Abstract: An apparatus for cleaning an inner surface of a marine riser (62) or a production riser (62), having an inside diameter in a range from 16 inches (40 cm) to 20 inches (51 cm), has a mandrel (16) and at least one brush member (12) and at least one centralizer (14) mounted on the mandrel (16). The brush member (12) has an outside diameter adapted to operate inside the riser (62) with sufficient contact to clean the inner surface thereof. The centralizer (14) has at least two adjustable positioning members (24) protruding from its outer circumference, which cooperate to each contact the inside surface of the riser (62), thereby positioning the mandrel (16) substantially coaxial with a longitudinal axis of the riser (62). A drive fluid causes the brush member (12) to oscillate and propel the apparatus along the length of the riser (62). A method for removing debris from a marine riser (62) or a production riser (62) uses the apparatus of the present invention.
METHOD AND APPARATUS FOR CLEANING MARINE AND PRODUCTION RISERS

RELATED APPLICATION

[0001] This application claims priority to U.S. Provisional Application Serial No. 62/251,606 filed Nov. 5, 2015.

FIELD OF THE INVENTION

[0002] This invention relates to methods and tools for cleaning pipes, particularly marine and production risers.

BACKGROUND OF THE INVENTION

[0003] Marine and production risers are conduits for transfer of materials between the seabed and a surface drilling or production facility. In particular, a marine riser is a conduit communicating between a seabed and a floating vessel or rig, while a production riser is a conduit used with stationary vessels or rig. Marine and production risers may be used for example to contain a drill pipe used in drilling, and/or to help prevent drilling fluids and oil from getting into the surrounding sea waters. Marine and production risers may also be used like pipelines or flow-lines to transport produced hydrocarbons and/or production materials, such as injection or control fluids.

[0004] To maintain satisfactory operation, marine and production risers must be cleaned of solid material or debris from time to time. Cleaning methods and tools for cleaning pipes are commonly known and used. Often such methods use a pressured air supply connected to one end of a vibrating tool with a brush that is inserted into the pipe to be cleaned. The tool imparts vibration to the brush that causes the tool to work its way along the length of the pipe to be cleaned. When the tool has reached the far end of the pipe, the direction of the brush bristle changes, causing the tool to work its way back along the pipe to an operator operating the tool. Alternatively, the air supply is turned off and the tool is retrieved, or manually turned around.

[0005] US 7,676,878B2 by the present inventor relates to an apparatus for cleaning a tubular. The apparatus has a vibratory motor contained in a sleeve. A nose end cap and a tail end cap seal the ends of the sleeve. The nose end cap and the tail end cap are provided with centralizer bodies to guide the motor unit in the bore being
cleaned. The centralizer bodies are sized to be received by the bore being cleaned. Accordingly, a variety of centralizer bodies are required to fit the desired inside diameter. Collar-shaped brushes are assembled on a central with flange spacers and held in place with the nose end cap and the tail end cap.

The apparatus described in US7,676,878B2 is particularly suitable for cleaning pipes having a 4 1/2 to 5 inch (11.4 to 12.7 cm) outside diameter (O.D.). However, the apparatus becomes quite cumbersome when scaled-up for cleaning larger diameter marine and production risers. Marine and production risers have an inside diameter in a range from 16 inches to 20 inches. A vibratory brush as described above, that is useful for cleaning drill pipe, falls out of a marine or production riser when the brush reaches the distal end of the marine or production riser. Because of the marine and production riser's significantly larger size and length or height, the brush is not easily pulled back into the pipe or retrieved manually. Furthermore, the rigid centralizer bodies would be heavy for operators to manipulate and would have a tendency to jam inside a larger diameter marine or production riser, becoming difficult, if not impossible, to remove from the riser. Improvement to avoid such problems when cleaning marine and production risers is desired.

