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(54) AUTOMATED UNDERWATER PAINTING METHOD FOR A SHIP OR UNDERWATER STRUCTURE, AND APPARATUS FOR PERFORMING THE SAME

(71) We, JAPAN SHIP'S MACHINERY DEVELOPMENT ASSOCIATION and MITSUI ENGINEERING AND SHIPBUILDING CO., LTD., both Japanese Body Corporates of 35 Shiba Kotohira-cho, Minato-ku, Tokyo, Japan and 6-4, Tsukiji 5-chome, Chuo-ku, Tokyo, Japan respectively, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a method of and apparatus for automatically painting with a water-curable paint a ship's hull or other underwater structure.

Recently, newly built ships are getting larger, as is the case with oil tankers. At the same time, there is increased building in the field of ocean steel structures such as oil rigs. These tendencies present serious problems as to the underwater painting and underwater mechanical maintenance for such large ships and structures, because of a shortage of large sized docks capable of accommodating the large ships and because of the long periods between dockings. Concerning ocean structures such as oil rigs, the problems as to the underwater anti-corrosion painting cleaning and maintenance are more serious because of the immovable nature of the structure after the structure has been towed and installed at a fixed offshore point.

Conventionally, various methods have been proposed for underwater maintenance, especially concerning the underwater cleaning of a ship's hull, but no practical method has been established up to now for underwater painting. Thus, a typical one of the conventional methods of underwater painting involves divers who manually apply a water-curable paint to the surface to be coated. In another conventional method, the painting is

performed by a spatula adapted to be fed by pressure. However, these conventional methods have been found unacceptable, although they can effect underwater painting to a certain degree, because of insufficient thickness, smoothness and affinity of the resultant painted layer. For instance, the affinity or force by which the paint is held by the objective surface in question is as small as 1/3 to 1/4 of that obtained by painting in the atmosphere. Thus, these conventional methods could not form a satisfactory coating layer of paint.

To avoid these shortcomings, it has been proposed to use a waterproof box for defining an underwater painting space. In this method, the objective surface is dried by infrared rays, after rinsing. Then, conventional solvent type paint is applied to the surface by means of a roller, and infrared rays are used to dry the paint.

This method also has been found unsatisfactory, because of the imperfect waterproof nature of the box and the excessive time required for painting due to the use of the roller. In addition, since the drying of the surface before and after the painting relies upon the infrared rays the area treated in a unit time becomes inevitably small. At the same time, since the commercially available solvent type paint is applied only once, the coating layer cannot provide a satisfactory anti-corrosion effect, although the thickness thereof may be even.

According to one aspect of the present invention there is provided a method of automatically effecting underwater painting on a ship or other underwater structure including the steps of moving an underwater painting apparatus to the desired position on the underwater surface to be painted and fixing said apparatus at that position, forming a painting space sealed against surrounding water by inflating inflatable sealing means, draining water from said painting space, and spraying a water-

curable paint onto said surface to effect painting of said surface.

In another aspect of the present invention provides apparatus for performing underwater painting on a ship or other underwater structure such apparatus including a main body having a water-sealing box adapted to define a painting space on an underwater surface to be painted, shifting means for shifting the position of the whole painting apparatus to a desired painting position, fixing means for fixing said apparatus at said painting position, inflatable sealing means to contact the surface and seal said painting space, upon inflation, against surrounding water in a watertight manner, filling and draining means for filling water into said painting space and draining water therefrom, and means to spray water-curable paint onto said surface in said space.

