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(54) Apparatus for treating an underwater surface

(57) Apparatus (1) for treating an underwater surface (2) comprises a wheeled chassis (3) manoeuvrable over the surface (2), at least one rotatable surface treating brush or pad (8), a motor (9) for rotating the brush or pad (8) and a control system (13—19) for moving the or each brush or pad between a first position in which it is rotatable against the surface to be treated and a second position in which it is spaced from the surface to be treated, the arrangement being such that in either position the or each rotating brush or pad generates sufficient suction to hold the apparatus against the surface being treated.

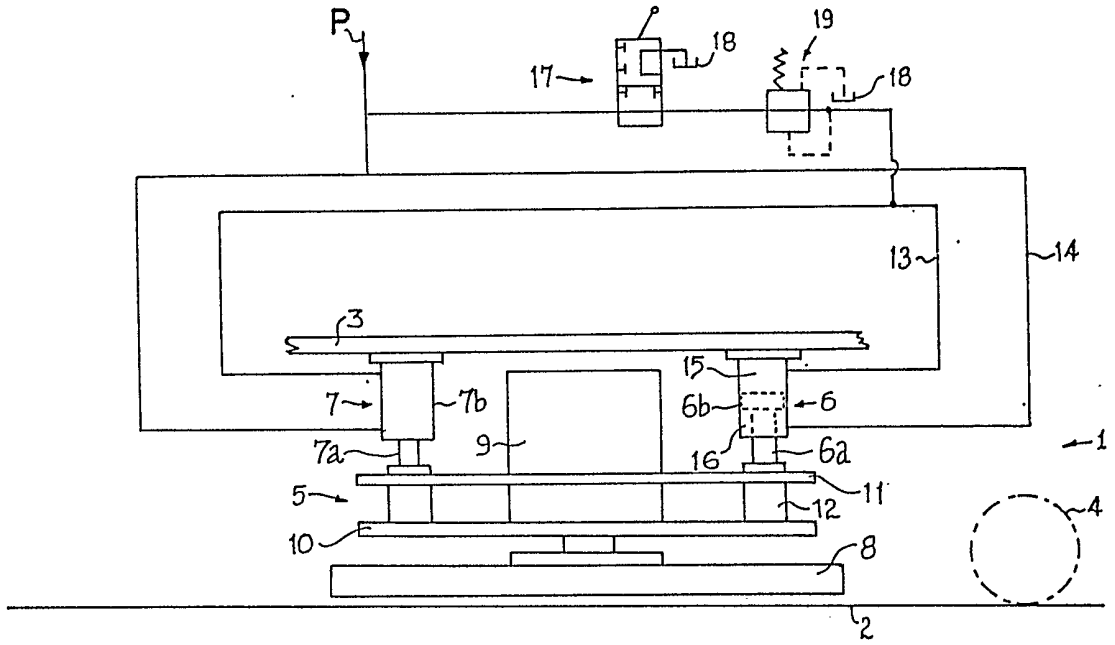

FIG. 1

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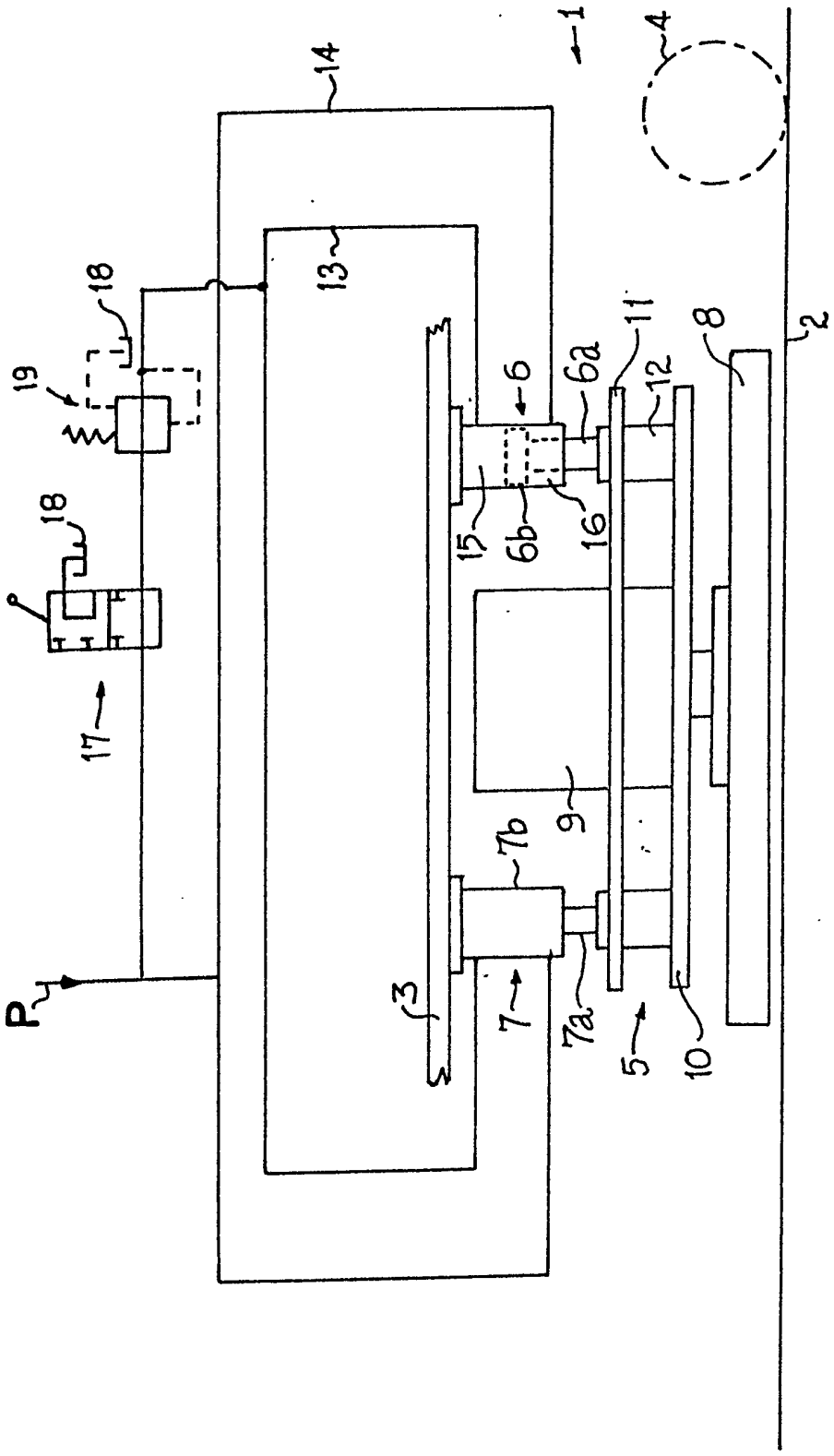

