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(54) **Cleaning device and method for cylindrical object**

(57) An object having a cylindrical object surface and a longitudinal object axis is cleaned by a device having a ring which defines a ring passage opening allowing passage of the object through the ring. The ring carries a cleaning structure configured to clean the object surface by brushing when the ring moves relative to the object surface. The cleaning device has a frame which defines a frame passage opening allowing passage of the object through the frame. The frame passage opening is aligned with the ring passage opening. The ring is connected to the frame. The frame carries a ring drive assembly to rotate the ring relative to the frame. A frame coupling structure is attached to the frame, and couples the frame to the object to allow a displacement of the frame and ring along the object surface parallel to the object axis. When the ring drive assembly is energized for rotating the ring, and the frame is moved in the direction of the object axis, the cleaning structure cleans part of the object surface covered by the cleaning structure rotating with the ring.

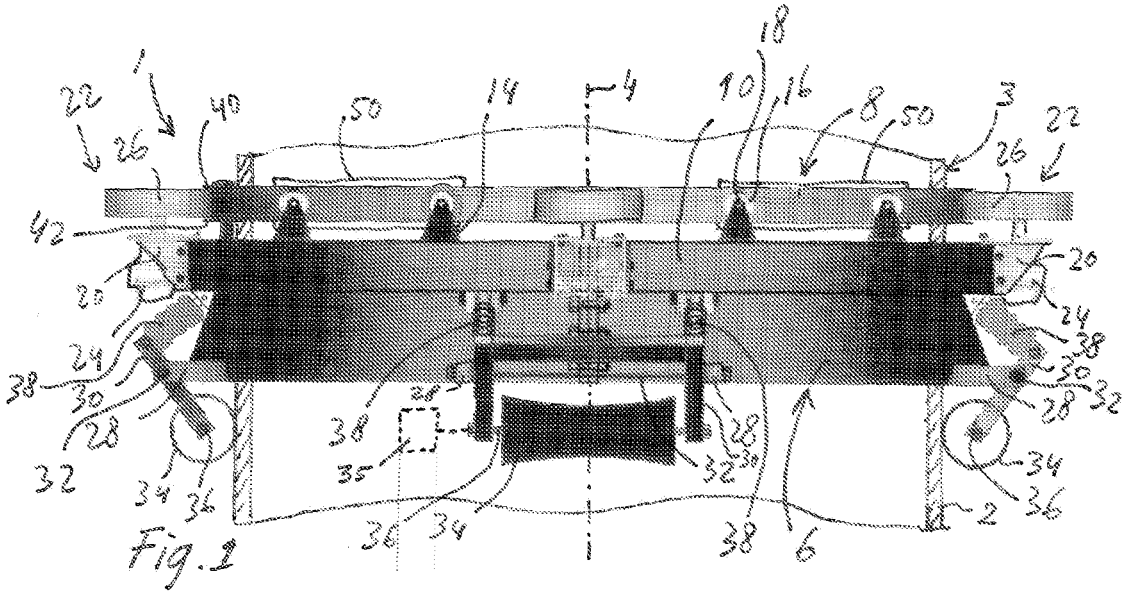

Fig. 1

EP 2 532 578 A1

Description

FIELD OF THE INVENTION

[0001] The invention relates to the field of cleaning a cylindrical object, and more specifically to a device and associated method for cleaning a cylindrical surface of an object. More in particular, the invention may relate to a device and method for removal of marine growth on an offshore generally cylindrical structure which is at least partly underwater, such as a pile or pillar or column (hereinafter commonly referred to as pile). Marine growth may comprise mussels and other plant and animal organisms.

[0002] Herein, the word "cylindrical" is taken to mean elongated, and having a cross-section which is circular or polygonal.

BACKGROUND OF THE INVENTION

[0003] In offshore structures, whether floating or mounted on the seabed, piles may extend at least partly under water. Typically, organisms grow on the underwater surface of the pile. By this marine growth, the piles will gradually become heavier, and the growth will add to the volume of the pile. Specifically the latter aspect will cause the drag resistance at the pile to increase when a water current flows along the pile. The increased drag resistance results in undesired increased forces exerted on the pile and, if applicable, on its foundation or on a marine structure connected to the pile. This can lead to problems, such as stability problems. From this point of view, a need for removing the marine growth from the pile, and thus for cleaning the pile, arises.

[0004] Marine growth on the pile may further lead to a problem of obscuring or covering the pile surface to an extent that inspection or testing of the pile, such as an inspection of a surface condition, or a surface test of structural integrity, becomes difficult or impossible. Also from this point of view, a need for removing the marine growth from the pile, and thus for cleaning the pile, arises.

[0005] It is noted that marine growth may also occur on other generally elongate cylindrical objects below the sea level, such as on cables or pipelines extending at various angles relative to the sea level. Here, e.g. problems associated with an increased weight and/or drag resistance of the cylindrical object by marine growth on it may occur, where increased bending forces and stresses may lead to intolerable risks of failure of the structure. Again a need for cleaning the cylindrical object arises.

[0006] Cleaning piles mounted offshore may be performed by water jetting, as e.g. described in EP 2 305 556 A1.

SUMMARY OF THE INVENTION

[0007] It would be desirable to provide a simple device and method for effectively cleaning a cylindrical object. It would also be desirable to provide a robust device and method for effectively cleaning a cylindrical object.

[0008] To better address one or more of these concerns, in a first aspect of the invention a device for cleaning an object having a cylindrical object surface and a longitudinal object axis is provided, the device comprising: a ring defining a ring passage opening allowing passage of the object through the ring, and comprising a cleaning structure configured to clean the object surface; a frame defining a frame passage opening allowing passage of the object through the frame, and being aligned with the ring passage opening, the frame being connected to the ring, and comprising a ring drive assembly to rotate the ring relative to the frame; and a frame coupling structure attached to the frame, and configured to couple the frame to the object to allow a displacement of the frame and ring along the object surface parallel to the object axis.