SUMMARY OF THE INVENTION

According to one aspect of the present invention, there is provided an apparatus for cleaning an inner surface of a riser, comprising: a mandrel having a drive assembly disposed therein and adapted for connection to a drive fluid; at least one brush member operably mounted on the mandrel, the at least one brush member having an outside diameter adapted to operate inside the riser with sufficient contact to clean the inner surface of the riser, the riser selected from the group consisting of marine risers and production risers, having inside diameters in a range from 16 inches (40 cm) to 20 inches (51 cm); at least one centralizer mounted on the mandrel, the at least one centralizer having an outside diameter less than the outside diameter of the at least one brush member and less than the inside diameter of the riser; at least two adjustable positioning members protruding from an outer circumference of the at least one centralizer, thereby producing an effective outside diameter for the centralizer that is substantially equal to the inside diameter of the riser, the at least two adjustable positioning members cooperating to each contact the inside surface of the riser, thereby positioning the mandrel substantially coaxial with a longitudinal axis of the riser; the at least two
adjustable positioning members allowing for movement of the apparatus along the longitudinal axis of the riser.

[0008] According to another aspect of the present invention, there is provided a method for removing debris from the inner surface of a riser, comprising the steps of: providing an apparatus comprising: a mandrel having a drive assembly disposed therein and adapted for connection to a drive fluid; at least one brush member operably mounted on the mandrel, the at least one brush member having an outside diameter adapted to operate inside the riser with sufficient contact to clean the inner surface of the riser, the riser selected from the group consisting of marine risers and production risers, having inside diameters in a range from 16 inches (40 cm) to 20 inches (51 cm); at least one centralizer mounted on the mandrel, the at least one centralizer having an outside diameter less than the outside diameter of the at least one brush member and less than the inside diameter of the riser; at least two adjustable positioning members protruding from an outer circumference of the at least one centralizer; adjusting a length of the at least two adjustable positioning members to produce an effective outside diameter for the centralizer that is substantially equal to the inside diameter of the riser, thereby positioning the mandrel substantially coaxial with a longitudinal axis of the large diameter conduit; the at least two positioning members allowing for movement of the apparatus along the longitudinal axis of the large diameter conduit; positioning the apparatus in the interior of the riser at a proximal end of the riser; supplying drive fluid to the apparatus, thereby causing the at least one brush member to oscillate and travel along the length of the riser to a distal end of the riser; and pulling the apparatus towards the proximal end of the riser.

**BRIEF DESCRIPTION OF THE DRAWINGS**

[0009] The apparatus of the present invention will be better understood by referring to the following detailed description of preferred embodiments and the drawings referenced therein, in which:

[0010] Fig. 1a is a top plan view of one embodiment of an apparatus of the present invention having one brush member and one centralizer;

[0011] Fig. 1b is a side elevation view of the embodiment of the apparatus of Fig. 1a;

[0012] Fig. 2a is a top plan view of one alternate embodiment of a brush member of an apparatus of the present invention with a solid brush wheel;
Fig. 2b is a top plan view of a second alternate embodiment of a brush member of an apparatus of the present invention with a brush wheel having cutouts;

Fig. 2c is a top plan view of a third alternate embodiment of a brush member of an apparatus of the present invention with a brush wheel having spokes;

Fig. 3a is a side elevation view of a fourth alternate embodiment of a brush member of an apparatus of the present invention having bristles arranged around the entire circumference of the brush wheel;

Fig. 3b is a side elevation view of a fifth alternate embodiment of a brush member of an apparatus of the present invention having bristles arranged in two sections of the circumference of the brush wheel;

Fig. 3c is a side elevation view of a sixth alternate embodiment of a brush member of an apparatus of the present invention having a brush wheel with bristles arranged in a helical pattern about the circumference of the brush wheel;

Fig. 3d is a side elevation view of a seventh alternate embodiment of a brush member of an apparatus of the present invention having a brush wheel with two heights of bristles arranged about the circumference of the brush wheel;

Figs. 4a - 4d illustrate an embodiment of a brush member having an adjustable outside diameter, wherein Figs. 4a and 4c are top plan views of a brush member at a 1st and a 2nd outside diameter, respectively, and Figs. 4b and 4d are cross-sectional exploded views of the brush member in Figs. 4a and 4d, along the line b-b and d-d, respectively;

Figs. 5a - 5c depict various embodiments, in a side cross-sectional view, of an adjustable positioning member of an apparatus of the present invention;

Figs. 5d - 5f depict various embodiments, in a side elevation view, of an adjustable positioning member of an apparatus of the present invention;

Fig. 6 is a cross-sectional view of another embodiment of an apparatus of the present invention showing a drive assembly for operating the apparatus;