FIG. 1

FIG. 2

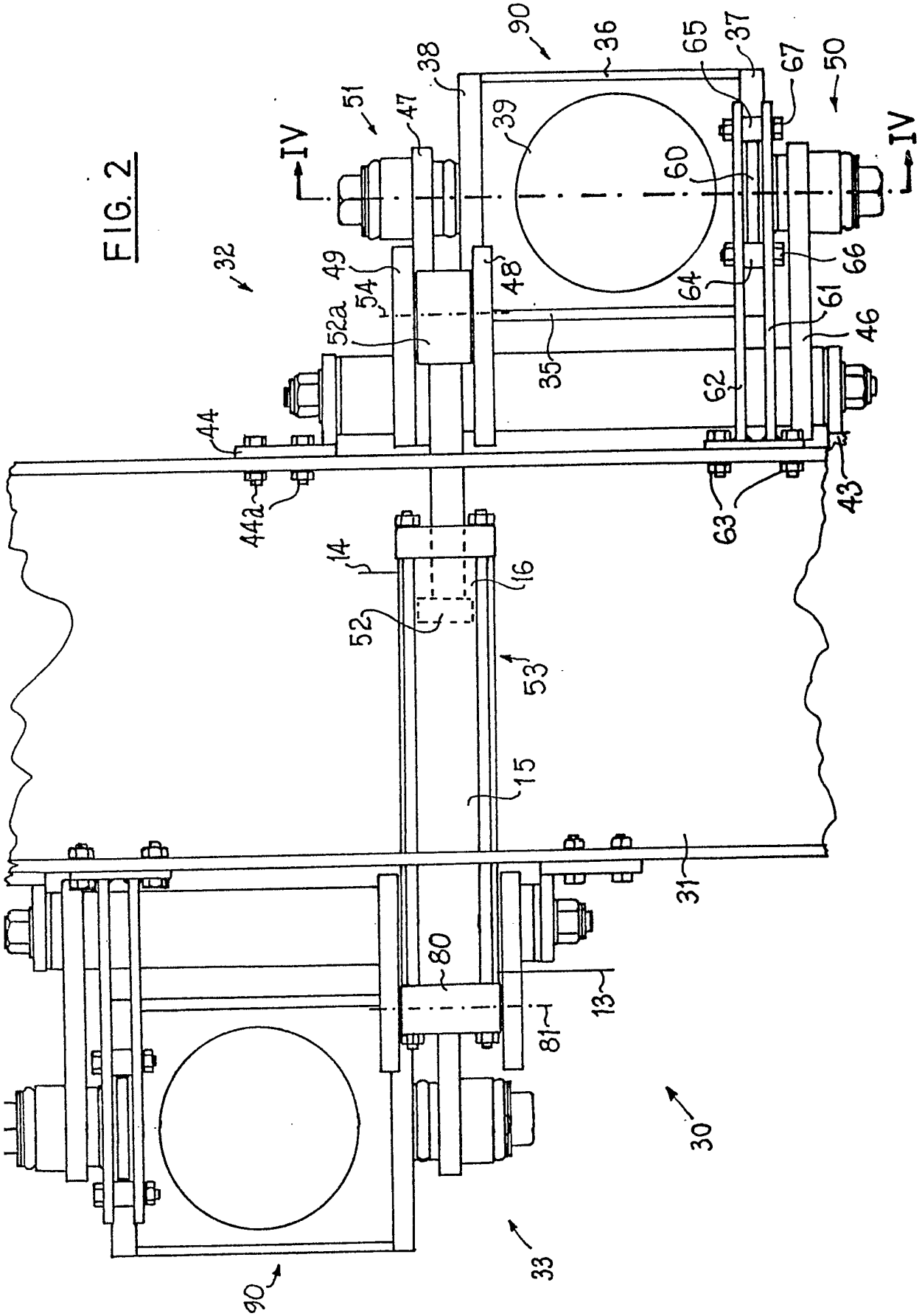
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FIG. 3