[0009] When at least the ring of the cleaning device, and normally the frame and the ring of the cleaning device take a position on the object surface, for example on an object surface part which is clean, and near an object surface part which is to be cleaned, the ring drive assembly may be energized to rotate the ring, whereby the cleaning structure will rotate around the object. Accordingly, a part of the object surface is treated by the cleaning structure rotating together with the ring on which the cleaning structure is provided. By moving or conveying the frame (and thereby the ring) with an appropriate speed along the object surface in the direction of the object axis towards and into the object surface part to be cleaned, the cleaning structure will treat a specific length per unit of time of the cylindrical object surface to clean this object surface part. In fact, in this movement, a point on the ring will make a spiral movement when seen from a fixed point in space.

[0010] As a provision for placing the cleaning device on the cylindrical object, the ring and the frame may be constructed such that each one comprises at least two parts which may be detached from each other before the placement, and connected to each other again after the placement. As an example, the ring may be composed of two half rings which may be temporarily disconnected to allow for mounting the ring around the object. A similar provision may be made for the frame.

[0011] In an embodiment of the cleaning device, the cleaning structure comprises at least one brush configured to contact the object surface. The ring may be provided with a continuous, endless brush along its circumference, or the ring may be provided with one or more discrete brushes provided along its circumference, for example depending on the desired effectiveness of the cleaning treatment of the object, the speed of movement of the ring, the speed of movement of the cleaning device in the direction of the object axis, the design of the brush (es), etcetera. Different brushes, or different parts of each brush may have different brushing properties by varying bristle stiffness, number of bristles per brush, length of bristles, material of bristles, etcetera.

[0012] Since the brush(es) contact the object surface, they will be subject to wear. In an embodiment, the at least one brush is detachably connected to the ring to allow for a cost-effective and possibly selective replacement of worn brushes.

[0013] In an embodiment of the cleaning device, the ring drive assembly comprises at least one worm drive comprising a motor coupled to a worm shaft, the ring is provided with teeth along its length, and the worm shaft engages the teeth for rotating the ring. A worm drive provides a high driving force for the ring at a relatively low speed of rotation of the ring, making such ring drive assembly well suited for the purpose. The worm shaft extends generally tangentially to the ring. The ring teeth may be provided along the length of the ring, thus forming a ring of teeth having a diameter equal to, or larger than the inner diameter of the ring. The teeth may extend from the local ring surface generally at right angles to the local ring surface.

[0014] In an embodiment of the cleaning device with the worm drive, the ring drive assembly comprises N ($N \geq 2$) worm drives engaging the teeth of the ring at angular positions (360/N)° apart. A plurality of worm drives allows for a distribution, in particular a more even distribution of driving power to the ring to obtain a more balanced load on the cleaning device construction and the object to be cleaned.

[0015] In an alternative embodiment, the ring drive assembly comprises at least one roller drive comprising a motor coupled to a roller, the ring is provided with an outer ring drive surface, and the roller engages the outer ring drive surface for rotating the ring. The roller may engage the outer ring drive surface based on friction at the contact surface, or the roller may be provided with a profile, such as a toothed profile, the engage a matching profile provided at the outer ring drive surface.

[0016] In an embodiment of the cleaning device with the roller drive, the ring drive assembly comprises N ($N \geq 2$) roller drives engaging the outer ring drive surface at angular positions (360/N)° apart. A plurality of roller drives allows for a distribution, in particular a more even distribution of driving power to the ring to obtain a more balanced load on the cleaning device construction and the object to be cleaned.

[0017] In an embodiment, the ring of the cleaning device along its circumference is provided with two spaced outwardly extending collars, wherein the frame comprises a plurality of roller bearings engaging the ring between the collars for mounting the ring rotatable relative to the frame. While providing the rotatable mounting of the ring, the collars at the same time prevent the ring from moving relative to the frame in a direction of the object axis since they provide stop surfaces for the roller bearings.

[0018] In an embodiment, the frame is provided with a frustoconical guide collar extending from the frame passage opening. The frustoconical guide collar provides a self-centering feature to the frame, in particular when the cleaning device is mounted at an end of the object for the object to be inserted into the frame passage opening.

[0019] In an embodiment, the frame coupling structure comprises a plurality of wheels, each wheel configured to be rotatable around an axis at right angles to the object axis, and configured to engage the object surface. The frame coupling structure may provide for a positioning, such as a centering, of the ring relative to the object. Hereby, a generally even action of the cleaning structure over the object surface may be obtained.

[0020] In an embodiment, the frame coupling structure comprises at least one wheel drive comprising a motor coupled to at least one of the wheels for rotating the wheel. By rotating the wheel(s), the cleaning device moves along the object in a direction of the object axis. Alternatively, or additionally, the cleaning device may be moved along the object by external conveying means, such as by a remotely operated vehicle, ROV, coupled to the frame of the cleaning device, or by a crane coupled to the frame of the cleaning device.

[0021] In an embodiment, the wheel of the frame coupling structure has an axial length and a diameter varying along the length to provide a shape matching the object surface. As an example, when the object has a circular cross-section, an axial cross-section of the wheel may have e.g. a double concave shape. On the one hand, this provides a large contact surface which is favorable for generating sufficient friction when the cleaning device is moved along the object surface in the direction of the object axis by driving the wheel(s), while on the other hand in the tangential direction, at right angles to the object axis, and parallel to the wheel axis, sufficient friction may be generated to prevent the frame from rotating around the object when the ring rotates.

[0022] The friction generated between the wheel(s) and the object surface may be increased in an embodiment wherein the frame coupling structure comprises a biasing structure for each wheel, the biasing structure being configured for biasing the wheel against the object surface. The biasing structure comprises a spring and/or a hydraulic actuator. The biasing structure, providing a movement of the wheel(s) towards and away from the object surface within a limited range, and forcing the wheel(s) against the object surface, allow a continuous contact between the frame and the object, even when the dimensions of the object vary along its length.

[0023] In an embodiment, the motor of the motor drive assembly and/or the motor of the frame coupling assembly is an electric motor or a hydraulic motor, providing inter alia a desired ruggedness, power, control, lifetime, and reliability at a low volume.

