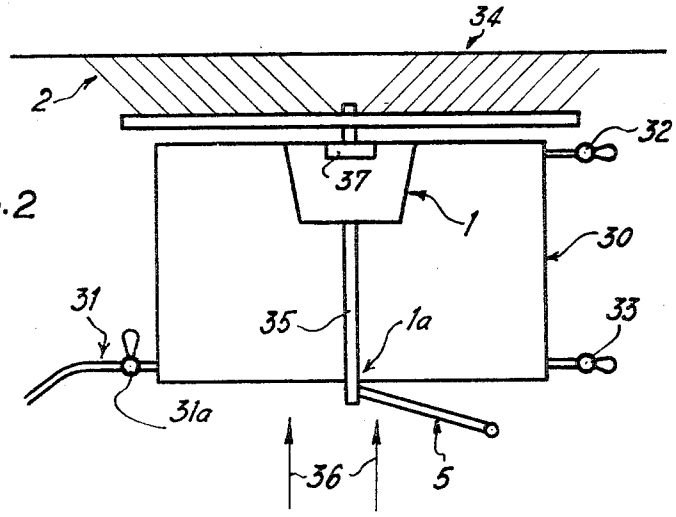
Feb. 14, 1967 J. C. SIERRA ET AL 3,303,812

UNDERWATER MECHANICAL BRUSH

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Fig.2