Figs. 7 and 8 are side elevation views of further embodiments of an apparatus of the present invention having one brush member and two centralizers;

Figs. 9 and 10 are side elevation views of yet further embodiments of an apparatus of the present invention having one brush member and three centralizers;

Figs. 11 and 14 are side elevation views of further embodiments of an apparatus of the present invention having two brush members and two centralizers;
Fig. 12 is a side elevation view of yet another embodiment of an apparatus of the present invention having two brush members and one centralizer;

Fig. 13 is a side elevation view of yet another embodiment of an apparatus of the present invention having two brush members and three centralizers; and

Figs. 15a - 15f illustrate operation of the embodiment of the apparatus depicted in Fig. 9.

**DETAILED DESCRIPTION OF THE INVENTION**

The present invention provides a method and apparatus for cleaning marine and production risers, without the problems previously encountered with prior art tools. The present apparatus retains the simplicity needed for practical use while eliminating the need to recover or manually assist the tool at the distal end of the marine or production riser.

The method and apparatus can be used to clean rust, scale, dried drilling mud, and deposits from marine and production risers. Marine and production risers, hereinafter "riser" or "risers," typically have an inside diameter from 16 inches (40 cm) to 20 inches (51 cm).

The apparatus of the invention comprises at least one brush member and may have multiple brush members, in line along a central mandrel that receives and facilitates the flow of a drive fluid, for example, compressed air, for operation. The brush member oscillates to enable the apparatus of the present invention to self-propel forward or backwards to clean the interior of the riser. Bristles of the brush member are driven by the interference layback direction of the brush member to remove deposit from the riser. At least one, preferably two or three, centralizers are mounted on the mandrel of the apparatus proximate to or at least near a brush member, particularly the brush member nearest the distal end of the apparatus if the apparatus has more than one brush member. These centralizers may be positioned on each side of a brush member. The centralizers keep the brush member in a favorable contact position to re-enter the bore of the riser without assistance, beyond a tug on a tether and/or a drive fluid line to urge a reverse layback direction, when the brush member exits of the riser after or during cleaning.

The outside diameter of the apparatus of the invention may be comparable to but slightly less than the inside diameter of a typical riser, so as to fit inside the riser.
while providing full coverage of the riser interior to reduce the number of passes needed through the riser for cleaning.

[00033] The method of the invention employs an apparatus such as the one of the invention for cleaning the interior of a riser, having at least one centralizer for stabilizing at least one brush member or similar cleaning device, mechanism or means, so that the brush member may be pulled back into the riser when it exits the riser at one end, without need for operator assistance in manually retrieving or manually turning the apparatus at that end.

[00034] Referring now to Figs. 1a and 1b, one embodiment of the apparatus 10 of the present invention comprises a single brush member 12 and a centralizer 14. The brush member 12 is operably mounted on a mandrel 16. The brush member 12 shown in Figs. 1a and 1b has a brush wheel 18 with bristles 22 extending from the circumference of the brush wheel 18.

[00035] It will be understood by those skilled in the art that various embodiments of the brush wheel 18 are possible without departing from the spirit of the invention. Some possible embodiments of the brush wheel are depicted in Figs. 2a-2c, without limitation, showing the brush wheel 18 as a solid (Fig. 2a), provided with cutouts (Fig. 2b) or spoked (Fig. 2c). Preferably, the brush wheel 18 is spoked or provided with cutouts to reduce weight of the apparatus 10 without compromising strength and/or robustness.

[00036] The bristles 22 may be formed of any material suitable for the material being removed from the riser. Preferably, the bristles 22 are made of strands of a plastic, a metal, or combinations thereof. The bristles 22 may be provided individually or in groupings, in a regular or irregular pattern. It will be understood by those skilled in the art that the bristles 22 may be arranged on the circumference of the brush wheel 18 in a variety of configurations, for example, depending on the cost of the bristles 22, the weight of the apparatus 10, the mode of operation of the brush wheel 18, the surface and debris being treated, and the like. Figs. 3a - 3d illustrate, without limitation, some possible embodiments of the bristles 22 on the brush wheel 18. Fig. 3a shows bristles 22 arranged around the entire circumference of the brush wheel 18, while Fig. 3b shows bristles 22 arranged in two sections of the circumference of the brush wheel 18. Fig. 3c shows bristles 22 arranged in a helical pattern about the circumference of the brush wheel 18 and Fig. 3d shows two heights of bristles 22 arranged about the circumference
of the brush wheel 18. The bristles 22 of different heights may be made of the same or
different material.