[0024] Some cylindrical objects have an end which allows for inserting the object in the passage openings of the ring and the frame to reach the surface area to be cleaned. If this is not possible, in an embodiment the ring and the frame each comprise at least two parts which are detachably connected to each other to allow for providing the ring and the frame, respectively, on the object. The ring may thus be opened, as well as the frame, to

mount the ring and the frame around the object at an arbitrary longitudinal position of the object.

[0025] In a second aspect of the invention, a method of cleaning an object having a cylindrical object surface and a longitudinal object axis is provided, the method comprising: providing a device according to the invention; mounting the device with its frame coupling structure on the object surface; energizing the ring drive assembly for rotating the ring; and moving the frame in the direction of the object axis, whereby the cleaning structure cleans part of the object surface covered by the cleaning structure rotating with the ring.

[0026] In an embodiment, the frame is coupled to a conveying means, such as a remotely operated vehicle, ROV, or a crane (such as a crane operated from a vessel) for moving the frame in the direction of the object axis.

[0027] In a third aspect of the invention, the device of the invention or the method of the invention is used for removing marine growth from an underwater part of a cylindrical object.

[0028] These and other aspects of the invention will be more readily appreciated as the same becomes better understood by reference to the following detailed description and considered in connection with the accompanying drawings in which like reference symbols designate like parts.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029]

Figure 1 depicts a side view of an embodiment of a cleaning device of the invention, provided on a cylindrical object shown in longitudinal section.

Figure 2 depicts an elevated view of the cleaning device of Figure 1, the cylindrical object shown in cross-section.

Figure 3 depicts a perspective view of a further embodiment of a cleaning device of the invention, part of the structure being removed to show details of a frame coupling structure.

Figure 4 depicts a perspective view of a detail of the cleaning device of Figure 3, on an enlarged scale.

Figure 5 depicts a perspective view of the cleaning device of Figure 3, provided on a cylindrical object, and shown in combination with a schematically indicated conveying means.

DETAILED DESCRIPTION OF EMBODIMENTS

[0030] Figures 1 and 2 depict an embodiment of a cleaning device 1 which may be placed on the outer surface of a cylindrical object 2 to clean an object surface 3. The object 2 has an object axis 4 in a longitudinal direction thereof. The cleaning device 1 comprises a frame 6 and a ring 8.

[0031] The frame 6 comprises a support ring 10 and a flaring ring-shaped guide collar 12. The support ring 10 carries a plurality of cams 14 (in the embodiment shown: eight cams 14) each provided with a freely rotatable roller 16 mounted on a shaft 18 extending radially. The frame 6 further is provided with supports 20 (in the embodiment shown: four supports 20) each carrying a roller drive 22. Each roller drive 22 comprises an electric or hydraulic motor 24 driving a roller 26. The frame 6 further is provided with a frame coupling structure comprising pairs of arms 28 (in the embodiment shown: four pairs of arms 28), each pair of arms 28 supporting a suspension fork 30 hingable around an axis 32. At the ends of the teeth of each suspension fork 30, a roller 34 is mounted freely rotatable around an axis 36 which extends tangentially relative to the ring-shaped frame 6. The roller 34 is configured to contact the object 2, and for a maximum contact surface area is shaped concavely to conform to the shape of the object surface 3. Each suspension fork 30 is supported to the frame 6 by a biasing structure embodied as a pair of springs 38 which bias the roller 34 in the direction of an object surface 3. Alternatively, the biasing structure may comprise a hydraulic actuator or a pneumatic spring or actuator.

[0032] The ring 8 has a generally U-shaped or C-shaped or I-shaped cross-section, and comprises a central body and two spaced, outwardly extending ring-shaped flanges or collars, an upper collar 40 and a lower collar 42. The rollers 16 mounted on the cams 14 each contact one of the upper collar 40 and the lower collar 42, thereby providing roller bearings for the ring 8. The central body of the ring 8 provides an outer ring drive surface on which the rollers 26 of the roller drives 22 engage. The four roller drives 22 engage the outer ring drive surface at angular positions 90° apart. The engagement may be by friction or by mechanical engagement between a roller 16 surface profile and a matching outer ring drive surface profile. Accordingly, the ring 8 may be rotated in either one of the directions of double arrow 44 by the roller drives 22.

[0033] The ring 8 is provided with a cleaning structure configured to contact the object surface 3 for removing material from the object surface 3. The cleaning structure may be detachably mounted, and may comprise discrete cleaning elements 50 along the inner circumference of the ring 8, or may be continuous along the inner circumference. The cleaning structure may comprise one or more brushes, scrapers and/or wipers.

[0034] The frame 6 may be assembled from two or more separable frame parts to enable the frame 6 to be placed around the object 2. Likewise, the ring 8 may be assembled from two or more separable ring parts to enable the ring 8 to be placed around the object 2. As an example, Figure 2 shows separation lines 29 indicating a location where two frame halves and/or two ring halves may be disconnected from one another to facilitate placement of the frame and/or ring around the object 2, and be connected again afterwards when the frame and/or ring has/have been placed.

[0035] The cleaning device 1 is operated as follows.

The cleaning device is placed on a cylindrical object 2 adjacent to a part of the object surface 3 to be cleaned. As an example, when the part of the object surface 3 is situated underwater, such as under sea level, marine growth may have developed on the part of the object surface 3 to be cleaned. The part of the object surface 3 to be cleaned may be situated either at the side of the cleaning device 1 adjacent to the ring 8 and facing away from the frame 6, or may be situated at the side of the frame 6 and facing away from the ring 8. When starting a cleaning operation, one or more of the motors 24 of the roller drives 22 are energized to drive the corresponding roller(s) 26, the number of motors e.g. depending on the power required for the cleaning. In turn, the roller(s) 26 drive(s) the ring 8 to rotate in one of the directions of double arrow 44. The energizing of the motor(s) 24 may be controlled to reverse the rotation direction of the ring 8 based on a sensed condition, e.g. when the power consumed by the motor(s) 24 exceeds a predetermined threshold indicating that the ring 8 may be blocked. Reversal of the rotation direction 44 may also be set according to a predetermined timing sequence.