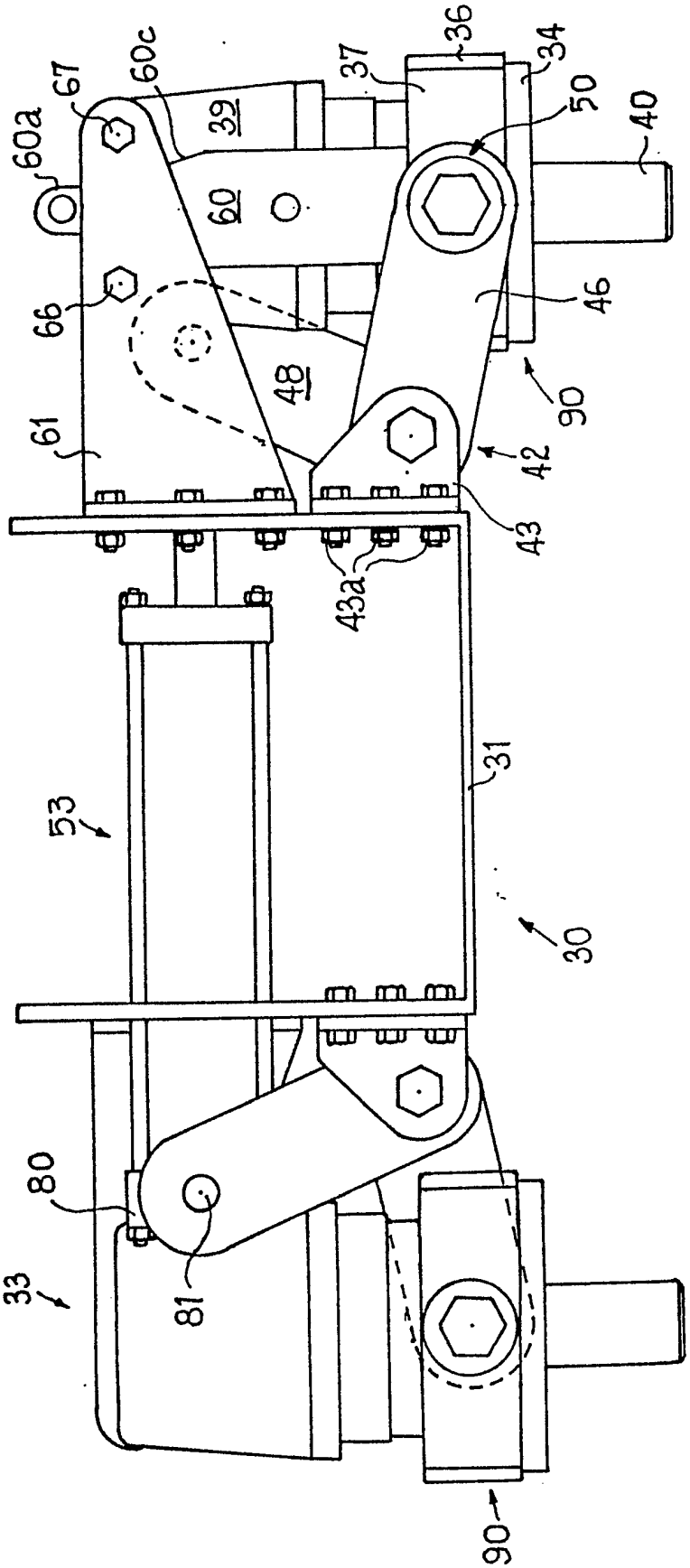
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