[00037] It will be understood that, without departing from the spirit of the present
invention, various combinations of the brush wheels in Figs. 2a - 2c and bristle 22
configurations in Figs. 3a - 3d may be made, without or without further modifications
that would be apparent to one skilled in the art.

[00038] The brush member 12 has an outside diameter equal to or greater than the
inside diameter of the riser to be treated. The brush wheel 18 will have an outside
diameter that is less than the inside diameter of the riser to be treated, with the bristles 22
forming the remainder of the outside diameter of the brush member 12. Preferably, the
brush member 12 is sized to have an interference fit with the inside surface of the riser to
be treated so as to contact substantially the entire inner surface of the riser as it travels in
one or both directions of the riser (as will be explained in more detail below). More
preferably, the brush member 12 is sized to have an outside diameter larger than the
inside diameter of the riser, so that the bristles 22 flex or bend against the inside surface
of the riser. Preferably, when in position with an interference fit, the bristles 22 lay back
at a layback angle in a range of from 5 degrees to 15 degrees, more preferably in a range
from 8 degrees to 12 degrees.

[00039] In a preferred embodiment, illustrated in Figs. 4a - 4d, brush member 12
has two mating wheel members 18.1 and 18.2, allowing for an adjustable outside
diameter of the brush member 12. At least two, preferably three, more preferably four
flanges 20 are disposed between the mating wheel members 18.1 and 18.2. The flanges
20 have bristles 22 on the outer circumference thereof and oblong mounting holes 23.
Bolts 21, for example, are threaded through mating wheel members 18.1, 18.2 and
intermediate flange 20. Before tightening bolt 21, the flange 20 is moved relative to the
mating wheel members 18.1, 18.2 along oblong mounting hole 23 to project the bristles
22 of the brush member 12 to the desired outside diameter (example provided below).
Bolt 21 is then tightened to lock the flange 20 in position. Figs. 4a and 4b demonstrate
the brush member 12 at a 1st outside diameter, where the flanges are moved outwardly
along oblong mounting holes 23. Figs. 4c and 4b demonstrate the brush member 12 at a
smaller 2nd outer diameter, where the flanges are moved inwardly along oblong mounting
holes 23. It will be apparent to those skilled in the art that other configurations and
fasteners may be suitable, without departing from the spirit of the present invention.
Returning to Figs. 1a and 1b, the centralizer 14 has a smaller outside diameter than the outside diameter of the brush member 12. The centralizer has at least two adjustable positioning members 24, preferably at least three positioning members 24, protruding from the outer circumference of the centralizer 14. Fig. 1a illustrates an embodiment of the centralizer 14 with six adjustable positioning members 24.

The adjustable positioning members 24 cooperate to provide contact with the inside surface of the riser, in a manner to position the mandrel 16 substantially coaxial with a longitudinal axis of the riser.

The adjustable positioning members 24 can be made in a variety of configurations and/or materials so that the apparatus 10 is maintained substantially centralized relative to the riser while the apparatus 10 is in use. The adjustable positioning members 24 are selected to allow the apparatus 10 to move by rolling or sliding on or against, without sticking to or jamming against, the inside surface of the riser.

The adjustable positioning members 24 are intermittently or regularly positioned around or about the circumference of the centralizer 14. The adjustable positioning members 24 may be straight, curved or angled knobs 26 (depicted in Figs. 5a - 5c), springs 28 (depicted in Fig. 5d) or wheels 32 (depicted in Figs. 5e - 5f). As a unit, the adjustable positioning member 24 will be sturdy enough to position the centralizer 14, but preferably has flexibility in structure and/or material to adjust to the inside diameter of the riser, for example, which may change after cleaning.

The adjustable positioning members 24 are preferably threaded at one end, for example as shown in Fig. 5b, to be threaded into the circumference of the centralizer 14 to allow for adjustment of the effective outside diameter of the centralizer 14, the effective outside diameter being the diameter of the centralizer 14 plus the protruding length of the positioning members 24.

