thin features may
24 be thickened, for example, for clarity of illustration. All references to direction and

position, unless otherwise indicated, refer to the orientation illustrated in the drawings.

DETAILED DESCRIPTION OF CERTAIN EMBODIMENTS

[0013] It will be apparent to those skilled in the art, that is, to those who have knowledge or experience in this area of technology, that many uses and design variations are possible for the remotely operated vehicle assembly disclosed here. The following detailed discussion of various alternate features and embodiments will illustrate the general principles of the invention with reference to a remotely operated vehicle assembly for use in a wide variety of subsea applications. Other embodiments suitable for other applications will be apparent to those skilled in the art given the benefit of this disclosure.

[0014] Turning now to the drawings, Fig 1 shows a mobile offshore drilling unit 12 shown here as an offshore platform such as an oil extraction platform. A remotely operated vehicle 10 is connected to an umbilical 11. The umbilical 11 extends from the offshore platform 12 and provides at least one of electrical power, fiber optic connections and hydraulic power to the remotely operated vehicle. A driving mechanism (not shown) on the platform 12 unwinds the umbilical which in turn lowers the remotely operated vehicle 10 to perform sub sea operations, such as performing maintenance on underwater equipment 100 such as a deep-sea drill or wellhead, for example. Reverse of the driving mechanism urges the umbilical to wind on the platform 12 and pull the ROV back up to the surface. The umbilical may comprise an armoured umbilical, which can be, for example a structurally robust

1 steel assembly with a circular cross section defining a central passageway, slot or
2 channel into which a hydraulic line, an electric power line or a fiber optic cable, etc.
3 may be received.

4
5 [0015] In accordance with a highly advantageous feature, the remotely operated
6 vehicle 10 is adjustable or movable with respect to the umbilical 11. In the
7 embodiments shown in the Figs. the ROV is rotatable with respect to the umbilical.
8 Allowing for relative movement at an interconnection between these two parts
9 advantageously reduces residual stresses, allows for greater freedom of movement
10 of the ROV and decreases the need for maintenance.

11
12 [0016] Fig. 2 shows an isometric view of the remotely operated vehicle 10. The ROV
13 comprises a flotation block 24, a frame 25 and a base 26. The umbilical 11 extends
14 into a funnel 22 positioned in the centre of the flotation block 24. The flotation block
15 is attached to the frame 25. Frame 25 is rotatable about and with respect to the
16 umbilical 11. The base 26 is independently rotatable with respect to the frame 25
17 and umbilical 11. Thrusters 20 rigidly attached to the frame 25 above manipulators
18 14 provide forward and reverse movement of the ROV.

19
20 [0017] The flotation block 24 has a plurality of thrusters 20 which drive the remotely
21 operated vehicle 10 in multiple directions. Attached to the frame are also numerous
22 devices such as manipulator arms 14, 16 which can perform various functions.
23 Optionally the base 26 is rotatable with respect to the umbilical 11, creating a lazy
24 susan design allowing for relative movement of the base 26 both with respect to the
25 frame 25/flotation block 24 and with respect to the umbilical 11 allowing for access to

1 tools in the basket 42. Such tools can be stored there until grasped by manipulator
2 arm 14 to perform various tasks.

3
4 [0018] Figs. 3-4 shows several views of the remotely operated vehicle 10. The
5 flotation block 24 is shown here rigidly attached to the frame 25 via tie rods 67. Both
6 the base 26 and the flotation block can be provided with a flotation material such as
7 syntactic foam. When the ROV is sitting on a deck of platform 12 it can weight as
8 much as 5 tons. By adding the buoyancy of the flotation material, the ROV 10
9 becomes relatively easy to move with respect to the umbilical 11 when submerged.
10 That is, movement of the ROV by the thrusters is assisted by addition of flotation
11 material.

12
13 [0019] The funnel 22 is attached to an adaptor 29. The funnel 22 limits lateral
14 movement of the flotation block 24 with respect to the umbilical. The funnel reduces
15 rubbing of the umbilical as would occur when the ROV changes direction, such as
16 turning. The funnel also helps avoid excess strain on the umbilical by preventing the
17 umbilical from bending beyond a bend radius. The funnel also acts as a guide for a
18 surface latch mechanism (not shown) used to grasp the ROV at the termination 28,
19 typically when the ROV is on the surface or on the platform 12

20
21 [0020] A pair of sonar assemblies or sonars (front and rear) 32 can be located on the
22 frame 25 adjacent to the floatation block 24. Additional thrusters 20 are mounted on
23 the frame. As shown in the top view in Fig. 4, for example, the thrusters 20 on the
24 flotation block are spaced circumferentially around the flotation block. The
25 combination of thrusters allows both large movements of the ROV and for fine lateral

1 movement and adjustment when close to submerged subsea drilling equipment, for
2 example. Pan and tilt cameras 34 may also be mounted on the frame 25.
3 Electronics pod 44 is also mounted on the frame 25.