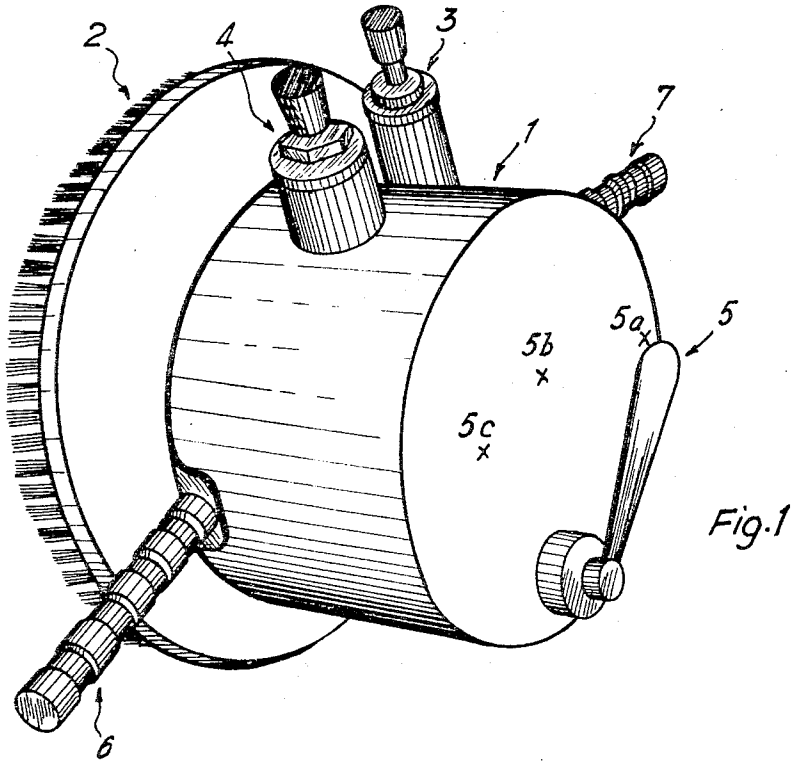


Fig.1

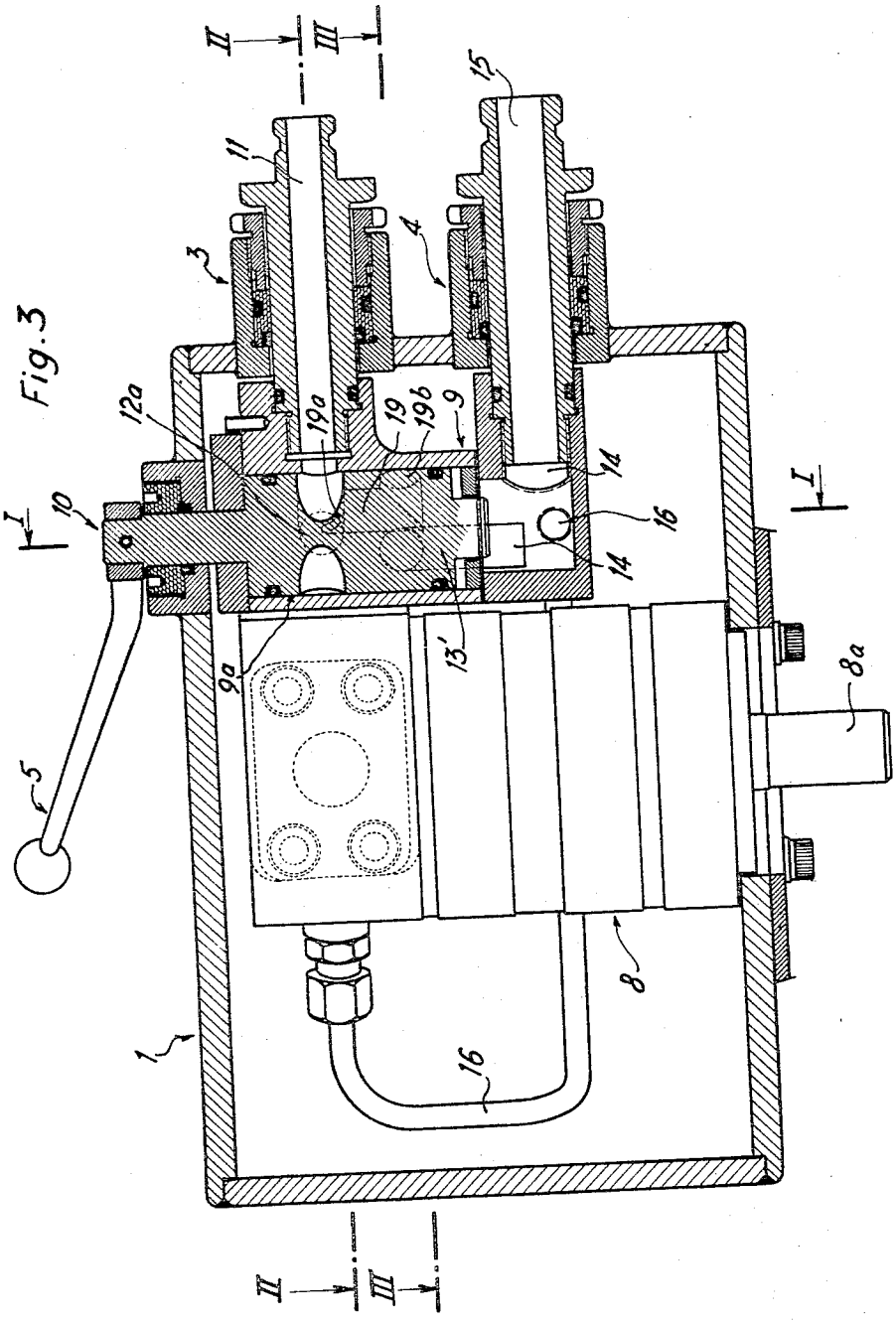
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UNDERWATER MECHANICAL BRUSH

