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CLEANING DEVICE WITH USE OF PRESSURIZED WATER

The present invention relates to a cleaning device with use of pressurized water, and more particularly to such a device which is suitable for cleaning hulls, tanks and other articles having a relatively large surface area.

It has been thought useful to remove shells, rust and like deposits, for example, from side walls or bottom walls of hulls by jetting pressurized water at the wall. However, a manual gun for jetting pressurized water is difficult to use in close proximity to the hull and unable to fully remove deposits. If the gun is used at an increased flow rate and elevated water pressure to achieve a higher efficiency, the user will be unable to hold the gun and exposed to an enhanced hazard due to the resulting reaction force.

An automatic pressurized water cleaning device is known which comprises a vertical terminal pipe connected to a pressurized water source and having a plurality of jet nozzles, and a support carrying the terminal pipe and automatically movable in directions perpendicular to and parallel with the surface of the hull to be cleaned. Although the cleaning force of the device is adjustable by moving the terminal pipe with the support toward or away from the hull, the terminal pipe is unable to clean

uniformly when brought close to the hull for effective cleaning, since the terminal pipe is disposed vertically. More specifically the nozzle fail to clean the surface uniformly unless positioned at some distance therefrom because the water jetting out from the nozzles fans out. (At too large a distance, nevertheless, the jets of water forced out from adjacent nozzles will interfere with each other, possibly producing an adverse effect.)

The present invention seeks to provide a pressurized water cleaning device which is capable of cleaning articles uniformly at all times even when jetting out pressurized water at varying distances therefrom to produce the desired cleaning effect.

According to the present invention, there is provided a device for cleaning a surface with pressurized water comprising a support adapted to move along the surface in facing relation thereto, and a terminal pipe adapted to be connected to a pressurized water source and adapted to be supported by the support in facing relation to the surface, the terminal pipe having a plurality of jet nozzles spaced longitudinally along the pipe for jetting pressurized water at the surface, the device including means for reciprocatingly pivoting the terminal pipe within a predetermined angular range about an axis substantially perpendicular to the surface.

According to a preferred embodiment of the invention, the device further has means for moving the terminal

pipe relative to the support toward or away from the surface to be cleaned. With this embodiment, the cleaning force is variable by moving the terminal pipe only, so that the embodiment is more advantageous in respect of power than when the terminal pipe must be moved with the support and other parts associated therewith. Moreover, the cleaning force is finely adjustable.

The terminal pipe may be provided with at least one stop valve between adjacent jet nozzles, whereby the force of pressurized water to be jetted from the nozzles is variable without altering the capacity of the water source. Accordingly the combination of stop valves with the terminal pipe being pivotable and movable toward and away from the surface affords various cleaning modes.

Preferably, the device further comprises means for reciprocatingly pivoting the terminal pipe about its own axis through a predetermined angle.

Various features and advantages of the present invention will become apparent from the embodiment to be described below with reference to the accompanying drawings, in which:

Fig. 1 is an overall front view schematically showing an entire apparatus having incorporated therein a pressurized water cleaning device according to the invention while the apparatus is being used for cleaning the outer surface of a hull;

Fig. 2 is a schematic plan view partly showing the entire apparatus;

Fig. 3 is a front view showing the cleaning device in a cleaning mode;

Fig. 4 is a plan view showing the cleaning device;

Fig. 5 is a side elevation showing a terminal pipe of the cleaning device;

Fig. 6 is a view in section taken along the line VI-VI in Fig. 3;

Fig. 7a to Fig. 7d are diagrams showing the pattern of jetting pressurized water from the terminal pipe in the above-mentioned cleaning mode;

Fig. 8 is a front view showing the cleaning device in another cleaning mode;

Fig. 9 is a plan view showing the cleaning device in the same cleaning pattern;

Fig. 10 is a diagram showing the pattern of jetting water in the same cleaning mode; and

Fig. 11 is a diagram given merely for illustrative purposes and showing the pattern of jetting water in a postulated cleaning mode.

With reference to Figs. 1 and 2, an entire apparatus 2 adapted to clean the outer surface of a hull 1 comprises a truck 3 movable alongside the hull 1 in the directions of arrow A and B, a boom 4 supported at its one

end on the truck 3 and rotatable about a vertical pivot and a horiontal pivot, a station 5 attached to the other end of the boom 4, and a pressurized water cleaning device 6 supported by foldable stowing means 7 on the station 5. The cleaning device 6 is connected to a pressurised water pump 8 by a supply hose 9 which can be wound around and paid off from a reel 10.