The invention improves on the known techniques and apparatus by decreasing the time required for painting a given area, improving the paint coating as to thickness, smoothness and affinity and, accordingly, giving an improved durability of the coating layer of paint. Little pollution of water resources occurs thanks to the use of a water-curable low-solvent type paint, while the apparatus has a simple construction, consisting of a small number of parts and is easy to handle due to its reduced weight. The time required for painting is especially short due to the use of rinsing water and/or jetted air, when the cleaning and/or drying of the objective surface is necessary. The surface to be painted can be flat or curved and the interior of the water-sealing box is completely insulated from the ambient water by the sealing means, which is preferably an inflatable tube with or without the assistance of a resilient outer shell. The application of the paint is performed by an air spray or airless spray painting nozzle, while the fixing of the water-sealing box is made by fixing means such as underwater electromagnets.

The apparatus may be moved by driving wheels with which it may be provided, these preferably having inflatable members such as rubber tyres. Thus, the apparatus can be moved to any desired position on the surface with the fixing means, such as electromagnets, being energized when the driving wheels are pneumatically inflated. The apparatus can then be fixed at a new position, by a subsequent release of gases from the driving wheels.

If necessary, cleaning and drying of the surface to be painted can easily be performed by applying rinsing water and/or high-velocity jetted air, by means of a nozzle fixed to the water-sealing box.

In order that the invention may be more

clearly understood, the following description is given by way of example only, with reference to the accompanying drawings.

Fig. 1 is a side elevational view of an underwater painting apparatus in accordance with the invention.

Figs. 2A to 2D show steps of underwater painting method of the invention in order, in which:

Fig. 2A shows a running of the painting apparatus,

Fig. 2B shows positioning and draining of the painting apparatus,

Fig. 2C shows a rinsing, drying and painting performed by the painting apparatus, and

Fig. 2D shows a water-filling and a jacking up of the apparatus.

Fig. 3 is a side elevational view of another embodiment in accordance with the invention, and

Fig. 4 is a bottom plan view of the apparatus of Fig. 3 as viewed in the direction of arrow A—A of Fig. 3.

Referring now to the drawings, particularly to Fig. 1, a main body of an underwater painting apparatus of the invention is generally designated at numeral 1, and is provided with wheels 2 for longitudinal movement of the main body 1 and driving wheels 3 for lateral movement. These wheels 2 and 3 are inflatable members such as rubber tyres, and are capable of jacking up the main body 1 when inflated. As a pneumatic or electric motor 4 is actuated upon magnets 5, 6 being energized, the main body 1 can run in any desired direction while being held on the object to be painted by the force exerted by these magnets. The main body 1 is provided, in addition to the wheels 3, 4 and magnets for preventing the main body 1 from being dropped or excessively floated, with a valve 7 for filling and draining.

A water-sealing box 8 is provided at the inside of the main body 1. The space between the main body 1 and the water-sealing box 8 constitutes a buoyancy tank 9, while the space inside of the water-sealing box 8 form a painting chamber 10. A nozzle fitting 11 is located at an upper portion of the water sealing box to which a nozzle or nozzles for rinsing water to clean the objective surface, high-velocity air for drying the surface and for spraying the water-curable paint are attached. Thus, a single nozzle port may be used for performing these functions or, alternatively, a plurality of nozzle ports may be provided for respective purposes. It is also possible to use a nozzle for rinsing water and the high-velocity air, and another nozzle for painting. An inflatable sealing tube 12 made of rubber or the like material and an outer

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sleeve 13 for the tube are provided around the lower periphery of the water-sealing box 8. The arrangement is such that the painting chambers 10 within the sealing-box 8 is sealed against the ambient sea water in a watertight manner, when the tube 12 is inflated. Although the tube 12 may be solely inflated to provide the seal, a resilient outer shell (not shown) made of sponge rubber may be provided around the tube 12 so that the sealing may be effected by an expansion force and a pressing force exerted by the tube 12 and the outer shell. A flexible air vent pipe 14 is connected to the water-sealing box 8.

The manner of operation of the apparatus will be described hereinafter with reference to Figs. 2A to 2D.