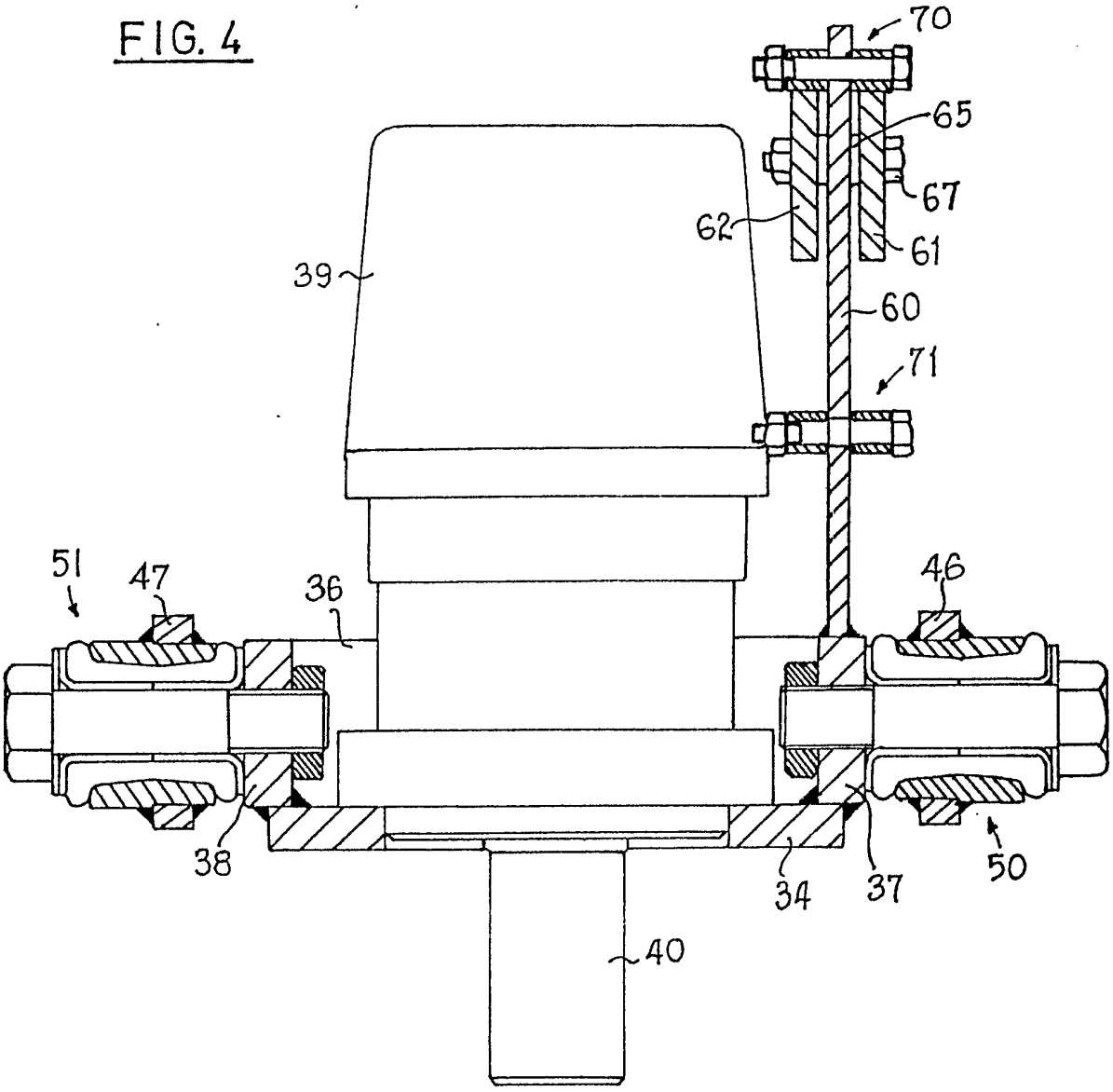
FIG. 4