As shown in Figs. 3 to 6, the cleaning device 6 has a pair of vertical bars 11, horizontal bars 12 extending from opposite sides of a pair of rectangular frames 13A and 13B and pivotably connected to the vertical bars 11 by pins 14, and a cross member 15 having a horizontal portion 15a and a vertical portion 15b and pivotably connected at the horizontal portion 15a to the midportions of the vertical bars 11 by pins 16. One of the rectangular frames 13A, is provided with a pair of horizontal guide rails 17 for guiding a slider 18 therealong. A bearing 19 is rotatably mounted on the silder 18 by pins 20. A terminal pipe 21 connected to the water supply hose 9 is rotatably supported by the bearing 19. The terminal pipe 21 is provided at one side thereof ~~to be~~ opposite ~~to~~ the hull 1 with a multiplicity of (fourteen in this embodiment) water jet nozzles N1 to N14 arranged longitudinally of the pipe at a suitable spacing. The terminal pipe 21 has a stop valve 22 at an intermediate portion of its channel, for example,

between the 10th and 11th nozzles N10 and N11. Like the frame 13A, the other rectangular frame 13B has a pair of horizontal guide rails 17 and a slider 18 thereon. One end of a motor 23, which in this embodiment is a hydraulic motor, is pivotally supported by a pin 24 on the slider 18 on the frame 13B. The motor 23 has a drive shaft 23a which is connected to one end of the terminal pipe 21 concentrically therewith. The motor 23, when reciprocatingly pivoted, pivots the terminal pipe 21 about its own axis to change the direction of the nozzles N relative to the hull 1. If a crank mechanism is used, the terminal pipe 21 is reciprocatingly pivotable about its own axis by a motor which rotates in one direction. A hydraulic cylinder 25 is interposed between and pivotally connected to the vertical portion 15b of the cross member 15 and each of the vertical bars 11. The vertical bars 11 are reciprocatingly pivotally movable with the terminal pipe 20 in the directions of arrows C and D shown by simultaneously extending and retracting the piston rods 25a of the hydraulic cylinders 25. A hydraulic cylinder 26 is attached to the side of each of the rectangular frames 13A and 13B opposite to the side thereof facing the hull 1. When the piston rod 26a of each cylinder 26, connected to the slider 18, is extended or retracted in the direction of arrow E or F, the terminal pipe 21 is movable within the frame 18 toward or away from

the hull 1. Indicated at 27 are wheels rotatably mounted on the outer ends of the horizontal bars 12 and adapted to come into contact with the outer surface of the hull 1, and at 28 curtain members for preventing jets of water from splashing.

As shown in Fig. 2, the foldable stowing means 7 has support arms 29 and 30 each foldably hinged as at 31 to the other at one end. Attached to the underside of the station 5 is a drive motor 32 having a drive shaft 32a which is rotatably supported by a pair of brackets 33 on the underside of the station 5. The drive shaft 32a is fixedly provided with a rotary member 34 integral with a projection 34a. The support arm 29 is supported at the other end thereof by the projection 34a and is pivotally movable by a torque actuator 35 in the directions of arrows G and H. The other support arm 30 is connected at the other end thereof to the cross member 15 of the cleaning device 6 by a universal joint 36 having posture control means. The cleaning device 6 can be stowed under the station 5 by operating the torque actuator 35 to rotate the arms 29 and 30 in the direction of arrow H and fold them at the hinge 31 and, at the same time, rotating the rotary member 34 by the motor 32 in the direction of arrow I.

The outer surface of the hull 1 is cleaned in

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the following manner by the entire apparatus 2 of the above construction.

First, the truck 3 and the boom 4 are suitably moved to position the station 5 suitably relative to the hull 1. Next, the foldable stowing means 7 is operated to withdraw the cleaning device 6 from under the station and bring the wheels 27 into contact with the outer surface of the hull 1. The device 6 is now so positioned as seen in Fig. 2, ready for cleaning.

When deposits are lodging on the hull 1 with very low adhesion, the terminal pipe 21 is positioned vertically by the hydraulic cylinders 25 and moved by the hydraulic cylinders 26 away from the hull 1 the largest distance, and the stop valve 22 is opened, as seen in Figs. 3 to 6, whereby pressurized water is jetted out from all the nozzles N1 to N14 in a planar fanned-out form as shown in Figs. 7a and 7c. The hydraulic motor 23 is further operated to reciprocatingly pivot the terminal pipe 21 through an angle α as shown in Fig. 7d. Now pressurized water is jetted out in a pattern indicated at Wa in Fig. 7b. When the truck 3 is moved in this state in the direction of arrow A or B, the hull 1 can be cleaned longitudinally thereof over a width $\ell 1$ by a single one-way travel of the truck.

If it is desired to jet water with an increased

force, the valve 22 is closed, whereby the supply of pressurized water to the nozzles N11 to N14 is discontinued. Consequently the force of water jetting out from the nozzles N1 to N10 correspondingly increases. However, the width to be cleaned by a single one-way travel of the truck 3 decreases to $\ell 2$.

If the terminal pipe 21 is brought close to the hull 1 by the hydraulic cylinders 26 to the greatest possible extent as shown in Fig. 9 and the stop valve 22 is opened, the pattern of water jetting from the nozzles N1 to N14 becomes smaller both in width and length as indicated at Wb in Fig. 11, while the water strikes the hull 1 with an increased force. However, a space 37 occurs between the patterns Wb of water jetting out from each two adjacent nozzles N, with the hull left partly uncleaned. Accordingly the hydraulic cylinders 25 are operated to incline the terminal pipe 21 along with the vertical bars 11 toward the direction of arrow C as shown in Fig. 8. This results in the jet pattern shown in Fig. 10. When the truck 3, i.e., the terminal pipe 21, is moved in this state toward the direction A or B (B in Fig. 10), adjacent two nozzles N produce a lap O in the cleaning pattern, with the result that the hull can be cleaned completely over a width $\ell 3$ by a single one-way travel of the truck 3. It is noteworthy that the jets of

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water from the two adjacent nozzles, although producing a lap in the cleaning pattern, do not overlap each other directly and are therefore free of interference that would entail a reduced effect.