By way of example, for cleaning a riser having an inside diameter of 20 inches (50.8 cm), having a low degree of debris, a brush member 12 may be selected to have an outside diameter of 20-1/16 inches (51 cm). The positioning member 24 may be positioned to produce an effective outside diameter for the centralizer 14 of 19-15/16 inches (50.6 cm).

Knobs 26 and wheels 32 are comprised of, or have ends and/or end coverings 34 comprised of a flexible or low friction material, such as for nonlimiting example natural or synthetic rubber, vinyl, plastic, thermoplastic, or a soft metal. In one
embodiment, knobs 26 are comprised of, or have, a ball roller end 34 comprised of a thermoplastic or soft metal. Preferably, adjustable positioning members 24 are a sufficient length to touch or enable the centralizer 14 to reach the inner surface of the riser without causing the apparatus 10 to stick in the riser or to not be able to enter the riser at all. The adjustable positioning members 24 contribute to the stabilizing effect of the centralizer 14 on the apparatus 10 and/or the positioning of the apparatus 10 in the riser.

[00047] Beyond supporting the centralizer 14 and brush member 12, the mandrel 16, shown in Fig. 1b, houses a drive assembly for moving the apparatus 10 through the riser, as generally depicted in Fig. 6. It will be apparent to those skilled in the art that various embodiments of a drive assembly 42 are suitable for the apparatus 10 of the present invention, without departing from the spirit of the present invention.

[00048] The drive assembly 42 causes the brush member 12 to contact the inner surface of the riser with an action selected from the group consisting of vibration, oscillation, partial rotation, continuous rotation, and combinations thereof.

[00049] One type of drive assembly 42, preferably powered by compressed air, supplied through a drive fluid supply line 44, causes the mandrel 16, or a portion thereof, to rotate, oscillate and/or vibrate. Such rotation, oscillation and/or vibration and the layback of the end bristles 22 of the brush member 12, bending back or away from the direction of movement, facilitate the movement of the apparatus 10 through the riser. It will be apparent to those skilled in the art the various types of motors that could be used to implement the apparatus 10 of the present invention, without departing from the spirit of the present invention. One suitable motor is a vibratory motor, for example, of the type described in inventor’s prior US7,676,878B2.

[00050] Compressed air is provided at relatively lower pressure compared to water pressures of up to 10,000 psi in prior art devices that rely on pressurized water for cleaning risers. For example, compressed air may be supplied in a range of from 100 to 120 psig (689 kPa(g) to 827 kPa(g)).

[00051] One or more tethers 46 may be fastened to the brush member 12, as shown in Fig. 6, or the centralizer 14 or mandrel 16, to allow an operator to tug the apparatus 10 towards a proximal end of a riser, as will be explained in more detail below with reference to Figs. 15a-15f.

[00052] The apparatus 10 of the present invention has at least one brush member 12 and at least one centralizer 14 mounted on the mandrel 16. The brush members 12
may be provided in sections (not shown) to be secured to the mandrel 16 or connected, for example by threading, directly or indirectly, to sections of the mandrel 16. Preferably, the apparatus 10 has at least two centralizers 14, more preferably at least three centralizers 14. Figs. 7 and 8 illustrate embodiments of the apparatus 10 of the present invention having one brush member 12 and two centralizers 14, while Figs. 9 and 10 illustrate embodiments of the apparatus 10 of the present invention having one brush member 12 and three centralizers 14. In yet another embodiment of the apparatus 10 of the present invention, there is at least one support rod 52, preferably two support rods 52, parallel to the mandrel 16 between one or more centralizers 14 and/or one or more brush members 12. In the embodiment shown in Fig. 10, two support rods 52 are shown connecting two centralizers 14 and the brush member 12.

The support rods 52 provide strength to the apparatus 10 and/or can be used to provide operators with a handle for transporting and/or positioning the apparatus 10.

Figs. 11 and 14 illustrate embodiments of the apparatus 10 of the present invention having two brush members 12 and two centralizers 14. The embodiment shown in Fig 12 has one centralizer 14 and two brush members 12. This embodiment further illustrates an embodiment of having two different styles of brush members 12. Here, the brush member 12 on top, which would follow the bottom brush member 12 on its initial traverse through the riser, may be selected to have a material for providing a finer polish of the inner surface of the riser, compared to a rougher cleaning of the first bottom brush member 12.