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Fig. 3

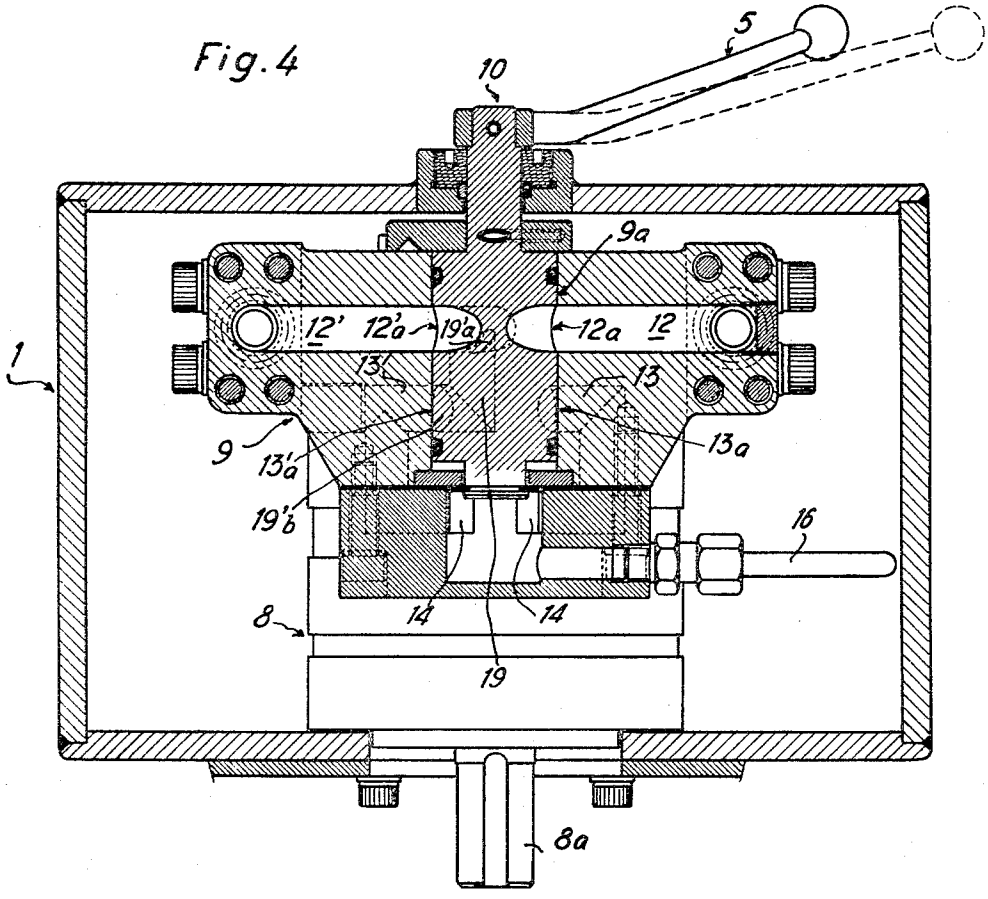


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UNDERWATER MECHANICAL BRUSH

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Fig. 4



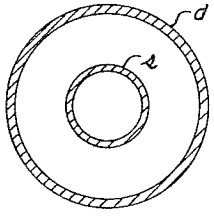


Fig. 9

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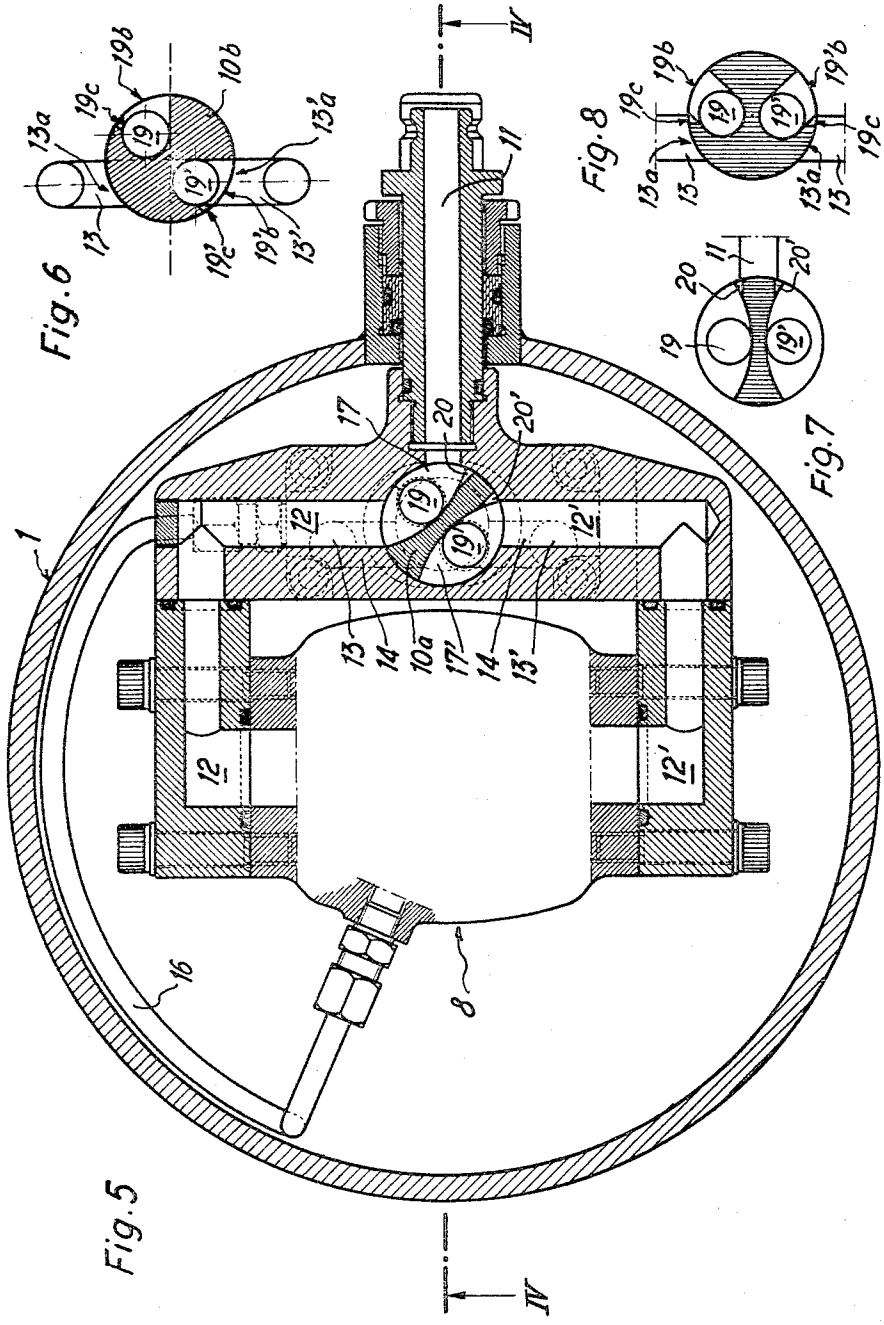