Referring at first to Fig. 2A showing the apparatus in the running state as viewed from the sea-surface side, the driving wheels 2 or 3 are supplied with pressurized gas and inflated. After the wheels are inflated to have a suitable pressure, the electro-magnet 5 is energized so that the main body 1 is attracted to an object 15 to be painted, e.g. a steel plate of a ship's hull 15, slightly spaced from the latter. Then, the driving wheels are powered to move the main body 1 to any desired painting position.

After the main body has arrived at the desired painting position, the pressure of the driving wheels is relieved, so that the main body is tightly fixed at this position on the object 15 by the attracting force exerted by the electromagnet 5.

Subsequently, the sealing tube 12 is supplied with air. Consequently, the painting chamber 10 within the water sealing box 8 is insulated from the ambient sea water in a watertight manner, by the expanding force of the tube 12 and by the pressing force exerted by the resilient outer shell, as shown in Fig. 2B. As the air is fed into the painting chamber 10, through an air inlet port 16 in communication with the flexible tube 14 as shown by an arrow in Fig. 2B, the internal pressure of the painting chamber 10 is increased to expel the residual sea water from the painting chamber 10 through a draining and filling port 17 in communication with the filling and draining valve 7.

After the painting chamber 10 is completely drained, the chamber 10 is vented to the ambient air through the flexible tube 14. If it is necessary to clean the surface to be painted, a rinsing water is injected from an injection nozzle provided at the nozzle fitting 11. The surface is then dried by the high-velocity air.

Subsequently, a water-curable paint is sprayed from a painting nozzle provided at the nozzle fitting 11 over the entire surface to be painted, as shown in Fig. 2C.

After the painting is completed, sea water is introduced into the chamber 10 through the filling and draining port 17. At the same time, one (for example, left-hand side one of Fig. 2D) of the electromagnets is deenergized and the driving wheels at that side are inflated, to cause the main body 1 to float or lift at one side as shown in Fig. 2D. After energizing the electromagnet 5, a similar operation is performed on the other side of the main body 1, so that the painting chamber 10 is filled with water to allow the main body 1 to move to the next painting position.

Fig. 3 shows a side elevation of another embodiment of the invention, while Fig. 4 is a bottom plan view of the apparatus of Fig. 3 as viewed in the direction of arrow A—A. In these Figures, members corresponding to those of the foregoing embodiments are denoted by the same numerals having suffix *a*. In this embodiment, the main body 1a of the underwater painting apparatus is provided at its bottom with four inflatable driving wheels 2a which allow the movement of the main body 1a along a line. However, driving means 2b are arranged to drive the driving wheels at alternative sides of the main body 1a independently. Thus, after the painting is finished for one line, the driving wheels at one side of the main body are driven, while the wheels at the other sides are not driven, so that the main body 1a is turned to perform the painting for the next line. In this embodiment, four electromagnets 5a are provided at the bottom of the main body 1a, so as to hold the main body 1a on the surface to be painted, during the running of the main body 1a and during the painting work. A single painting chamber 10a is provided at the center of the main body 1a, and is surrounded by an inflatable sealing tube 12a and an outer sleeve 13a for the tube. The sealing tube is adapted to seal the painting chamber 10a against the ambient water in watertight manner, when inflated. It is of course possible to employ a resilient outer-shell made of sponge rubber or the like material to enhance the sealing effect.

Six nozzle fittings 11a for securing paint-spraying nozzles are arranged in the painting chamber in a staggered manner. The positions of these nozzles may be changed optionally. Although the main body 1a has a rectangular shape in its bottom plan, similarly with the foregoing embodiment, any other shape can be adopted as necessitated.

The underwater painting technique based on the above stated structural features and operations provides the following advantages.

(a) Since the sealing of the painting chamber 10 within the water-sealing box 8

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against the ambient water is performed by an inflatable tube 12 which exerts an expanding force or by a combination of the inflatable tube 12 and a resilient outer shell made of sponge or the like material which exerts an expanding and pressing force, a satisfactory sealing effect is obtained regardless of the concavity and convexity of the objective surface.