[0036] Energizing the motor(s) 24 and thereby rotating the ring 8 relative to the frame 6 will move the cleaning structure, such as the cleaning elements 50 relative to the object surface 3 to exert a cleaning action at the surface area covered by the cleaning structure. When this cleaning action has been performed, the rotation of the ring 8 may be stopped by disabling the energizing of the motor(s) 24, and then the cleaning device 1 may be moved over a predetermined distance along the object surface 3 parallel to the object axis 4 to position the cleaning structure for cleaning a further part of the object surface 3. The motor(s) 24 may then be energized again for a cleaning action at the further surface area covered by the cleaning structure.

[0037] Alternatively, the rotation of the ring 8 is continued when moving the cleaning device 1 along the object surface 3 parallel to the object axis 4, to provide a continuous cleaning action by the cleaning structure connected to the ring 8.

[0038] The cleaning device 1 may be moved along the object surface 3 parallel to the object axis 4 by connecting it to an external conveying means. An example of such conveying means, when the cleaning device 1 is to clean an underwater object 2, is a remotely operated vehicle, ROV, which may be detachably connected to the frame 6, and configured to exert a force on the frame 6 in a direction parallel to the object axis 4. Another example of a conveying means is a crane, which may be detachably connected to the frame 6, and which is appropriate when the object extends vertically.

[0039] When moving the cleaning device 1 along the object surface 3 parallel to the object axis 4, the rollers 34 facilitate this movement, while at the same time the rollers 34 prevent the frame 6 from moving around the object axis 4, by virtue of friction forces generated between the rollers 34 and the object surface 3.

[0040] Instead of moving the cleaning structure 1 along the object 2 by an external conveying means, one or more of the rollers 34 may be coupled to an electric or hydraulic drive motor 35, as schematically indicated in Figure 1 with dashed lines.

[0041] Figures 3, 4 and 5 illustrate another embodiment of a cleaning device 61, which may be placed on the outer surface of a cylindrical object 62 to clean an object surface 63. The object has an object axis 64 in a longitudinal direction thereof. The cleaning device 61 comprises a frame 66 and a ring 68.

[0042] The frame 66 comprises a support ring 70 and a flaring ring-shaped guide collar 72. The support ring 70 carries a plurality of cams 74 (in the embodiment shown: twelve cams 74) each provided with a freely rotatable roller 76 mounted on a shaft 78 extending parallel to the object axis 64. The frame 66 further is provided with a worm drive 82 comprising an electric or hydraulic motor 84 driving a worm shaft 86.

[0043] The frame 66 further is provided with a frame coupling structure comprising pairs of arms 88 (in the embodiment shown: four pairs of arms 88), each pair of arms 88 supporting a suspension fork 90 hingable around an axis 92. At the ends of the teeth of each suspension fork 90, a roller 94 is mounted freely rotatable around an axis 96 which extends tangentially relative to the ring-shaped frame 66. The roller 94 is configured to contact the object 62, and for a maximum contact surface area is shaped concavely to conform to the shape of the object surface 63. Each suspension fork 90 is supported to the frame 66 by a biasing structure embodied as a pair of springs 98 which bias the roller 94 in the direction of an object surface 63. Alternatively, the biasing structure may comprise a hydraulic actuator or a pneumatic spring or actuator.

[0044] The ring 68 has a generally U-shaped or C-shaped or I-shaped cross-section, and comprises a central body and two spaced, outwardly extending ring-shaped flanges or collars, an upper collar 100 and a lower collar 102. The rollers 76 mounted on the cams 74 support the ring 68 in a direction parallel to the object axis 64, the rollers 76 being confined between the upper collar 100 and the lower collar 102. The central body of the ring 68 provides an outer ring drive surface on which the rollers 76 engage, thereby providing roller bearings for the ring 68. Accordingly, the ring 68 is rotatable in either one of the directions of double arrow 104.

[0045] The ring 68 is provided with a toothed ring 106 having teeth engaging the worm shaft 86 of the worm drive 82, as illustrated in detail in Figure 4. More than one, N, worm drives 82 may be provided, e.g. engaging the teeth of the toothed ring 106 at angular positions (360/N)° apart.

[0046] The ring 68 is provided with a cleaning structure configured to contact the object surface 63 for removing material from the object surface 63. The cleaning structure may be detachably mounted, and may comprise discrete cleaning elements 110 (Figure 4) provided along

the inner circumference of the ring 68, or may be continuous along the inner circumference. The cleaning structure may comprise one or more brushes, scrapers and/or wipers.

[0047] As illustrated for the cleaning device 1 in Figure 2, the cleaning device 61 of Figures 3-5 may have the frame 66 assembled from two or more separable frame parts to enable the frame 66 to be placed around the object 62. Likewise, the ring 68 may be assembled from two or more separable ring parts to enable the ring 68 to be placed around the object 62.

[0048] The cleaning device 61 is operated as follows. The cleaning device is placed on a cylindrical object 62 adjacent to a part of the object surface 63 to be cleaned. As an example, when the part of the object surface 63 is situated underwater, such as under sea level, marine growth may have developed on the part of the object surface 63 to be cleaned. The part of the object surface 63 to be cleaned may be situated either at the side of the cleaning device 61 adjacent to the ring 68 and facing away from the frame 66, or may be situated at the side of the frame 66 and facing away from the ring 68. When starting a cleaning operation, the motor 84 of the worm drive 82 is energized to drive the corresponding worm shaft 86. In turn, the worm shaft 86 drives the ring 68 through the toothed ring 106 connected thereto to rotate the ring 68 in one of the directions of double arrow 104. The energizing of the motor 84 may be controlled to reverse the rotation direction of the ring 68 based on a sensed condition, e.g. when the power consumed by the motor exceeds a predetermined threshold indicating that the ring 68 may be blocked. Reversal of the rotation direction 104 may also be set according to a predetermined timing sequence.