4
5 [0021] The ROV further comprises a slip ring assembly 50 which is attached to a
6 slew ring assembly 35. The slip ring assembly 50 allows for continuous transmission
7 of electrical power between the umbilical 11 and the ROV 10. A connecting lead 45
8 extends from the slip ring assembly 50 and ends at an electrical termination 46
9 mounted on the frame 25.

10
11 [0022] The adaptor 29 is rigidly attached to an outer gear 38 and operatively
12 connected to a mechanical termination 28. The adaptor 29 cooperates with a
13 junction box 30 to transfer load between the ROV and the umbilical via the
14 mechanical termination 28 and worm gear 38. Optionally, as shown in Figs. 3-4, the
15 junction box 30 is positioned within the adaptor 29. The umbilical extends through
16 the mechanical termination 28 and electrically terminates at the junction box 30.

17
18 [0023] Fig. 5 shows a close up view of the remotely operated vehicle 10. The slew
19 ring assembly 35 provides for relative rotation of the ROV 10 with respect to the
20 umbilical 11. The slew ring assembly 35 comprises an outer gear 38, a bearing race
21 40 and a bearing assembly 39 positioned between the outer gear and the bearing
22 race. The outer gear 38 is attached to the adaptor 29 such that these two parts
23 move together, along with the umbilical. The bearing race 40 is attached to the
24 frame 25 such that it is rotatable with the ROV (with respect to the umbilical). A

worm gear 36 is operable to rotate the outer gear 38 with respect to the bearing race 40.

[0024] The armored umbilical 11, mechanical termination 28, adaptor 29, outer gear 38, along with funnel 22, and junction box 30 are all held in place with respect to each other. The rest of the ROV rotates around these components. A drive motor 66 is fixed to the frame 25. Operation of the drive motor rotates the worm gear 36 which in turn causes relative movement of the outer gear 38 with respect to the bearing race 40. That is, the outer gear is rotatable with the umbilical and the bearing race is rotatable with the remotely operated vehicle. The armoured umbilical preferably has two layers of a contra-helically wound high strength plow steel wire jacket on the outside of the umbilical terminated into termination 28 to enhance torsional stiffness.

[0025] As noted above, the base 26 of the ROV 10 can be rotatable with respect to the frame 25. This can be advantageous where the base 26 defines a basket 42 which can be used for storing tools, equipment and the like. Rotation of the base with respect to the frame 25 can optionally allow for access to the basket. To allow for relative rotation of the base with respect to the frame 25, a second slew ring assembly 55 can be used. As shown in Figs. 3-4, second slew ring assembly operates similar to the first slew ring assembly 35 and rotatably interconnects the base 26 to the frame 25.

[0026] A slip ring assembly 50 is attached to the slew ring assembly 35 allowing for continuous transmission of electric power between the umbilical 11 and the remotely

1 operated vehicle 10. The slip ring assembly 50 consists of a conductive band
2 mounted on a shaft and insulated from it. Electrical connections from the rotating
3 part of the assembly are made to the ring. Fixed contacts or brushes run in contact
4 with the ring, transferring electrical power or signals to the exterior, static part of the
5 system. Fiber optics, if present, can terminate at a fiber optic rotary joint
6 incorporated into the slip ring assembly 50.

7
8 [0027] Several pumps and motors may be used to drive the various slew ring
9 assemblies and provide power to the equipment used on the ROV. For example, a
10 hydraulic pump 48 can be used to provide drive force to the equipment, a hydraulic
11 valve pack 65 and drive motor 66 can be used to drive the first slew ring assembly
12 35, a hydraulic drive motor 56 can provide drive force for the second slew ring
13 assembly 55, and reservoirs 60, 62 can be used with the pumps and drive motors,
14 as needed. Transformer 68 may also be provided to transfer electrical energy from
15 one circuit on the ROV to another as required.

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17 [0028] Use of the remotely operated vehicle assembly as disclosed herein can
18 advantageously be used without need for a cage (a container for the ROV separate
19 from the vessel 100). Elimination of the cage advantageously reduces costs and
20 complexity by elimination of hardware. The ROV assembly could still be used with a
21 cage, if needed. Further, the slew ring assembly or other device which allows for
22 rotation of one component with respect to the other can be used between the
23 umbilical and the cage, or more generally between a tether management system and
24 the cage, either in combination with the slew ring assemblies 35, 55 discussed
25 above or independent of such slew ring assemblies.

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[0029] The ROV assembly disclosed herein, unlike known ROVs, uses the top slew ring assembly 35 to orient the ROV for directional control. Moving the ROV with the thrusters and controlling the heading of the ROV with the slewing allows for greatly improved (reduced) turning radius. Thus the ROV assembly disclosed herein allows for ease of turning and fine position adjustment. Such fine position adjustment reduces the amount of sediment thrown up when moving near the sea floor, enhancing visibility, and makes extraction from potential entanglement situations easier.