(b) The spray of the water-curable paint from an air spray or airless spray nozzle provided on the nozzle fitting 11 in the sealing box 8 affords an automatic application of the paint over a large area, ensuring a good thickness of the coating, smoothness of the coating surface and a satisfactory affinity of the paint to the objective surface which in combination ensures a good painting for a long-term maintenance.

(c) Thanks to the use of the water-curable paint, it is possible to apply water on to the printed surface and to move the apparatus, soon after the painting. This considerably shortens the time for the painting work, and promises to be advantageous also from the view point of pollution prevention.

(d) The number of parts are reduced, as well as the weight of the apparatus, due to the use of specific underwater or submerged type electromagnets 5, 6 capable of performing a fixing of the apparatus to the objective surface and holding of the apparatus on the surface during running thereof.

(e) The use of inflatable driving wheels 2, 3 capable of jacking up the main body 1 for shifting the position of the latter simplifies the construction and contributes to reduce the weight and, therefore, ensures an improved working efficiency.

(f) When it is required to clean and dry the objective surface, rinsing water is injected from a nozzle provided on the nozzle fitting 11 of the sealing box 8 and, after stopping the water injection, high-velocity air is jetted from the nozzle to dry the surface after rinsing. This arrangement enables the apparatus to treat a larger area as compared with conventional apparatus making use of a specific heat source such as a heater, greatly contributing to improve the working efficiency.

WHAT WE CLAIM IS:—

1. A method of automatically effecting underwater painting on a ship or other underwater structure including the steps of moving an underwater painting apparatus to the desired position on the underwater surface to be painted and fixing said apparatus at that position, forming a painting space sealed against surrounding

water by inflating inflatable sealing means, draining water from said painting space, and spraying a water curable paint onto said surface to effect painting of said surface.

2. A method as claimed in claim 1 including the use of an air spray or airless spray for applying said paint.

3. A method as claimed in claim 1 or 2, wherein said painting space is sealed against surrounding water by inflation of an inflatable tube.

4. A method as claimed in claim 3, wherein the inflatable tube is used with a resilient outer shell.

5. A method as claimed in any preceding claim including the steps of cleaning said surface prior to the application of said paint by injecting rinsing water from a nozzle into said painting space, and drying said surface subsequent to the cleaning by jetting high-velocity air after discharging the injection of said rinsing water.

6. Apparatus for performing underwater painting on a ship or other under water structure such apparatus including a main body having a water-sealing box adapted to define a painting space on an underwater surface to be painted, shifting means for shifting the position of the whole painting apparatus to a desired painting position, fixing means for fixing said apparatus at said painting position, inflatable sealing means to contact the surface and seal said painting space, upon inflation, against surrounding water in a watertight manner, filling and draining means for filling water into said painting space and draining water therefrom and means to spray water-curable paint onto said surface in said space.

7. Apparatus as claimed in claim 6, wherein said sealing means includes an inflatable tube in a sleeve located on the side of the tube remote from the surface in use.

8. Apparatus as claimed in claim 7, including a resilient outer shell provided around said inflatable tube and between the tube and the sleeve.

9. Apparatus as claimed in claim 6, 7 or 8, wherein said shifting means include inflatable rubber tyres adapted to perform, when inflated, a double function of shifting said apparatus and lifting said apparatus from said surface.

10. Apparatus as claimed in claim 6, 7, 8 or 9, wherein said fixing means are electromagnets adapted to exert, when energized, an attracting force to fix said apparatus to the object to be painted.

11. A method of automatically effecting underwater painting of a ship or other structure, substantially as hereinbefore described with reference to the accompanying drawings.



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against the ambient water is performed by an inflatable tube 12 which exerts an expanding force or by a combination of the inflatable tube 12 and a resilient outer shell made of sponge or the like material which exerts an expanding and pressing force, a satisfactory sealing effect is obtained regardless of the concavity and convexity of the objective surface.