Fig. 5

Fig. 6

Fig. 7

Fig. 8

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UNDERWATER MECHANICAL BRUSH

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Filed Apr. 13, 1965, Ser. No. 447,728

Claims priority, application France, Apr. 13, 1964, 20,545; Feb. 11, 1965, 5,184

11 Claims. (Cl. 114—222)

This application is a continuation-in-part of U.S. Patent application Serial No. 389,262, filed August 13, 1964, and now abandoned.

This invention relates to an underwater mechanical brush for use inter alia for brushing away, below the level of sea or river water, dirt sticking to the underwater part of the hull of a ship or in general sticking to the surface of an immersed structure.

The invention, of use more particularly for cleaning and rubbing down ships' bottoms, will be described with reference to this use which is of course merely a preferred use and does not exclude other uses of the invention.

Conventional underwater brushes are at best pneumatically driven brushes which, although better than mere manual brushing, have many disadvantages, inter alia because they can rotate only in one direction and speed is varied by variation of the volume of driving air. The reason for this is that an underwater mechanical brush which must be carried under the water by a diver in relatively difficult working conditions cannot exceed a predetermined size, and the restricted size makes it impracticable to provide the brush with a compressed-air motor adapted to rotate selectively in either direction a shaft, fitted with a brush element either because the motor itself would be too bulky or because, since the reversal of rotation would be produced by reversal of gears in a reduction system, the diver would have to come to the surface to reverse the drive. On the other hand, rotation of the brush develops centrifugal forces sufficient to move the device lengthwise along the bottom of the ship, and the brush operator, who is less affected by gravity than in the air and who can move very easily, merely has to let himself be pulled along by the device. Clearly, therefore, a diver having a brush rotatable only in one direction can be moved along the ship's bottom only in one direction and must return "under his own power" to his starting place when he has finished a first working "pass"; he cannot use the brushing device during his return since such use would tend to move him in the opposite direction, or he would have to press the tool very strongly to get a brushing effect.

It is almost essential to use a pneumatic brush to ensure the variations in the speed of brush rotation which must be available to ensure satisfactory working conditions in view of the nature and state of the actual brush element and of the proliferation and adherence of soil to the structure to be cleaned, speed variations being produced by varying the volume of air, but such variation would in the case of a reduction decrease the driving torque and make the tool unusable. Since a pneumatic brushing device has such a low driving torque, it is in practice impossible to use large-diameter disc-shaped brush elements, for a large-diameter brush element would require the presence of a speed reducer between the motor and the brush element, with the result that the centre of gravity of the device would be raised and impair stability and weight would increase. The raising of the centre of gravity of the device relatively to the brush element would unbalance the same when it encountered an unevenness and would start an oscillating movement which would cease only when the motor stopped. Another disadvantage of pneumatic brushes is that they require powerful and therefore costly compressors, and only the relatively small figure of 10 or 12% of compressor power can actually be used. A compressed air turbine motor loses power very rapidly because of wear of the vanes and stator, and the resulting air leak is so much power lost.

The present invention aims to obviate these disadvantages of pneumatic brushes and to provide a novel kind of mechanical brush.

It is an object of the invention to provide a mechanical brush which is of reduced size and which can rotate in both directions.