In the embodiment shown in Fig. 13, the apparatus 10 of the present invention has two brush members 12 and three centralizers 14. In the embodiment shown in Fig. 14, two support rods 52 are shown connecting the centralizer 14 and two brush members 12.

The apparatus 10 of the present invention may travel the length of a riser and back, with the centralizer 14 providing stability such that if and when brush 12 exits the riser at the distal end of the riser, the apparatus 10 may be readily pulled back into the riser, without assistance at that distal end from the operator to manually turn or retrieve the apparatus 10.

The apparatus 10 of the present invention is portable and readily operated by two operators. The apparatus 10 has utility onshore or offshore, at surface or in
storage. The apparatus 10 is particularly advantageous for use on an off-shore vessel, rig or platform, where space is at a premium, because of its relatively small footprint.

[00058] The method of the invention, with non-limiting, example steps, is illustrated in Figs. 15a - 15f. The method of the present invention provides for cleaning of a riser 62 with a cleaning apparatus 10 that moves through a riser 62, with a rotating, oscillating, and/or vibrating brush member 12 having an outside diameter slightly larger than the inside diameter of the riser 62, as depicted in Fig. 15a. The apparatus 10 is stabilized by at least one centralizer 14 (three centralizers 14 are illustrated in Fig. 15a - 15f) on the apparatus 10, which enables the apparatus 10 to be pulled back into the riser 62 when/if the distal end of the apparatus 10 exits the end of the riser 62. The apparatus 10 may thus reverse direction at the end of the riser 62 and return down the length of the riser 62 to further clean the riser 62 and return the apparatus 10 to the operator.

[00059] Preferably, the bristles 22 of the brush member 12 are sized to cause an interference fit with the inner surface of the riser 62, to bend or flex the bristles backwards at the desired layback angle Θ when the apparatus 10 is inserted in the interior of the riser 62 at the front end thereof, as shown in Fig. 15b. Preferably, the bristles 22 lay back at a layback angle, Θ in a range of from 5 degrees to 15 degrees, more preferably in a range from 8 degrees to 12 degrees. When a drive fluid is supplied to the drive assembly 42 through drive fluid supply line 44, the brush member 12 is caused to vibrate or oscillate. Because the bristles 22 are laid back, the brush member 12 and therefore the apparatus 10 is constricted by the inside diameter of the riser 62. Accordingly, supplying a drive fluid causes the apparatus 10 to move forward to the distal end of the riser 62, effectively the apparatus 10 is self-propelled to the distal end of the riser 62, as shown in Fig. 15c.

[00060] The apparatus 10 stops at end of riser 62 when the brush member 12 exits the distal end of the riser 62, as shown in Fig. 15d, because the brush member 12 is no longer constricted by the riser 62 inside diameter and the bristles 22 straighten. An operator can detect that the apparatus 10 is no longer moving forward and tugs on the drive fluid supply line 44, and/or the tether 46 to pull the apparatus 10 backward until the brush member 12 reenters the riser 62, as depicted in Fig. 15e, thereby changing the layback direction of the bristles 22. Specifically, as the bristles 22 bend backward at the desired layback angle Θ (Fig. 15e), the apparatus 10 is propelled in reverse direction to the front end of the riser 62, as shown in Fig. 15f.
When there is a significant amount of debris in the riser 62, it may be necessary to repeat the steps in Figs. 15a - 15f. Sometimes, the debris may be too significant for the apparatus 10 to self-propel from the proximal end to the distal end of the riser 62 in a single pass. In such a case, the apparatus 10 may stop making sufficient forward progress. At that time, an operator will detect that the apparatus 10 is not making forward progress because the drive supply line 44 is no longer being carried into the riser 62 by the apparatus 10. The operator can tug on the drive fluid supply line 44 and/or the tether 46 to change the layback direction of bristles 22, thereby changing the direction of travel of the apparatus 10. The operator may optionally discontinue drive fluid supply to the apparatus 10 prior to tugging on the drive fluid supply line 44 and/or the tether 46. When the apparatus 10 returns then to the proximal end of the riser 62, the operator can stop the apparatus 10 by discontinuing drive fluid supply to pull the brush member 12 out of the riser 62, or allow the apparatus 10 to travel until the brush member 12 exits the riser 62, which stops the apparatus 10 from being self-propelled. The operator then reinserts the apparatus 10 into the riser 62 to layback the bristles 22 at angle Θ and supplies drive fluid through drive fluid supply line 44 allow the apparatus 10 to self-propel through the riser 62 again.