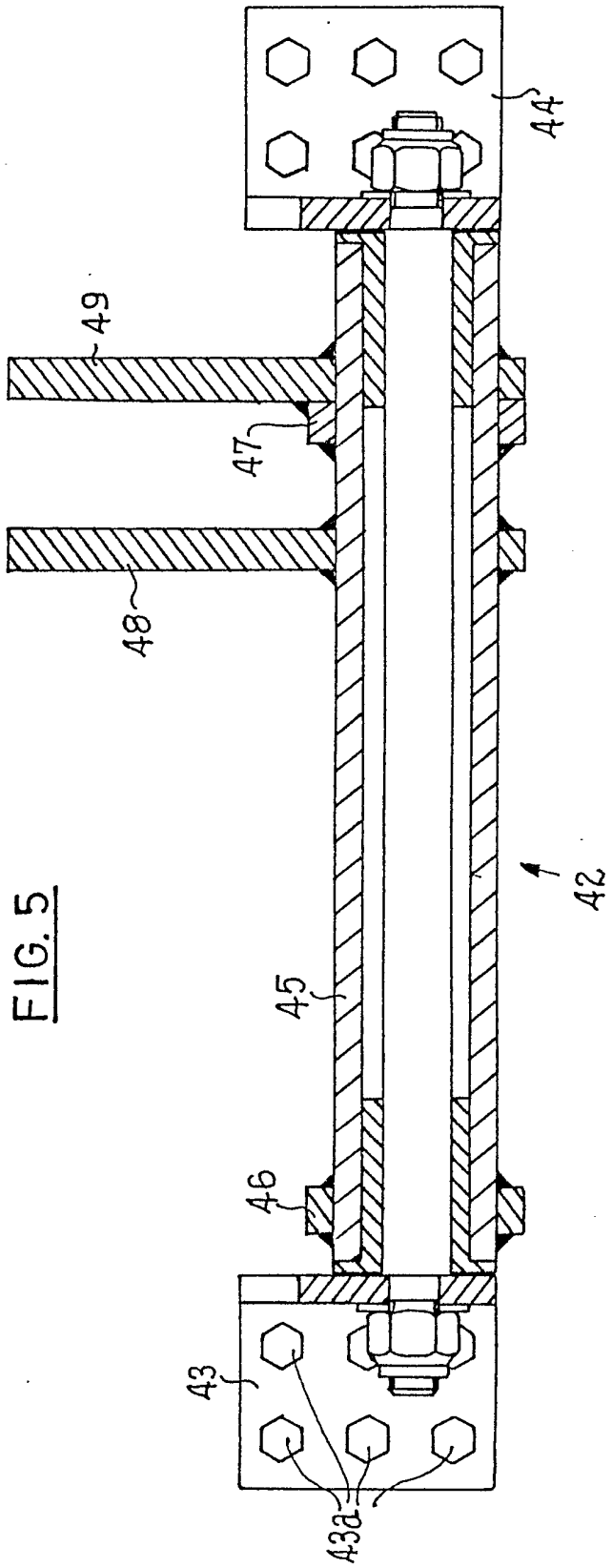


FIG. 5

SPECIFICATION

Apparatus for treating an underwater surface

This invention relates to an apparatus for treating an underwater surface, e.g. a hull or a propeller of a ship or a submerged surface of an oil rig.

A known apparatus for treating an underwater surface is provided with rotatable brushes which in use are rotated against the underwater surface to be treated. The rotating brushes have a twofold purpose. Firstly they treat, e.g. clean, the underwater surface and secondly they generate suction forces which serve to hold the apparatus against the underwater surface.

Up until now it has been considered essential for the rotating brushes of such known apparatus to be in contact at all times with the underwater surface being treated in order for the suction forces generated to hold the apparatus against the underwater surface. However, this leads to problems when the apparatus is in a stationary position on the surface being treated. The problems arise because the continuously rotating brushes operate on the same localised areas of the underwater surface for the entire period that the apparatus remains in the stationery position possibly resulting in damage to these localised areas. This damage is particularly apparent in the treatment of an underwater surface, e.g. a ship's hull, having a coating of comparatively thick anti-fouling marine paint. Such marine paint is relatively soft and can be severely worn away by cleaning brushes rubbing against it for a length of time.

An aim of the present invention is to reduce or eliminate the above-identified problems associated with known apparatus for treating underwater surfaces.

According to the present invention an apparatus for treating an underwater surface comprises a wheeled chassis manoeuvrable over the underwater surface to be treated, at least one rotatable surface treating member, drive means for rotating said surface treating member(s), and control means for moving the or each treating member between a first position in which it is rotatable against an underwater surface to be treated and a second position in which it is spaced from an underwater surface to be treated, the treating member(s) when rotated in either of the first or second positions being arranged to generate sufficient suction, in use of the apparatus, to hold the apparatus against an underwater surface to be treated.

Suitably said drive means comprises a separate drive motor for driving the or each treating member, the or each drive motor being mounted on a separate support unit which is mounted for movement relative to the chassis. For example the or each support unit may be mounted on the chassis by means of at least one double acting ram actuable under the control of said control means. Typically a single double-acting ram, e.g. an hydraulic ram, is provided for moving two support units relative to the chassis between first limit positions in which the treating members are each in said first position and second limit positions in which the treating members are each in said second positions. Conveniently in this latter case each support unit is connected to a separate pivoting unit pivotable by the double-acting ram.

The control means suitably comprises valve means, operable by an operator, e.g. a diver, operating the apparatus to control the supply of working fluid (air or hydraulic fluid) to, and the withdrawal of working fluid from, the (or each) double-acting ram to position the or each support unit in either of its two limit positions. Typically the valve means is operable, in use of the apparatus, to counteract the suction force generated by the treating member(s) thereby to control the force with which the or each treating member is applied against the underwater surface to be treated.

The or each surface treating member is preferably in the form of a pad or a brush. Typically each treating member has an annular treating surface.

Embodiments of the invention will now be described by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic view of part of one embodiment of an apparatus according to the invention for treating an underwater surface,

Figure 2 is a plan of part of another apparatus according to the invention for treating an underwater surface,

Figure 3 is an end view of part of the apparatus shown in Figure 2,

Figure 4 is a sectional view taken on the line IV—IV of Figure 2, and

Figure 5 is a sectional view of a pivot assembly of the apparatus shown in Figures 2 to 4.

In Figure 1 the reference numeral 1 designates one embodiment of apparatus for treating, e.g. cleaning, an underwater surface 2. The apparatus 1 includes a chassis (a part 3 of which is shown in the figure) carrying surface contacting wheels 4 (one of which is shown in chain lines in the figure), at least one surface treating assembly generally designated by the reference numeral 5 and four double-acting hydraulic rams 6, 7 mounting the or each surface treating assembly 5 on the chassis part 3.

The surface treating assembly 5 comprises a treating member 8, typically in the form of an annular finishing or cleaning pad or brush, a hydraulic motor 9 carried on a mounting plate 10 and a pressure adjusting plate 11 connected to the plate 10 via resilient or flexible mounting means 12. The mounting means 12 provide the mounting plate 10, and the treating member 8 carried thereby, a degree of universal movement relative to the plate 11.