It is a further object of the invention to provide a mechanical brush which has a high driving torque and whose speed can be varied without any great reduction thereof, so that speed can be varied and large-diameter disc-shaped brush elements, for instance, of 400 mm. diameter as compared with the conventional 200 mm. diameter, can be used with a consequent improvement in efficiency and, by the centre of gravity being lowered, with less risk of pendulous or oscillatory movement.

The brushing device according to the invention characteristically has a driving motor adapted to rotate in either direction and operated by a driving liquid. According to the invention, the driving liquid is preferably a liquid whose density is less than the density of water—e.g. a low-density oil—which flows in a closed circuit between a pumping station and the brushing device and which is preferably supplied thereto through a supply line disposed in a larger-diameter duct via which the liquid returns to the pumping station. The return duct may have a diameter large enough for the liquid which it contains to be present in sufficient quantity to lighten the duct and, by reducing its density to below the density of water, to make the duct buoyant. Another advantage of this feature is that the liquid flowing through the large-diameter duct is slowed down and cooled by transfer of heat from the duct to the water. As an example, the feed duct can be about 10 mm. in diameter and be disposed in a return duct of about 30 mm. in diameter and 50 metres long. In this event, assuming a drive liquid reaching a pressure of some 100 kg./cm.^{2}, the expansion produced for a given rate of flow has the effect of reducing the flow pressure of the returning liquid to about 2 kg./cm.^{2}. The closed circuit supply feature means that the same power is provided and maintained, however deeply the device may be immersed.

The high flow pressure of the liquid in the supply duct might cause considerable and dangerous water-hammer effects upon abrupt cessation of the flow due to closure of the valve controlling distribution of the liquid in the brushing device. The brushing device may therefore be provided with a valve such that the liquid is not stopped thereby when the valve is operated to stop the motor but by-passes the motor to return to the return duct.

According to another feature of the invention, the disc-shaped brush element can be directly fitted to the end of the shaft of the hydraulic motor, thus ensuring a very stable mounting, and an anti-friction thrust block can be disposed below the shaft to prevent axial thrusts from being transmitted to the gearing. According to another feature of the invention, the brush motor is disposed in a hermetic protective casing containing air in a volume so calculated in dependence upon the mass of the brushing device that the weight of the complete device when immersed in the water is, due to buoyancy, such that it can be readily handled by a driver. Advantageously, moreover, the device can have at least one float with provision for ballasting. If required, the float can be adapted to receive the motor of the device or the motor casing. The float may take the form of an extra hermetic covering around the motor or the motor casing, the covering hav-

ing ballast valves and a controlled inlet for a pressure fluid, such as compressed air. Advantageously, therefore, water can be introduced into the float in a quantity sufficient to give the device the required characteristics of negative or positive buoyancy for dealing with vertical or inclined or horizontal surfaces; for instance, the water thus introduced can be expelled and replaced by air to give the device positive buoyancy.

This positive buoyancy is used to deal with the horizontal or substantially horizontal surfaces of the hull of a ship, since such surfaces are, as a rule, uneven and acquire considerable dirt at places which could not be treated with protective paint when the ship was last in dry dock because they were in contact with the cradle. In practice, such surfaces have to be treated with thick-tufted metal brush elements which have to rotate slowly if the stiff metal bristles are not to be pulled out, and the low speed reduces the forces tending to urge the brush elements against the surface being treated since such forces are produced by rotation of the device. The positive buoyancy which the invention provides compensates for the reduction in the forces tending to urge the brush elements against the surface being treated by imparting an upwardly directed thrust to the device.

Advantageously, control of the operation of the device according to the invention can be reduced to the operation of a handle acting on the moving part of the valve associated with the driving liquid, such handle being rotatable in either direction from a stop position, the speed of rotation of the brush element increasing progressively as the handle is moved away from the stop position, as a result of action on the rate of flow and the pressure of the driving liquid.

In one typical practical example, a device according to the invention can treat an area of from 500 to 600 m.^{2}/hour, and a team of four divers can brush a tanker 220 metres in length, 30 metres wide and with 6 metres draught in 3 hours, or approximately twice the rate possible with conventional compressed-air devices.

Advantageously, the driving liquid for the device according to the invention can be supplied by a motor and pump set disposed at a hydro-mechanical station which also supplies compressed air to the divers using the device. Such station can be disposed on a plastics raft, and the whole can be carried on board the ship on which it is to be used. A ship fitted in this way with one or more mechanical brushes according to the invention and with a raft-mounted hydro-mechanical station is completely independent of port installations for bottom cleaning; bottom cleaning can be performed as required by the raft being set afloat and the brush elements being operated by divers, the raft being moved progressively around the ship as the work advances along the hull.