The method of the present invention may be practiced onshore or offshore, at surface or in storage.

It should be understood that the invention is not to be unduly limited to the foregoing which has been set forth for illustrative purposes. Various modifications and alternatives will be apparent to those skilled in the art without departing from the true scope and spirit of the present invention. While there has been, illustrated and described, particular embodiments of the present invention, it will be appreciated that numerous changes and modifications will occur to those skilled in the art, and it is intended to cover those changes and modifications which fall within the true spirit and scope of the present invention.
WE CLAIM:

1. An apparatus for cleaning an inner surface of a riser, comprising:
   - a mandrel having a drive assembly disposed therein and adapted for connection to a drive fluid;
   - at least one brush member operably mounted on the mandrel, the at least one brush member having an outside diameter adapted to operate inside the riser with sufficient contact to clean the inner surface of the riser, the riser selected from the group consisting of marine risers and production risers, having inside diameters in a range from 16 inches (40 cm) to 20 inches (51 cm);
   - at least one centralizer mounted on the mandrel, the at least one centralizer having an outside diameter less than the outside diameter of the at least one brush member and less than the inside diameter of the riser;
   - at least two adjustable positioning members protruding from an outer circumference of the at least one centralizer, thereby producing an effective outside diameter for the centralizer that is substantially equal to the inside diameter of the riser, the at least two adjustable positioning members cooperating to each contact the inside surface of the riser, thereby positioning the mandrel substantially coaxial with a longitudinal axis of the riser; the at least two adjustable positioning members allowing for movement of the apparatus along the longitudinal axis of the riser.

2. An apparatus according to claim 1, further comprising at least one support rod mounted parallel to the mandrel and connecting the at least one brush member to the at least one centralizer.

3. An apparatus according to claim 1, wherein the at least one brush member comprises a brush wheel having bristles mounted on a circumference of the brush wheel.

4. An apparatus according to claim 3, wherein the bristles are formed of plastic, metal, or combinations thereof.

5. An apparatus according to claim 1, wherein the at least one brush member is comprised of a pair of mating wheel members and at least two flange members
having bristles on an outer circumference of the flange, the flange members adjustably secured in position to produce a desired outer diameter of the brush member.

6. An apparatus according to claim 1, wherein the outside diameter of the brush member is selected to produce an interference fit with the inner surface of the riser.

7. An apparatus according to claim 6, wherein the interference fit causes the bristles to bend to a layback angle in the range of from 5 degrees to 15 degrees.

8. An apparatus according to claim 6, wherein the interference fit causes the bristles to bend to a layback angle in the range of from 5 degrees to 12 degrees.

9. An apparatus according to claim 1, wherein at least two centralizers are mounted on the mandrel.

10. An apparatus according to claim 1, wherein at least three adjustable positioning members protrude from an outer circumference of the at least one centralizer.

11. An apparatus according to claim 1, wherein the adjustable positioning members are formed from a material allowing the adjustable positioning members to roll or slide along the inner surface of the riser.

12. An apparatus according to claim 11, wherein the material is selected from the group consisting of natural or synthetic rubber, vinyl, plastic, thermoplastic, soft metal, and combinations thereof.

13. A method for removing debris from the inner surface of a riser, comprising the steps of:

   providing an apparatus comprising:

   a mandrel having a drive assembly disposed therein and adapted for connection to a drive fluid;

   at least one brush member operably mounted on the mandrel, the at least one brush member having an outside diameter adapted to operate inside the
riser with sufficient contact to clean the inner surface of the riser, the riser
selected from the group consisting of marine risers and production risers,
having inside diameters in a range from 16 inches (40 cm) to 20 inches (51
cm);

5 at least one centralizer mounted on the mandrel, the at least one
centralizer having an outside diameter less than the outside diameter of the at
least one brush member and less than the inside diameter of the riser;
at least two adjustable positioning members protruding from an outer
circumference of the at least one centralizer;