Each double-acting ram 6 (7) comprises a cylinder 6*b* (7*b*) fixed to the chassis part 3 and a piston 6*a* (7*a*) fixed to the pressure adjusting plate 11. Hydraulic lines 13 and 14 are connected to opposite ends of each cylinder 6*b* (7*b*) to communicate, respectively, with chambers 15 and 16 (only shown for ram 6 in the figure) on opposite sides of each piston 6*a* (7*a*). A constant source of high pressure P is led via hydraulic line 14 to the chamber 16 of each cylinder 6*b* (7*b*). A two position valve 17 is operable between a shut position, in which the pressure in

line 13 is connected to the reservoir 18, and an open position, in which the source of high pressure P is connected, via a variable pressure reducing valve 19 and hydraulic line 13, to the chamber 15 of each cylinder 6*b* (7*b*) thereby to enable application of variable pressure in the chambers 15. The valves 17 and 19 are suitably positioned on the apparatus 1 to be easily manually operable by an operator e.g. a diver.

In use of the apparatus 1, with valve 17 shut and hydraulic line 13 and hence chambers 15 exhausted to the reservoir 18, the constant pressure P in each chamber 16 will move the pistons 6*b* (7*b*) into their uppermost positions, thus raising (as viewed in the figure) the surface treating assembly 5. When the treating assembly 5 is so positioned the treating member 8 is spaced from the surface 2 to be treated although its rotation generates sufficient suction to hold the apparatus 1 in position on the surface 2. With the surface treating assembly in its uppermost position, the apparatus 1 may be driven over the surface 2 or halted in a stationary position by operation of a drive motor (not shown) providing drive to at least one of the wheels 4 of the apparatus.

When it is desired to treat the surface 2, the drive motor for providing the drive to one or more of the wheels 4 if not already in operation, is operated. The valve 17 is then operated to allow pressure P to pass to the variable pressure reducing valve 19 and each chamber 15 is subjected to a pressure P1 which can be varied manually, by adjusting valve 19, by a diver when using the apparatus. When P1 is increased so that force on top of each piston 6*a* (7*a*) starts to exceed the force on the underside of each piston 6*a* (7*a*), the pistons will move downwards lowering (as viewed in the figure) the surface treating assembly 5 until the surface treating member 8 is brought into contact with surface 2. By adjusting valve 19 to adjust pressure P1 in each chamber 15 the force of application of the rotating treating member 8 against the underwater surface 2 to be treated can be controlled.

If it is subsequently desired to halt the progress of the apparatus in its movement over the surface 2, the valve 17 is shut causing pressure in hydraulic line 13 and chamber 15 to be exhausted to the reservoir 18. Pressure P on the underside of each piston 6*a* (7*a*) will then raise the piston and assembly 5 into its uppermost position with the rotating treating member 8 clear of the surface 2 and the drive to one or more of the wheels 4 can be interrupted. In another embodiment (not shown) of the apparatus the action of valve 17 can be made to operate the drive to one or more of the wheels 4 so that the treating member 8 is automatically lifted clear of the surface 2 when the vehicle stops.

Only one surface treating assembly 5 has been described for the apparatus 1. However, it should be realised that apparatus having more than one assembly 5 may be provided. In this case the assemblies 5 are preferably mounted on separate mounting plates 8 although it is possible to mount them on a common mounting plate. It is also possible to dispense with the motor mounting plate 10 by mounting the motor on the plate 11. In this case the flexible mounting 12 would be provided between the treating member 8 and a backing plate therefor.

Another embodiment of apparatus, according to the invention for treating, e.g. cleaning, an underwater surface is generally designated by the reference numeral 30 in Figures 2—5.

The apparatus 30 comprises a main channel section chassis 31 carrying surface contacting wheels (not shown) and two surface treating assemblies, generally designated 32 and 33. The treating assembly 32 comprises a motor support unit, generally designated 90, comprising a support plate 34 having welded thereto spaced apart side walls 35 and 36 and spaced apart end walls 37 and 38. An hydraulic motor 39 is mounted on the plate 34 although fixing means for mounting the motor on the plate and hydraulic lines for operating the motor are not shown in detail. The motor 39 is provided with a driven shaft 40 on which is detachably mounted a treating member (not shown). e.g. an annular pad or brush.

The motor support unit 90 is mounted on the chassis by means of a pivot assembly (see Figure 5) generally designated 42. The pivot assembly 42 comprises a pair of brackets 43, 44 bolted to the chassis by means of bolts 43*a* and 43*b* and a cylindrical member 45 turnably mounted in bushes carried by the brackets 43, 44. The cylindrical member 45 has fixed, e.g. welded, rigidly thereto a first pair of axially spaced apart arms 46 and 47 and, angularly spaced therefrom, a second pair of axially spaced apart arms 48 and 49. The pivot assembly 42 is thus like a bell crank device with the arms 46, 47 fixed relative to arms 48, 49 and both sets of arms being pivotable about the longitudinal axis of the cylindrical member 45. The ends of the arms 46 and 47 remote from the cylindrical member 45 are pivotally mounted, via bushes 50 and 51, to the walls 37 and 38, respectively. The ends of the arms 48 and 49 remote from the cylindrical member 45 carry a pivot pin (not shown) for pivotally mounting therebetween an end 52*a* of a piston 52 of a double-acting hydraulic ram 53 for enabling pivoting of the arms 48 and 49 relative to the piston 52 about an axis 54 (shown in chain lines in Figure 2).