[0049] Energizing the motor 84 and thereby rotating the ring 68 relative to the frame 66 will move the cleaning structure, such as the cleaning elements 110 relative to the object surface 63 to exert a cleaning action at the surface area covered by the cleaning structure. When this cleaning action has been performed, the rotation of the ring 68 may be stopped by disabling the energizing of the motor 84, and then the cleaning device 61 may be moved over a predetermined distance along the object surface 63 parallel to the object axis 64 to position the cleaning structure for cleaning a further part of the object surface 63. The motor 84 may then be energized again for a cleaning action at the further surface area covered by the cleaning structure.

[0050] Alternatively, the rotation of the ring 68 is continued when moving the cleaning device 61 along the object surface 63 parallel to the object axis 64, to provide a continuous cleaning action by the cleaning structure connected to the ring 68.

[0051] The cleaning device 61 may be moved by connecting it to an external conveying means. An example of such conveying means, when the cleaning device 61 is to clean an underwater object 62, is a remotely operated vehicle, ROV, 120 (illustrated schematically in Figure 5) or a crane detachably connected to the frame 66, and configured to exert a force on the frame 66 in a direction parallel to the object axis 64.

[0052] When moving the cleaning device 61 along the object surface 63 parallel to the object axis 64, the rollers 94 facilitate this movement, while at the same time the rollers 94 prevent the frame 66 from moving around the object axis 64, by virtue of friction forces generated between the rollers 94 and the object surface 63.

[0053] As explained above, an object having a cylindrical object surface and a longitudinal object axis is cleaned by a device having a ring which defines a ring passage opening allowing passage of the object through the ring. The ring carries a cleaning structure configured to clean the object surface by brushing when the ring moves relative to the object surface. The cleaning device has a frame which defines a frame passage opening allowing passage of the object through the frame. The frame passage opening is aligned with the ring passage opening. The ring is connected to the frame. The frame carries a ring drive assembly to rotate the ring relative to the frame. A frame coupling structure is attached to the frame, and couples the frame to the object to allow a displacement of the frame and ring along the object surface parallel to the object axis. When the ring drive assembly is energized for rotating the ring, and/or the frame is moved in the direction of the object axis, the cleaning structure cleans part of the object surface covered by the cleaning structure rotating and moving with the ring.

[0054] It is noted that the cleaning structure may comprise a scraping device and/or a wiping device in addition to, or instead of a brushing device.

[0055] As required, detailed embodiments of the present invention are disclosed herein; however, it is to be understood that the disclosed embodiments are merely exemplary of the invention, which can be embodied in various forms. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a basis for the claims and as a representative basis for teaching one skilled in the art to variously employ the present invention in virtually any appropriately detailed structure. Further, the terms and phrases used herein are not intended to be limiting, but rather, to provide an understandable description of the invention.

[0056] The terms "a" or "an", as used herein, are defined as one or more than one. The term plurality, as used herein, is defined as two or more than two. The term another, as used herein, is defined as at least a second or more. The terms including and/or having, as used herein, are defined as comprising (i.e., open language, not excluding other elements or steps). Any reference signs in the claims should not be construed as limiting the scope of the claims or the invention.

[0057] The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

[0058] The term coupled, as used herein, is defined as connected, although not necessarily directly.

Claims

1. A device for cleaning an object having a cylindrical object surface and a longitudinal object axis, the device comprising:

   a ring defining a ring passage opening allowing passage of the object through the ring, and comprising a cleaning structure configured to clean the object surface;
   a frame defining a frame passage opening allowing passage of the object through the frame, and being aligned with the ring passage opening, the frame being connected to the ring, and comprising a ring drive assembly to rotate the ring relative to the frame; and
   a frame coupling structure attached to the frame, and configured to couple the frame to the object to allow a displacement of the frame and ring along the object surface parallel to the object axis.

2. The device of claim 1, wherein the cleaning structure comprises at least one brush configured to contact the object surface.

3. The device of claim 2, wherein the at least one brush is detachably connected to the ring.

4. The device of any of the preceding claims, wherein the ring drive assembly comprises at least one worm drive comprising a motor coupled to a worm shaft, the ring is provided with teeth along its length, and the worm shaft engages the teeth for rotating the ring.

5. The device of any of claims 1-3, wherein the ring drive assembly comprises at least one roller drive comprising a motor coupled to a roller, the ring is provided with an outer ring drive surface, and the roller engages the outer ring drive surface for rotating the ring.

6. The device of any of the preceding claims, wherein the ring is provided along it circumference with two spaced outwardly extending collars, and wherein the frame comprises a plurality of roller bearings engaging the ring between the collars for mounting the ring rotatable relative to the frame.

7. The device of any of the preceding claims, wherein the frame coupling structure comprises a plurality of wheels, each wheel configured to be rotatable around an axis at right angles to the object axis, and configured to engage the object surface.

8. The device of claim 7, wherein the wheel has an axial length and a diameter varying along the length to provide a shape matching the object surface.

9. The device of claim 7 or 8, wherein the frame coupling structure comprises a biasing structure for each wheel, the biasing structure being configured for biasing the wheel against the object surface.

10. The device of any of claims 7-9, wherein the frame coupling structure comprises at least one wheel drive comprising a motor coupled to at least one of the wheels for rotating the wheel.

11. The device of claim 4, 5 or 10, wherein the motor is an electric motor or a hydraulic motor.

12. The device of any of the preceding claims, wherein the ring and the frame each comprise at least two parts which are detachably connected to each other to allow for providing the ring and the frame, respectively, on the object.

13. A method of cleaning an object having a cylindrical object surface and a longitudinal object axis, the method comprising:

   providing a device according to any of the preceding claims;
   mounting the device with its frame coupling structure on the object surface;
   energizing the ring drive assembly for rotating the ring; and
   moving the frame in the direction of the object axis, whereby the cleaning structure cleans part of the object surface covered by the cleaning structure rotating with the ring.

14. The method of claim 13, wherein the frame is coupled to conveying means for moving the frame in the direction of the object axis.