The accompanying drawings show mainly by way of explanation a mechanical brush or cleaner according to the invention, without the supply and discharge ducting between the cleaner and a pumping unit for the supply of driving liquid.

In the drawings:

FIG. 1 is an external perspective view of a hydraulic cleaning device in accordance with the invention;

FIG. 2 is a diagrammatic section through a variable-buoyancy cleaner in accordance with this invention;

FIG. 3 is a partial section, taken along the line IV—IV of FIG. 5, of a hydraulic cleaner having a valve comprising a rotatable member in accordance with this invention, the section plane passing through the axis of rotation of such rotating member and through the axes of the driving liquid supply and discharge ducts, the rotating member of the valve being in a position corresponding to rotation of the cleaner motor at full speed to one hand;

FIG. 4 is a partial section through the cleaner on the line I—I of FIG. 3;

FIG. 5 is a partial section through the cleaner on the line II—II of FIG. 3;

FIG. 6 is a partial section through the cleaner on the line III—III of FIG. 3;

FIG. 7 is a partial view of the valve when in the position shown in FIG. 5, the rotating member of the valve being in a position corresponding to stoppage of the motor;

FIG. 8 is a partial view of the valve similar to FIG. 6, when the rotating member of the valve is in a position corresponding to stoppage of the motor.

Like references denote like elements throughout the drawings, and

FIG. 9 is a section through the supply and return ducts disposed one in another according to a preferred embodiment of the invention.

FIG. 1 is an external perspective view of one embodiment of a hydraulically driven underwater cleaner according to the invention. The cleaner comprises a casing **1**, a disc-shaped brush element **2** fitted to a shaft of a hydraulic motor disposed in the casing **1**, spigots **3**, **4** to which lines for the supply and discharge of the hydraulic medium for driving the motor can be connected, a handle **5** for controlling a valve for distributing the hydraulic medium in the cleaner, and grips **6**, **7** for handling the device. The handle **5** is shown in a position *5a* corresponding to rotation of the brush element in one direction at maximum speed; the handle has a stop position *5b* and a position *5c* corresponding to rotation of the brush element at maximum speed in the opposite direction.

FIG. 2 is a very diagrammatic section showing a cleaner disposed in accordance with the invention in an hermetic enclosure **30** which has ballast valves **32**, **33** and into which air can be supplied through a duct **31** under the control of a valve *31a*. The cleaner motor is represented by its casing **1**. The valve control handle **5** acts on a shaft **35** which is an extension of the moving part of the valve, the shaft **35** extending through an appropriate gland or the like *1a* of the enclosure **30**. Hermetic passages (not shown in FIG. 2) are also provided as required through the enclosure for the introduction of ducting for supplying to and removing from the cleaner the liquid required to operate its hydraulic motor which drives the brush element **2**.

When the valves **32**, **33** are opened, ambient water enters the enclosure **30** and ballasts the cleaner, the valves being closed when the cleaner has reached the required weight.

To treat a horizontal surface above it, such as a surface **34** in FIG. 2, the diver closes the valve **32** and opens the valves *31a*, **33** until air issues through the valve **33**. The cleaner then has positive buoyancy and experiences upwards thrust (diagrammatically represented by arrows **36**) which applies the cleaner in the required manner against the surface to be cleaned, with a force varying with the amount of air entering the enclosure **30**. A ballasted cleaner of this kind can be varied in many ways as regards the number and positioning of the hermetic passages formed in the enclosure, the shape and size of the enclosure, the arrangement of the motor in the enclosure, the motor possibly forming at least part of one side of the enclosure or being entirely received therein, the kind of motor used and so on; all such variants fall under this invention, which also covers the motor being disposed in the enclosure direct without having a hermetic casing, as **1**, around it, if the motor is itself hermetic.

The cleaner can, advantageously, have an anti-friction thrust block, for instance, of the ball bearing kind, disposed at **37** in FIG. 2, to take up axial thrusts which would otherwise be transmitted to the gearing.

A hydraulically driven cleaner according to the invention is operated by a driving liquid, usually oil, which is supplied to cleaner at a pressure of up to 100 kg./cm.^{2} and which leaves the cleaner at a much lower pressure of about 2 kg./cm.^{2}. If, therefore, no special steps were taken, the opening and closing of the admission of oil to the cleaner would cause considerable water-hammer in

the oil flow lines, and so the strength thereof would have to be increased with a consequent loss of flexibility and with disadvantages in the weight and size of the lines.