The treating assembly 32 further includes a positioning assembly comprising a guide plate 60 welded to the end wall 37, a pair of spaced apart side plates 61 and 62 bolted to the chassis 31 by means of bolts 63 and spaced apart guide rolls 64 and 65 mounted between the side plates 61 and 62 on the shanks of bolts 66 and 67, respectively. The guide plate 60 is positioned so as to be movable between the side plates 61 and 62 and between the guide rolls 64 and 65. In this respect it is to be noted that the upper part 60*a* (as viewed in Figure 3) of the plate 60 is narrower than the lower part 60*b* of the plate and that the upper and lower parts of the plate 60 are connected by sloping sides 60*c*. The width of the lower part 60*b* is slightly less than the spacing apart of the guide rolls 64 and 65. First and second stops, generally designated 70 and 71, are mounted, e.g. bolted, at spaced apart locations on the guide plate 60 above and below (as viewed in Figure 4) the

side plates 61 and 62 and serve to limit the downward and upward movement, respectively, of the motor support unit 90 relative to the chassis 31.

The treating assembly 33 is substantially similar to the treating assembly 32 and, where appropriate, the same reference numerals have been used to identify similar parts in the two assemblies. The only significant difference between the two assemblies is that in assembly 33, the two arms 48 and 49 are spaced slightly further apart to enable pivotal connection of the wider cylinder end 80 of the ram 53 therebetween about pivot axis 81.

Substantially the same hydraulic system as that employed in apparatus 1 is employed in the apparatus 30 and the reference numerals 13—19 are used in the ensuing description to identify correspondingly similar parts. The main difference in the two assemblies is that in apparatus 30 only a single hydraulic ram 53 is employed and thus only a single hydraulic line 13 and a single hydraulic line 14 are employed. Furthermore, there is only a single chamber 15 and a single chamber 16 for the ram 53.

In use of the apparatus 30, with valve 17 shut and hydraulic line 13 and hence chamber 15 exhausted to the reservoir 18, the constant pressure P in chamber 16 moves the piston 52 towards the left (as viewed in Figure 2). The pivotal connection of the piston end 52*a* to the arms 48 and 49 causes pivot assembly 42 to pivot about the axis of the cylindrical member 45 in a counterclockwise direction (as viewed in Figure 3). The pivotal movement of the assembly 42 causes the arms 46 and 47 to pivot and move the motor support unit 90 upwardly (as viewed in Figure 3). The upward movement of the support unit 90 is guided by the guide plate 60 during its travel between the guide rolls 64 and 65 and is stopped when the second stop 71 abuts against the lower surfaces of the side plates 61 and 62. In this upper limit position of the motor support unit 90, there is only a small clearance between the sides of the lower part 60*b* of the guide plate 60 and the spaced apart guide rolls 64 and 65. This therefore serves to minimise the amount of shake or judder created in use of the apparatus 30 by a rotating treating member when it is lifted away from a surface being treated.

The movement of the piston 52 to the left (as viewed in Figure 2) also causes the cylinder end 80 of the ram 53 to move to the right (i.e. the axes 54 and 81 are moved towards each other) and, in a similar manner to that described with reference to surface treating assembly 32, the motor support unit 90 of the surface treating assembly 33 is moved away from the surface being treated. With both treating members (not shown) in limit positions spaced from the surface being treated, their rotation is sufficient to generate enough suction to hold the apparatus 30 in position on the surface being treated. With the treating members in their raised positions it is possible to drive the apparatus over the surface to be treated or to halt it in a stationary position.

When it is desired to treat the surface, the drive motor for providing the drive to one or more of the wheels if not already in operation, is operated. The valve 17 is then operated to allow pressure P to pass to the variable pressure reducing valve 19 and the chamber 15 is subjected to a pressure P1 which can be varied manually, by adjusting valve 19, by a diver when using the apparatus. When P1 is increased so that force to the left (as viewed in Figure 2) of the piston 52 starts to exceed the force to the right of the piston 52, the piston will move to the right causing the piston end 52*a* to move to the right and the cylinder end 80 to move to the left (i.e. the pivot axes 54 and 81 are moved away from each other). These movements cause the motor support units 90 to move downwards (as viewed in Figure 3) until the surface treating members are brought into contact with the surface to be treated. This downward movement is controlled by the guide plate 60 and is limited by the first stops 70 contacting the upper surfaces of the side plates 61 and 62 to provide lower limit positions for the treating members. By adjusting valve 19 to adjust pressure P1 in the chamber 15, the force of application of the rotating treating members against the underwater surface to be treated can be adjustably controlled under the control of the diver operating the apparatus.