5 (b) The spray of the water-curable paint from an air spray or airless spray nozzle provided on the nozzle fitting 11 in the sealing box 8 affords an automatic application of the paint over a large area, ensuring a good thickness of the coating, smoothness of the coating surface and a satisfactory affinity of the paint to the objective surface which in combination ensures a good painting for a long-term maintenance.

10 (c) Thanks to the use of the water-curable paint, it is possible to apply water on to the printed surface and to move the apparatus, soon after the painting. This considerably shortens the time for the painting work, and promises to be advantageous also from the view point of pollution prevention.

15 (d) The number of parts are reduced, as well as the weight of the apparatus, due to the use of specific underwater or submerged type electromagnets 5, 6 capable of performing a fixing of the apparatus to the objective surface and holding of the apparatus on the surface during running thereof.

20 (e) The use of inflatable driving wheels 2, 3 capable of jacking up the main body 1 for shifting the position of the latter simplifies the construction and contributes to reduce the weight and, therefore, ensures an improved working efficiency.

25 (f) When it is required to clean and dry the objective surface, rinsing water is injected from a nozzle provided on the nozzle fitting 11 of the sealing box 8 and, after stopping the water injection, high-velocity air is jetted from the nozzle to dry the surface after rinsing. This arrangement enables the apparatus to treat a larger area as compared with conventional apparatus making use of a specific heat source such as a heater, greatly contributing to improve the working efficiency.

WHAT WE CLAIM IS:—

55 1. A method of automatically effecting underwater painting on a ship or other underwater structure including the steps of moving an underwater painting apparatus to the desired position on the underwater surface to be painted and fixing said apparatus at that position, forming a painting space sealed against surrounding

water by inflating inflatable sealing means, draining water from said painting space, and spraying a water curable paint onto said surface to effect painting of said surface.

2. A method as claimed in claim 1 including the use of an air spray or airless spray for applying said paint.

3. A method as claimed in claim 1 or 2, wherein said painting space is sealed against surrounding water by inflation of an inflatable tube.

4. A method as claimed in claim 3, wherein the inflatable tube is used with a resilient outer shell.

5. A method as claimed in any preceding claim including the steps of cleaning said surface prior to the application of said paint by injecting rinsing water from a nozzle into said painting space, and drying said surface subsequent to the cleaning by jetting high-velocity air after discharging the injection of said rinsing water.

6. Apparatus for performing underwater painting on a ship or other under water structure such apparatus including a main body having a water-sealing box adapted to define a painting space on an underwater surface to be painted, shifting means for shifting the position of the whole painting apparatus to a desired painting position, fixing means for fixing said apparatus at said painting position, inflatable sealing means to contact the surface and seal said painting space, upon inflation, against surrounding water in a watertight manner, filling and draining means for filling water into said painting space and draining water therefrom and means to spray water-curable paint onto said surface in said space.

7. Apparatus as claimed in claim 6, wherein said sealing means includes an inflatable tube in a sleeve located on the side of the tube remote from the surface in use.

8. Apparatus as claimed in claim 7, including a resilient outer shell provided around said inflatable tube and between the tube and the sleeve.

9. Apparatus as claimed in claim 6, 7 or 8, wherein said shifting means include inflatable rubber tyres adapted to perform, when inflated, a double function of shifting said apparatus and lifting said apparatus from said surface.

10. Apparatus as claimed in claim 6, 7, 8 or 9, wherein said fixing means are electromagnets adapted to exert, when energized, an attracting force to fix said apparatus to the object to be painted.

11. A method of automatically effecting underwater painting of a ship or other structure, substantially as hereinbefore described with reference to the accompanying drawings.

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5. 12. Apparatus for automatically effecting under water painting of a ship or other structure, substantially as hereinbefore described with reference to and as shown by the accompanying drawings.

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