Accordingly, to reduce water-hammer the cleaner has a specially designed valve for controlling the distribution of the driving liquid, and an embodiment of such valve is shown in FIGS. 3–8. This valve, which controls the operation of the hydraulic motor **8** on whose shaft **8***a* the brush element **2** (not shown in FIGS. 3–6) is mounted, is of the kind comprising a stationary member of casing formed with a bore in which a moving member or plug can rotate. The casing has the general reference **9** and the plug has the general reference **10**. The casing **9** is formed with a bore **9***a*. A line **11** through which the cleaner is supplied with driving liquid from a pumping station (not shown) is connected to the bore **9***a* at a first level; extending into the bore **9***a* at the same level is an orifice **12***a* of a line **12** communicating with the chamber of the hydraulic motor 8, and an orifice **12***a'* of another line **12'** communicating with the said chamber. Driving liquid can be supplied to and removed from said chamber through the lines **12, 12'**; the entries of such lines in the chamber are so disposed that the oil, when supplied through the line **12**, rotates the motor shaft in one direction and leaves through the line **12'**, whereas when the oil is supplied through the line **12'** and leaves through the line **12**, the motor rotates in the opposite direction.

Extending into the bore **9***a* at another level are orifices **13***a*, **13***a'* of two discharge lines **13, 13'** communicating with a discharge chamber **14** to which extends a line **15** via which the oil leaves the cleaner at a pressure of about 2 kg./cm.^{2} and returns to the pump. Also extending to the chamber **14** is a tube **16** for conveying leakage oil from the motor **8** to the chamber **14**.

The plug **10** is rotatably mounted in the passage **9***a* and has two deflecting channels **17, 17'** separated by a solid part **10***a* formed with two channels or apertures **20, 20'** whose function will be described hereinafter. The channel **17** serves to deflect towards the line **12** to the motor the high pressure oil supplied through the main feed line **11**, and the channel **17'** acts similarly in respect to the line **12'**. The plug **10** is also formed with two passages **19, 19'**; the passage **19** communicates at the top with the channel **17** via an entry orifice **19***a*, and the passage **19'** communicates at the top with the channel **17'** via an entry orifice **19***a'*. At the bottom ends thereof the two passages **19, 19'** emerge to the periphery of the plug **10** by way of outlet orifices **19***b*, **19***c* (for the passage **19'** and **19***b'*, **19***c'* (for the passage **19'**). The passage **19** serves inter alia to discharge the oil present in the line **12**; this discharge occurs when the plug is so positioned that the outlet orifice **19***b* registers with the orifice **13***a*. Similarly, the line **12'** discharges via the passage **19'** when the corresponding outlet orifice **19***b'* registers with the orifice **13***a'*, as is actually shown in FIG. 6.

A description will now be given, with reference to FIGS. 3–8, of the operation of the plug **10** which, in accordance with the invention, can be moved through an angle of 45° in either hand from a central normal position to cause the motor of the cleaner to rotate in one or the other direction, the normal position of the plug **10** being a position in which the motor is stopped.

FIGS. 3–6 show the plug **10** in a position in which the driving liquid rotates the cleaner motor at maximum speed in one direction, and FIGS. 7 and 8 show the plug in the motor stop position.

In the position shown in FIGS. 3–6, driving liquid arriving at high pressure through the line **11** (FIG. 5) enters the channel **17** but cannot depart via the passage **19** since the outlet orifice **19***b*, **19***c* is in contact with the wall of the bore (FIG. 6). The liquid therefore goes through the line **12** to the motor chamber and leaves the same via the line **12'**, channel **17'** and passage **19'** whose outlet orifice **19***b'* is in registration with the orifice **13***a'* of the discharge line **13'** (FIG. 6). The liquid then flows through the line **13'** and chamber **14** to the discharge line **15.**

The plug **10** is rotated anti-clockwise gradually to reduce the liquid delivery through the line **12** and slow down the motor.

When the plug **10** has reached the position shown in FIGS. 7 and 8—i.e., when the plug **10** has been pivoted through 45° from the fully open position shown in FIGS. 3–6—the liquid supplied through the line **11** does not pass to the motor chamber but is not stopped for, in accordance with the invention, the arriving liquid can go through the apertures **20, 20'** directly to the passages **19, 19'** (FIG. 7) and leave the same via the orifices **19***c*, **19***c'* which are now in registration with the orifices **13***a*, **13***a'* of the lines **13, 13'**, through which latter the liquid goes through the chamber **14** to the discharge line **15.**

Rotation of the plug **10** beyond this stop position will cause the motor to rotate in the opposite hand, the driving liquid flowing through the channel **17'**, line **12'** and so on.