[0030] From the foregoing disclosure and detailed description of certain embodiments, it will be apparent that various modifications, additions and other alternative embodiments are possible without departing from the true scope and spirit of the invention. For example, the slew ring assembly could be replaced with another assembly allowing for relative rotational movement of the ROV with respect to the umbilical, such as a ball and socket design, for example. The embodiments discussed were chosen and described to provide the best illustration of the principles of the invention and its practical application to thereby enable one of ordinary skill in the art to use the invention in various embodiments and with various modifications as are suited to the particular use contemplated. All such modifications and variations are within the scope of the invention as determined by the appended claims when interpreted in accordance with the breadth to which they are fairly, legally, and equitably entitled.

1		<u>Drawing Numbering Description</u>
2	10	Remotely Operated Vehicle
3	11	Armored umbilical
4	12	Vessel/ship/platform/mobile offshore drilling unit (MODU)
5	100	Underwater equipment/drill or wellhead
6	14	Manipulator arms (for example seven function manipulator arms)
7	16	Manipulator arm (for example five function manipulator arm)
8	20	Hydraulic Thruster
9	22	Funnel
10	24	Floatation block
11	25	Frame
12	26	Base
13	28	Armored Umbilical Mechanical Termination
14	29	Adapter
15	30	Junction box
16	32	Sonar – front and rear
17	34	Pan & tilt for camera – front and rear
18	35	Slew ring assembly
19	36	Worm gear (drive gear)
20	38	Outer gear
21	39	Bearing assembly
22	40	Inner bearing race
23	42	Basket (for tools, in base 26)
24	44	Electronics pod/controller
25	45	Connecting lead

1	46	Umbilical termination
2	48	Hydraulic Power Unit
3	50	Slip ring assembly
4	55	2 nd slew ring assembly
5	56	Hydraulic drive motor for 2 nd slew ring assembly
6	60	Hydraulic reservoir
7	62	Hydraulic compensation reservoir
8	65	Hydraulic valve pack
9	66	Hydraulic drive motor
10	67	Floatation block tie Rods
11	68	Transformer

CLAIMS

What is claimed is:

1. A remotely operated vehicle assembly adapted to be connected to an offshore platform, comprising, in combination:

a remotely operated vehicle and an umbilical connected to the remotely operated vehicle, and adapted to be connected to the offshore platform;

wherein the remotely operated vehicle is rotatable with respect to the umbilical.

2. The remotely operated vehicle assembly of claim 1 wherein the umbilical provides at least one of electrical power, and fiber optic connection to the remotely operated vehicle.

3. The remotely operated vehicle assembly of claim 1 wherein the remotely operated vehicle comprises a frame, a base and a flotation block.

4. The remotely operated vehicle assembly of claim 1 further comprising a slew ring assembly connecting the umbilical to the remotely operated vehicle, permitting relative rotation of the remotely operated vehicle with respect to the umbilical.

5. The remotely operated vehicle assembly of claim 4 further comprising a slip ring assembly attached to the slew ring assembly allowing for continuous transmission of electric power between the umbilical and the remotely operated vehicle.

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2 6. The remotely operated vehicle assembly of claim 4 wherein the slew ring
3 assembly comprises an outer gear, a bearing race and a bearing assembly
4 positioned between the outer gear and the bearing race.

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6 7. The remotely operated vehicle assembly of claim 6 wherein the outer gear is
7 rotatable with the umbilical and the bearing race is rotatable with the remotely
8 operated vehicle.

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10 8. The remotely operated vehicle assembly of claim 7 further comprising a
11 termination and an adaptor rigidly attached to the outer gear and operatively
12 connected to the termination, wherein the umbilical extends through the termination.

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14 9. The remotely operated vehicle assembly of claim 8 further comprising a
15 junction box positioned within the adaptor, wherein the adaptor and junction box
16 cooperate to transfer load from the umbilical to the outer gear and the umbilical
17 terminates at the junction box.

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19 10. The remotely operated vehicle assembly of claim 6 further comprising a worm
20 gear, operable to rotate the outer gear with respect to the bearing race.

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22 11. The remotely operated vehicle assembly of claim 3 wherein the flotation block
23 is attached to the frame and receives a funnel rigidly connected to the umbilical,
24 wherein the funnel limits lateral movement of the flotation block with respect to the
25 umbilical.

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2 12. The remotely operated vehicle assembly of claim 3 wherein the base is
3 rotatable with respect to the frame.

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5 13. The remotely operated vehicle assembly of claim 12 further comprising a
6 second slew ring assembly connecting the frame to the base.

7
8 14. The remotely operated vehicle assembly of claim 12 wherein the base defines
9 a basket.

10
11 15. The remotely operated vehicle assembly of claim 3 wherein the flotation block
12 and base contain a flotation material.

13
14 16. The remotely operated vehicle assembly of claim 1 wherein the remotely
15 operated vehicle has at least one of the following:

16 at least one thruster located on a floating block and/or a frame;

17 at least one manipulator arms; and

18 at least one pan and tilt camera.

19
20 17. The remotely operated vehicle assembly of claim 1 wherein the umbilical
21 comprises an armoured umbilical defining a central passageway adapted to receive
22 at least one of an electrical power line and a fiber optical cable.