10 adjusting a length of the at least two adjustable positioning members to produce
an effective outside diameter for the centralizer that is substantially equal to the
inside diameter of the riser, thereby positioning the mandrel substantially coaxial
with a longitudinal axis of the large diameter conduit; the at least two positioning
members allowing for movement of the apparatus along the longitudinal axis of
the large diameter conduit;

15 positioning the apparatus in the interior of the riser at a proximal end of the riser;
supplying drive fluid to the apparatus, thereby causing the at least one brush
member to oscillate and travel along the length of the riser to a distal end of the
riser; and

20 pulling the apparatus towards the proximal end of the riser.

14. A method according to claim 13, further comprising the step of allowing the at
least one brush member to exit the distal end of the riser before pulling the
apparatus towards the front end of the riser.

25 15. A method according to claim 13, wherein the at least one brush member
comprises a brush wheel having bristles mounted on a circumference of the brush
wheel.

30 16. A method according to claim 15, wherein the bristles are formed of plastic, metal,
or combinations thereof.

17. A method according to claim 15, wherein, in the positioning step, contact
between the inner surface of the riser causes the bristles to lay back from the

15
desired direction of travel, thereby propelling the apparatus in the desired
direction of travel.

18. A method according to claim 17, wherein the bristles lay back at an angle in a
range from 5 degrees to 15 degrees.

19. A method according to claim 17, wherein the bristles lay back at an angle in a
range from 8 degrees to 12 degrees.

20. A method according to claim 13, wherein at least two centralizers are mounted on
the mandrel.

21. A method according to claim 13, wherein the brush member contacts the inner
surface of the riser with an action selected from the group consisting of vibration,
oscillation, partial rotation, continuous rotation, and combinations thereof.

22. A method according to claim 13, wherein the drive fluid is compressed air.

23. A method according to claim 22, wherein the compressed air is supplied at a
pressure in the range of 100 to 120 psig (689 kPa(g) to 827 kPa(g)).
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

INV. B08B9/049 E21B37/04 F16L55/32 F16L55/40 F16L55/44
ADD. B08B9/055 F16L101/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B08B E21B A46B F16A F16L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>CN 201 529 644 U (MINGYANG GAO) 21 July 2010 (2010-07-21) abstract; figures</td>
<td>1-16, 20-23</td>
</tr>
<tr>
<td>X</td>
<td>US 2012/215348 AI (SKRINDE RICHARD ARTHUR [US]) 23 August 2012 (2012-08-23) abstract; figures</td>
<td>1-12</td>
</tr>
</tbody>
</table>

Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents:
  - "A" document defining the general state of the art which is not considered to be of particular relevance
  - "E" earlier application or patent but published on or after the international filing date
  - "L" document which may throw doubts on priority claim(s) on which the search is based
  - "O" document referring to an oral disclosure, use, exhibition or other means
  - "P" document published prior to the international filing date but later than the priority date claimed

*"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

*X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"A" document member of the same patent family

Date of the actual completion of the international search: 25 January 2017
Date of mailing of the international search report: 02/02/2017

Name and mailing address of the ISA:
European Patent Office, P.B. 5018 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Fax. (+31-70) 340-3016

Authorized officer: Kosički, Tobi

Form PCT/ISA/210 (second sheet) (April 2005)
<table>
<thead>
<tr>
<th>Patent document cited in search report</th>
<th>Publication date</th>
<th>Patent family member(s)</th>
<th>Publication date</th>
</tr>
</thead>
<tbody>
<tr>
<td>CN 201529644 U</td>
<td>21-07-2010</td>
<td>NONE</td>
<td></td>
</tr>
<tr>
<td>US 2012215348 Al</td>
<td>23-08-2012</td>
<td>US 2012215348 Al</td>
<td>23-08-2012</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 2014350722 Al</td>
<td>27-11-2014</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 2016082589 Al</td>
<td>24-03-2016</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wo 2012112835 Al</td>
<td>23-08-2012</td>
</tr>
<tr>
<td>US 7676878 B2</td>
<td>16-03-2010</td>
<td>US 2006218735 Al</td>
<td>05-10-2006</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 2010122425 Al</td>
<td>20-05-2010</td>
</tr>
</tbody>
</table>