The valve shown by way of example in FIGS. 3–8 is so devised that its plug is rotatable through 45° in either direotion from the inoperative position to control rotation of the brush element in either direction up to a maximum speed, but disposing the co-operating orifices of the lines and channels to give a maximum angle of plug rotated in either direction other than the 45° specified also falls under this invention.

The hydraulic supply and return lines can be disposed one inside another over much of their length, as hereinbefore referred to, or can be independent, FIG. 9 shows by way of example, the sections of a supply duct *s* within a return duct *d* of larger diameter. Also, the various lines can be led out of the cleaner casing through separate apertures or through a single aperture, and in cases where the lines issue through separate apertures it may be advantageous if they extend through the inside of hollow grips fitted to such apertures.

What is claimed is:

1. A unitary brushing device for underwater cleaning of the surface of an immersed structure, comprising a brush element and a shaft on which said element is mounted, a hydraulic motor for rotating the shaft, means for supplying the motor with a pressure liquid, means for withdrawing such liquid after its passage through the device, means for controlling the liquid distribution conditions in the device to control the speed of rotation of the brush element, the last-mentioned means comprising a valve cooperating with the supply means and the discharge means to receive the supplied liquid and direct the same towards the discharge, the moving part of the valve being operable to a motor stop position without the flow of liquid between the supply and the discharge being interrupted, said valve being of the kind comprising a plug rotating in a bore in a casing, at least one supply line for the driving liquid to the device terminating in an orifice in the said bore, at least one discharge line for the driving liquid leaving the device communicating with at least one port in the bore periphery, said plug having, at the level at which said supply line orifice is disposed, two channels separated by a partition and adapted to be selectively connected to the said supply line orifice in dependence upon the angular position of the plug in the casing, means enabling the liquid to pass through the valve without passing through the motor comprising at least one channel in that part of the partition which is opposite the said supply line orifice when the plug is in the motor stop position, said last-mentioned means also comprising at least one passage inside the plug and in communication at an inlet end with the said last mentioned channel, the said passage opening into the plug periphery by way of an outlet orifice, at least part of which is disposed opposite a port communicating with the discharge line when the plug is in the motor stop position.

2. A brushing unit device to be handled by a diver for

underwater cleaning of the surface of an immersed structure, comprising a disc-shaped brush element and a shaft on which said element is mounted, a hydraulic motor adapted for rotating the shaft, supply means for supplying the motor with a driving liquid from a pumping station, withdrawing means for returning the said liquid to the pumping station after its passage through the device, and means comprising a valve for controlling the distribution conditions of the said liquid in the device thereby controlling the speed and the direction of rotation of the brush element and handling means for the diver.

3. A brushing unit device as in claim 2 wherein said valve is operated from a handle rotatable by the diver from a position corresponding to rotation of the brush element at maximum speed in one direction up to a position corresponding to rotation of the brush element at maximum speed in the opposite direction, with an intermediary stop position.

4. A brushing device as in claim 2 wherein said valve is such that the driving liquid is not stopped when the valve is operated to stop the motor, said liquid then bypassing the motor to return to said pumping station.

5. A brushing device as in claim 2 and further comprising a float rigidly fixed thereto and covering the said motor, said float having ballast valves and a controlled inlet for a pressure fluid.

6. A brushing device as in claim 2 and wherein said motor is disposed in a hermetic protective casing containing a volume of gas calculated so that the apparent mass of the brushing device when immersed be small enough to be readily handled by a diver.

7. A brushing device as in claim 2 wherein the driving liquid supply and withdrawing means comprise two lines disposed one inside another at least most of their length, the inner line serving as supply line and the outer line serving as discharge line.

8. A brushing device as in claim 2 wherein the supply means and discharge means comprise lines which extend into the device through the interior of handling grips rigidly connected to the device.

9. A brushing device as in claim 2 wherein an antifriction thrust block is disposed below the brush element shaft in order to reduce axial thrusts and prevent the same from being transmitted.

10. A brushing device as in claim 2 together with a pumping station connected with the device by supply and discharge ducting for the driving liquid compressed at the pumping station.

11. A brushing device as in claim 10 wherein said driving liquid is a low-density oil.

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