15. The method of claim 14, wherein the conveying means comprises a remotely operated vehicle, ROV, or a crane.

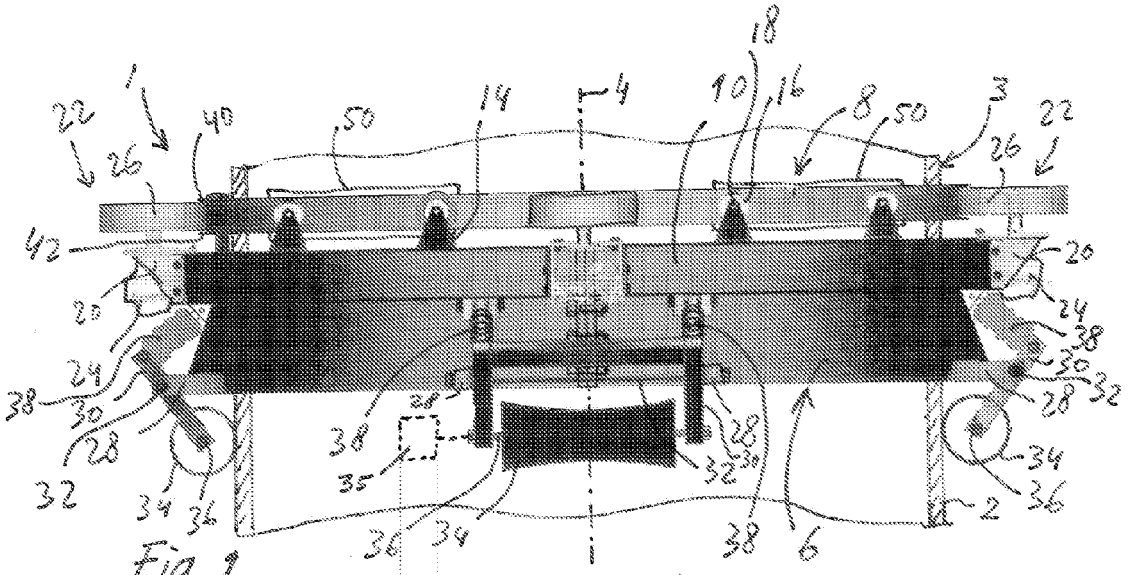

Fig. 1

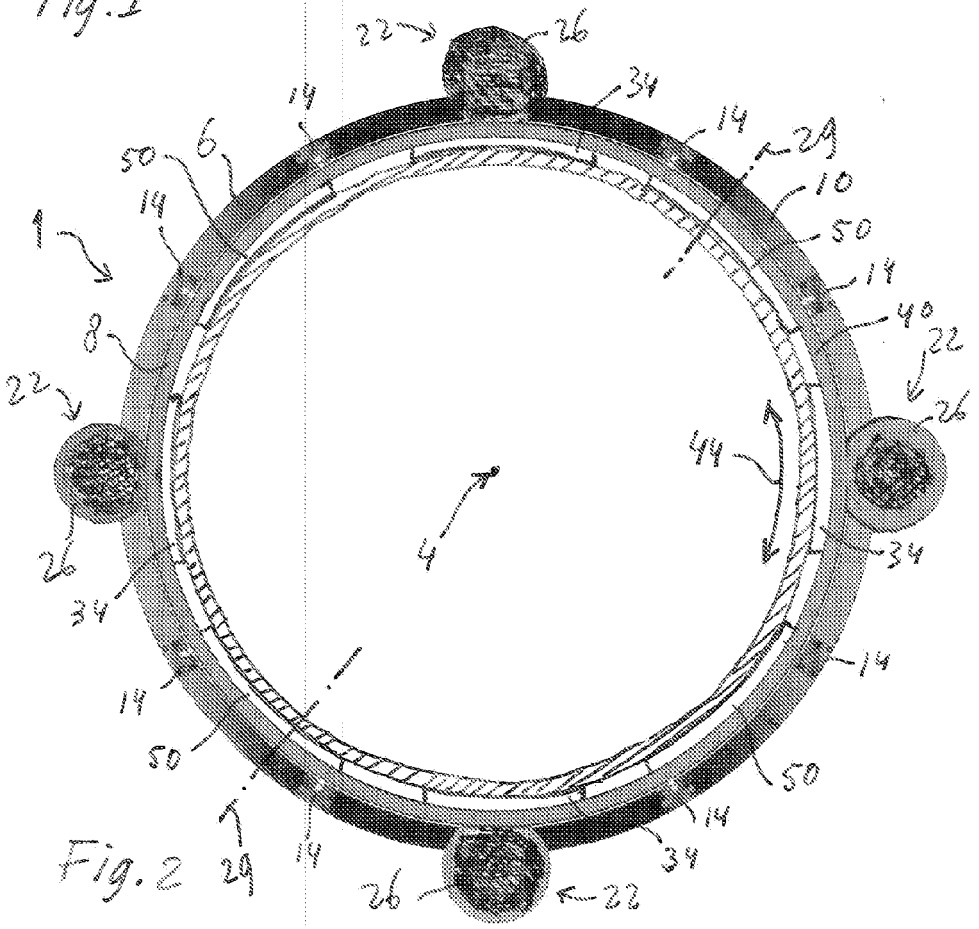

Fig. 2

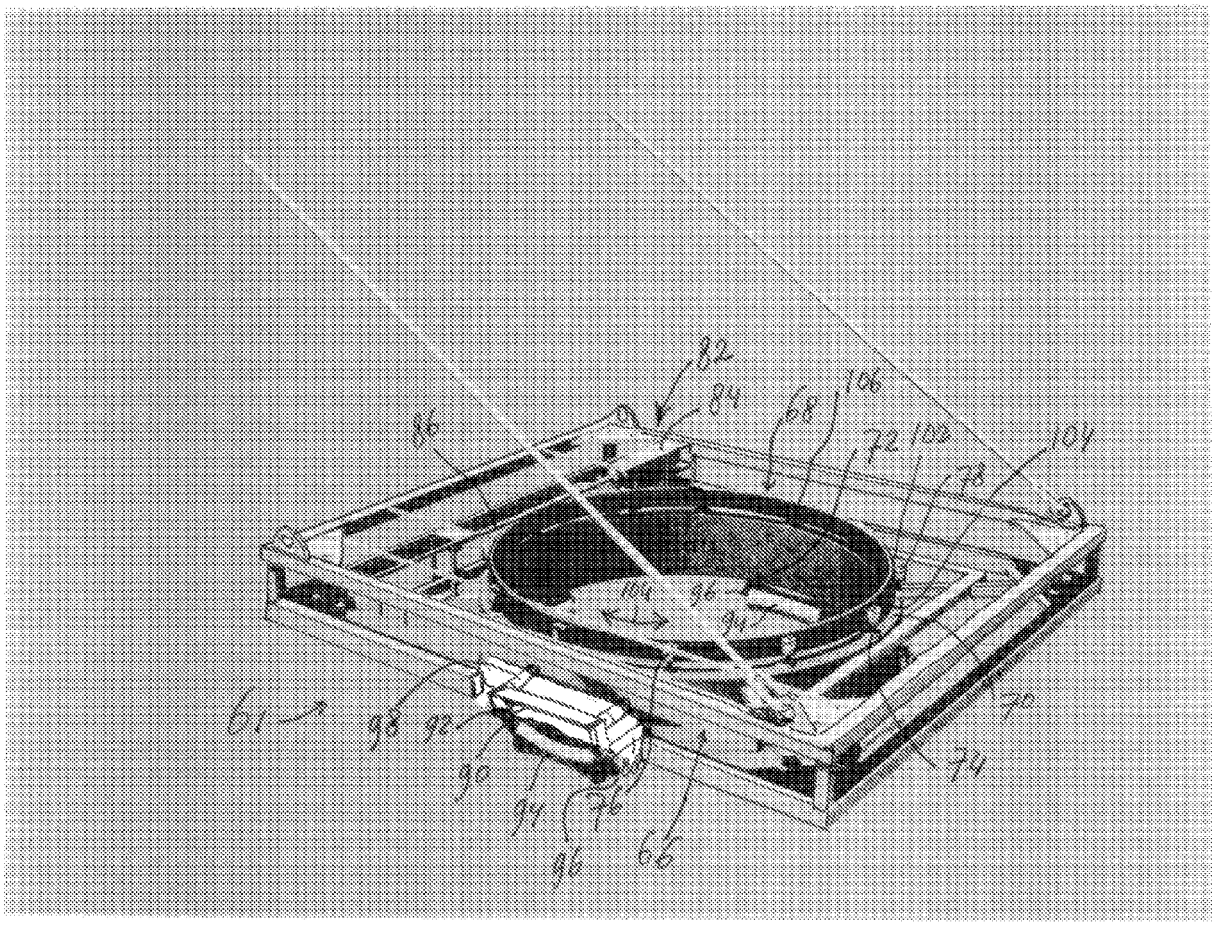

Fig. 3

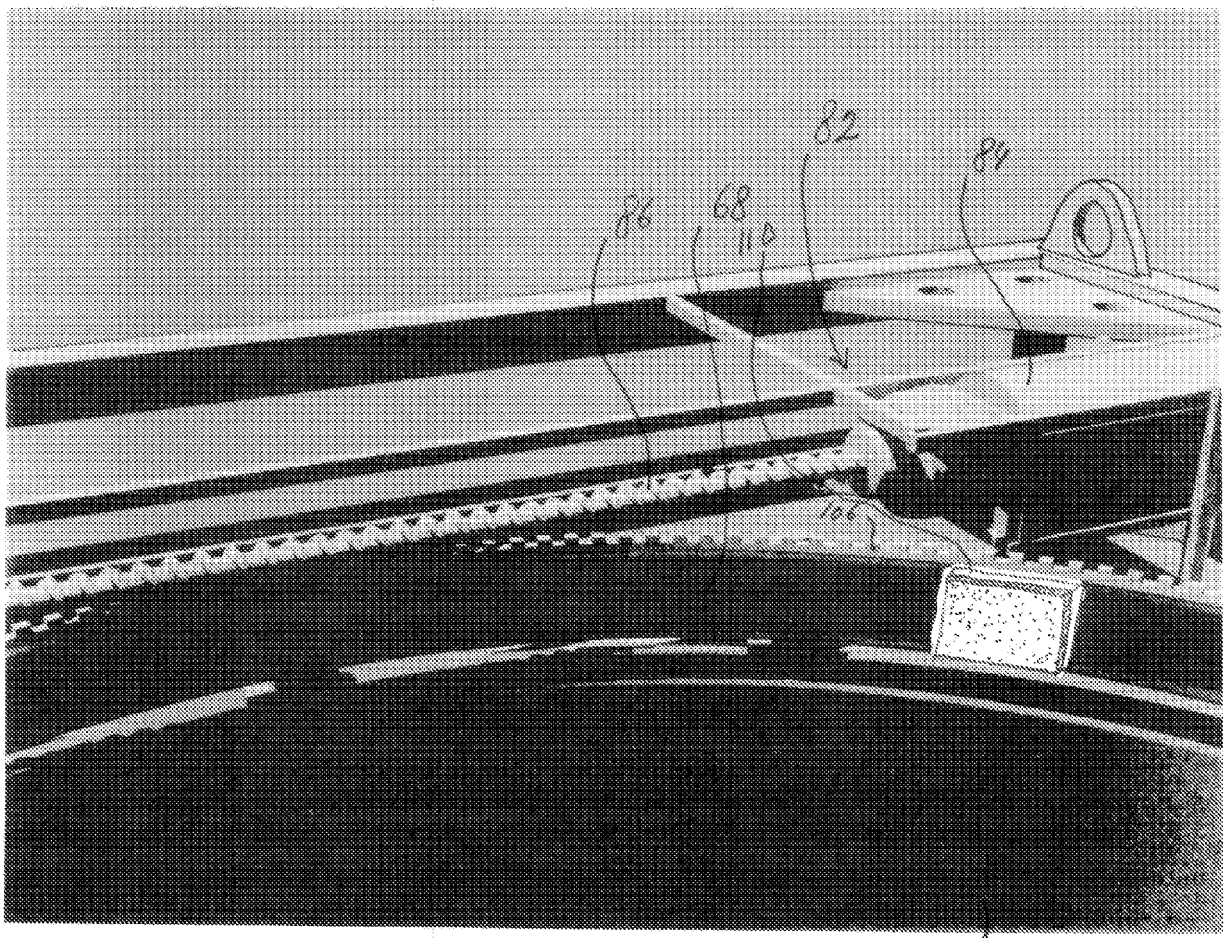

Fig. 4

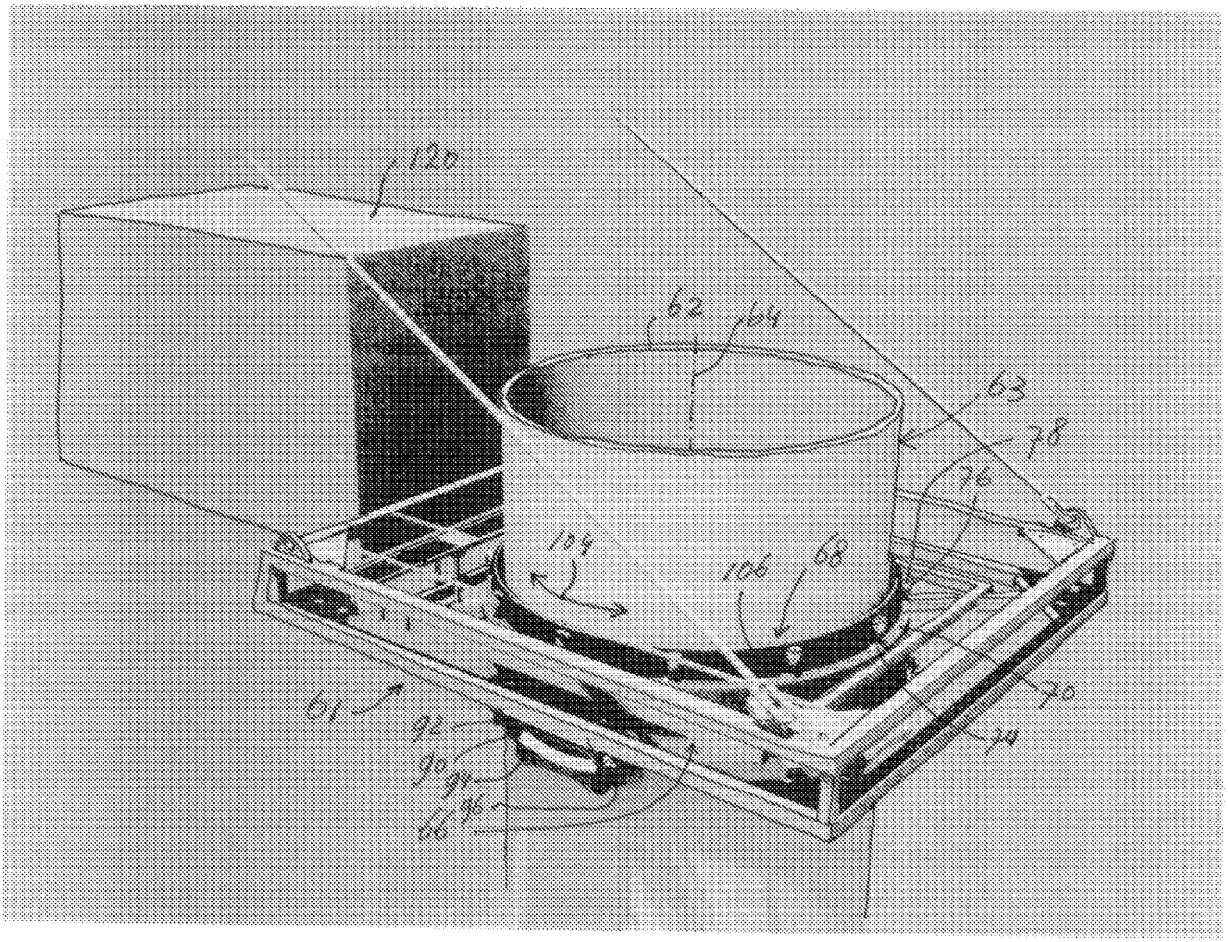

Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 11 16 9500

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	US 4 720 213 A (GERNHARDT MICHAEL L [US] ET AL) 19 January 1988 (1988-01-19) * column 5, line 26 - column 8, line 43; figures 1-8 *	1,4-6, 13-15 2,3,7, 9-11	INV. B63B59/10