If it is subsequently desired to halt the progress of the apparatus 30 in its movement over the surface being treated, the valve 17 is shut causing pressure in hydraulic line 13 and chamber 15 to be exhausted to the reservoir 18. Pressure P in chamber 16 will then move the piston 52 to the left and the motor support units 90 into their uppermost limit positions with the rotating treating members clear of the surface being treated. The drive to one or more of the wheels can then be interrupted. As with apparatus 1, the action of valve 17 can be made to operate the drive to one or more of the wheels so that the treating members are automatically lifted clear of the surface being treated when the vehicle stops.

It will be appreciated that in other embodiments of the invention it is possible to use one or more pneumatically actuated rams in place of the hydraulic ram or rams. Furthermore different valving systems may be employed for controlling the application of the treating members against an underwater surface to be treated.

In each of the apparatuses 1 and 30 specifically described above, the surface treating members are movable between two limit positions. In one of the limit positions the surface treating members are positioned so as to contact the surface to be treated and in the other of the limit positions the surface treating members are positioned so as to be just spaced from the surface to be treated. In use of either apparatus, suction generated by the surface treating members when in either of their limit positions, is sufficient to hold the apparatus against the surface to be treated.

An apparatus according to the invention is suitably designed to have a neutral or slightly positive buoyancy (i.e. so as just to float) in sea water. In use, on rotation of the or each surface treating member, a suction force of up to 2000 kg weight, typically 1000 kg weight, is generated by the rotating treating member(s) when either rotating

against or clear of the surface being treated. This force is sufficient to hold the apparatus firmly against the surface to be treated. Conveniently the rotational speed of the treating member(s) will slightly increase when lifted just off the surface being treated. This increase in speed will at least partly off-set any reduction in the suction force occasioned by the treating member(s) being slightly spaced from the surface being treated.

By way of example only, the apparatus 30 is typically provided with a single steerable front wheel and a pair of rear wheels. Each treating member suitably has a diameter of approximately 25 cm and the motor support units 90 are movable approximately 3.5 cm between their two limit positions.

CLAIMS

1. An apparatus for treating an underwater surface comprising a wheeled chassis manoevrable over the underwater surface to be treated, at least one rotatable surface treating member, drive means for rotating said surface treating member(s), and control means for moving the or each treating member between a first position in which it is rotatable against an underwater surface to be treated and a second position in which it is spaced from an underwater surface to be treated, the treating member(s) when rotated in either of the first or second positions being arranged to generate sufficient suction, in use of the apparatus, to hold the apparatus against an underwater surface to be treated.

2. An apparatus according to Claim 1, in which the drive means comprises a separate motor for driving the or each surface treating member, the or each motor being mounted on a separate motor support unit.

3. An apparatus according to Claim 2, in which the or each motor support unit is movable between a first limit position, in which the or each surface treating member is in the said first position, and a second limit position, in which the or each surface treating member is in the said second position, by means of double-acting ram means actuable under the control of said control means.

4. An apparatus according to Claim 3, in which the or each motor support unit is mounted on the chassis by means of a separate pivoting unit, the ram means acting on the pivoting unit to control pivotal movement of the latter for moving the or each motor support unit between said first and second limit positions.

5. An apparatus according to Claim 4, in which the or each pivoting unit comprises bell crank means having cylinder means, bearing means fixed to the chassis and supporting the cylinder means to enable pivotal movement of the latter about its longitudinal axis, first arm means rigidly fixed to the cylinder means and pivotally connected to the ram means and second arm means angularly spaced from the first arm means, rigidly fixed to the cylinder means and pivotally connected to the, or the associated, motor support unit.

6. An apparatus according to any of claims 3 to 5, in which there are provided two motor support units, each carrying a separate surface treating member, and a single double-acting ram constituting the ram means controlling the positions of said two motor support units.

7. An apparatus according to Claim 6 when dependent upon claim 5, in which the said double-acting ram comprises a cylinder part pivotally connected to said second arm means of one of the said bell crank means and a piston part pivotally connected to said second arm means of the other of the said bell crank means.

8. An apparatus according to any of claims 3 to 7, comprising guide means for guiding the or each motor support unit during movement between said first and second limit portions.

9. An apparatus according to Claim 2, in which the or each said support unit is mounted on the chassis by means of double-acting ram means actuable under the control of said control means.

10. An apparatus according to any of claims 3 to 9, in which the control means comprises valve means operable by an operator operating the apparatus to control the supply of working fluid to, and withdrawal of working fluid from, the double-acting ram means to position the or each motor support unit in either of said first and second limit positions.

11. An apparatus according to Claim 10, in which the valve means includes an adjustable valve operable, in use of the apparatus, to adjust the pressure of working fluid in the ram means for counteracting the suction force generated by the or each treating member when in its first position thereby to control the force with which the or each treating member is applied against the underwater surface to be treated.

12. An apparatus according to any of the preceding claims, in which or each treating member comprises a pad or brush.

13. An apparatus according to any of the preceding claims, in which the treating member is, or treating members are, designed to generate, in use, a suction force of up to 2000 kg weight to hold the apparatus against an underwater surface to be treated.

14. An apparatus according to any of the preceding claims; having a neutral or slightly positive buoyancy in sea water.

15. An apparatus for treating an underwater surface, the apparatus being constructed and arranged substantially as herein described with reference to, and as illustrated in, Figure 1 or Figures 2 to 5.

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