The greatest cleaning force is available by closing the stop valve 22. Pressurized water then flows only into the nozzles N1 to N10, from which the water jets out to clean the hull completely over a width ℓ4.

Listed below are numerical values specifically showing the four cleaning modes described above.

Table

Item \ Cleaning mode		Low-pressure jetting		High-pressure jetting	
		Long distance	Short distance	Long distance	Short distance
Water pressure		16 MPa	16 MPa	19 MPa	19MPa
Number of nozzles		14	14	10	10
Flow rate per nozzle		17 ℓ/min	17 ℓ/min	24 ℓ/min	24 ℓ/min
Nozzle jet angle (fanned-out angle)		20°	20°	20°	20°
Jetting distance		200 mm	100 mm	200 mm	100 mm
Cleaning width		1.0 m	0.8 m	0.7 m	0.6 m
Oscillation of nozzles	Angle (α)	45°	45°	45°	45°
	Frequency*	2-3 Hz	2-3 Hz	2-3 Hz	2-3 Hz

* Frequency required for completely cleaning article (hull) longitudinally thereof.

Although only four cleaning modes have been described above, the cleaning device of the invention can be adapted for various other cleaning modes. For example, the terminal pipe 21, as positioned the largest distance away from the hull 1 as seen in Fig. 4, may be inclined from the vertical position to cause each two adjacent nozzles to produce a lap in the cleaning pattern as shown in Fig. 10 to assure uniform cleaning. Further the distance of the terminal pipe 21 from the hull 1 and the angle of inclination of the pipe 21 with respect to the vertical are suitably adjustable by the hydraulic cylinders 26 and 25, respectively, to afford infinitely varying cleaning modes.

Although the terminal pipe 21 of the illustrated embodiment has only one stop valve, pressurized water can be jetted out from the nozzles N with at least three different forces without altering the capacity of the pump 8 if a plurality of valves are used.

Briefly, articles can be cleaned by the present device uniformly and efficiently in an optimum mode in accordance with the state of deposits thereon. The device is therefore very useful.

CLAIMS:

1. A device for cleaning a surface with pressurized water comprising a support adapted to move along the surface in facing relation thereto, and a terminal pipe adapted to be connected to a pressurized water source and adapted to be supported by the support in facing relation to the surface, the terminal pipe having a plurality of jet nozzles spaced longitudinally along the pipe for jetting pressurized water at the surface, the device including means for reciprocatingly pivoting the terminal pipe within a predetermined angular range about an axis substantially perpendicular to the surface.

2. A device as defined in claim 1 further comprising means for moving the terminal pipe relative to the support toward or away from the surface to be cleaned.

3. A device as defined in claim 1 or 2 wherein the terminal pipe has at least one stop valve positioned between adjacent jet nozzles.

4. A device as defined in any one of claims 1 to 3 further comprising means for reciprocatingly pivoting the terminal pipe about its own axis through a predetermined angle.

5. A device as defined in any one of claims 1 to 4 wherein the support comprises a parallelogramatic frame including a first pair of parallel side members, adjacent side members being pivotally connected to each other at the four corners of the frame, the terminal pipe being supported by the parallelogramatic frame in parallel with the first pair of side members, a cross member having a first portion parallel with the first pair of side members of the frame, and a second portion parallel with a second pair of side members of the frame being pivotally connected at opposite ends of the second portion to midportions of the first pair of side members of the frame, and wherein the pivoting means comprises a piston and cylinder assenbly pivotally connected at opposite ends respectively to the first portion of the cross member and one of the first pair of side members of the frame and operable to pivot said first pair of side members relative to said second pair of side members.

6. A device as defined in claim 5 wherein two sliders movable perpendicular to the plane of the frame are respectively supported on the second pair of side members of the frame, and the terminal pipe is pivotably supported by the sliders, the device further comprising a piston and cylinder assembly for moving each of the sliders perpendicular to the plane of the frame.

7. A device as defined in claim 6 wherein one end of the terminal pipe is connected to the drive shaft of a motor, and one end of the motor is pivotally supported by one of the sliders to cause said one slider to indirectly support the terminal pipe, the motor being adapted to reciprocatingly pivot through a predetermined angle.

8. A device as defined in claim 6 or 7 wherein each of the second pair of side members of the parallelogramatic frame comprises a rectangular frame having a pair of guide rails slidably guiding a corresponding slider perpendicular to the plane of the parallelogramatic frame and a pair of bars extending in opposite directions from the rectangular frame.

9. A device for cleaning a surface with pressurised water substantially as described herein with reference to, and as illustrated in, the accompanying drawings.