X	AU 36817 84 A (GOURLEY P K; CRESWELL R E; TOTH T) 20 June 1985 (1985-06-20) * page 7, line 12 - page 13, line 10; figures 1,2,9 *	1,5,6, 12-14	
Y A	WO 87/02640 A1 (DAWSON OFFSHORE PTY LTD [AU]) 7 May 1987 (1987-05-07) * page 2, paragraph 5 - page 4, paragraph 2; figure 1 *	2,3 11	
Y	WO 99/10232 A1 (EATHORNE RUSSELL JAMES [AU]) 4 March 1999 (1999-03-04) * page 5, line 12 - page 7, line 25; figures 11-5 *	7,9-11	
A	US 2008/135232 A1 (LAWLER KINTON [US] ET AL) 12 June 2008 (2008-06-12) * paragraphs [0011] - [0017]; figures 1-3 *	2,3,15	TECHNICAL FIELDS SEARCHED (IPC) B63B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	31 October 2011	Brumer, Alexandre

CATEGORY OF CITED DOCUMENTS

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31-10-2011

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4720213 A	19-01-1988	AU 594911 B2	15-03-1990
		AU 1312988 A	15-09-1988
		GB 2202887 A	05-10-1988
		NO 881132 A	19-09-1988
AU 3681784 A	20-06-1985	NONE	
WO 8702640 A1	07-05-1987	EP 0243408 A1	04-11-1987
WO 9910232 A1	04-03-1999	CN 1267263 A	20-09-2000
		EP 1003669 A1	31-05-2000
		JP 2001514116 A	11-09-2001
		US 6371696 B1	16-04-2002
US 2008135232 A1	12-06-2008	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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Patent documents cited in the description

- EP 2305556 A1 **[0006]**