

PATENT SPECIFICATION

(11) 1 508 231

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- (21) Application No. 1847/75 (22) Filed 15 Jan. 1975
(23) Complete Specification filed 14 Jan. 1976
(44) Complete Specification published 19 April 1978
(51) INT CL³ B05C 1/00
(52) Index at acceptance B2L H
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(54) SUBMERSIBLE PAINTING APPARATUS

(71) We, A/S JOTUNGRUPPEN, a Norwegian body corporate of Sandefjord, Norway, 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:—

This invention relates to a submersible painting apparatus and is concerned with an apparatus which can be used underwater for applying paint to a submerged surface, for example the hull of a ship, by remote control from the surface.

In order to apply an anti-corrosive or anti-fouling paint to a ship's hull in areas normally below the water-line, it has hitherto generally been necessary to place the ship in dry-dock. This is both expensive and time-consuming and entails the ship being out of use while the painting operation is being carried out, which means a considerable loss of revenue to the ship's owners particularly in the case of the large ships such as oil tankers now in use.

To mitigate the foregoing disadvantages, some marine paints for underwater applications have become available within the last few years. However such paints have hitherto only been applied with the aid of divers who are required to operate under water painting apparatus for applying said paints. The necessity to use divers limits the usefulness of such paints and underwater apparatus and reduces their cost effectiveness over normal dry-dock painting.

Hence there is a need for an apparatus by means of which marine paints can be applied underwater to a submerged surface without the necessity for using divers.

In accordance with the present invention, there is provided a remotely-controllable submersible apparatus for applying paint underwater to a submerged surface, the apparatus comprising a remotely-controllable vehicle capable of being driven along a submerged surface, the vehicle having a housing defining a chamber having an open side and a pressure-reducing device capable in use of continuously maintaining a

reduced pressure inside the chamber relative to the pressure outside the chamber so as to cause the vehicle to adhere to the submerged surface with the open side of the chamber facing the submerged surface, and located at the rear of the vehicle remotely-controllable painting means capable of applying by rotary brush means underwater paint to the submerged surface.

The remotely-controllable painting means is preferably detachably mounted on the remotely-controllable vehicle for ease of servicing and/or replacement.

The submersible painting apparatus can advantageously incorporate a device for surveying submerged structures, that is for measuring or determining the mechanical or physical condition thereof.

The vehicle advantageously comprises a steerable driven wheel mounted so that the vehicle can be driven along the submerged surface, a remotely-operable steering device for steering the steerable wheel, and a motor for driving the steerable wheel.

The vehicle is remotely operable from above the water surface, for example by way of a control cable connecting a control console positioned on a work boat at the surface of the water and a junction box on the vehicle.

The steerable driven wheel of such a vehicle may be mounted within the chamber so that its running surface projects through the open surface of the chamber. The vehicle can also include two or more supporting wheels in addition to the steerable wheel.

The driving motor may drive only the steerable wheel, or all the wheels provided in such a vehicle. Alternatively the supporting wheels may be driven by independent motors.

The driving motor can be an electric motor or can be a motor operated by a hydraulic medium under pressure.

The pressure reducing device can be an impeller having blades located within an outlet duct provided in the chamber wall. The impeller can be driven by an oil-cooled

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electric motor, and the cooling oil under pressure can be used as a hydraulic source of power for pumps or motors in the apparatus.

5 The edge region of the housing which bounds the open side and which comes into close proximity with the submerged surface can be provided with a series of corruga-
10 tions which, in use of the apparatus, establish turbulent conditions and reduce the ingress of water into the chamber; this means that less power is required to maintain a reduced pressure inside the chamber relative to the pressure outside the chamber. The
15 corrugations may be discontinuous but are preferably continuous.

The vehicle can also include a device for sensing and indicating the attitude of the vehicle, as well as a device for sensing the
20 position of the chamber relative to a submerged surface.

It is desirable that the apparatus of the present invention is either slightly buoyant or is of neutral buoyancy.

25 To assist in operating the apparatus of the present invention by remote control it is desirable to have a control console at the surface of the water. Advantageously the console can be positioned on a work boat
30 floating near the submerged surface (for example, part of the hull of a vessel) on which the underwater painting operation is to be carried out. Alternatively the console may be mounted on a vessel the submerged
35 surfaces of which are to be painted. The control console can include a paint pressure gauge, a tachometer which can be connected to any individual paint brush as
40 desired, means for controlling the supply of paint to the paint brushes, means for controlling the movement of the brushes to an inoperative position, and means for controlling the movement and position of the
45 apparatus on a submerged surface to be painted.

In practice, if the submerged surface is in need of cleaning, the cleaning is effected before the painting is carried out. Once the submerged surface is clean, the submerged
50 surface can be painted using the apparatus of the present invention.

The remotely-controllable painting means mounted on the rear of the vehicle (with respect to the normal forward direction of
55 movement) may comprise a plurality of rotary paint brushes, means for rotating the brushes and means for feeding underwater paint to each of said brushes. The brushes have bristles which are preferably sub-
60 stantially parallel to the axis about which each brush is rotatable.

The painting means is preferably provided with resilient suspension means for ensuring that each brush can move in a direction
65 substantially at right angles to the surface being

painted and can maintain a substantially constant pressure on said surface. In addition the painting means is preferably provided with remotely-operable hydraulic
70 means for withdrawing the plurality of brushes from an operative to an inoperative position and, when desired, for allowing the brushes to return to the operative position.

In order to enable a broad band of submerged surface to be painted during one
75 movement of the apparatus, the plurality of rotary brushes may be arranged in a manner such that during advancement of the apparatus, the areas covered by adjacent brushes overlap, thereby ensuring that the
80 desired broad band of submerged surface is painted. Thus the brushes may be arranged, for example, in two parallel rows with the brushes staggered, so as to ensure the aforementioned overlap. In such an arrangement it is desirable that one row of brushes should
85 rotate in a direction opposite to that of the other row, so as to reduce the tendency of the rotating brushes to cause the painting apparatus to creep sideways.

90 Paints capable of being applied under water are commercially available. If required, the application of a suitable underwater anti-fouling paint can be preceded by the application to the cleaned submerged surface of an underwater primer. The paint supply and the pump for feeding the paint to the brushes will generally be
95 mounted on a work boat (as for the control console) or on the vessel being painted.

100 As previously mentioned, the apparatus of the invention may incorporate a device capable of carrying out underwater surveying operations, i.e. measurement or detection of mechanical or physical
105 properties of submerged structures. Generally the underwater surveying will not be carried out at the same time as the underwater painting because of the deleterious effect which the paint may have on sensitive
110 parts of the surveying equipment. However simultaneous underwater painting and surveying may be possible provided the necessary precautions are taken. Different types of suitable underwater surveying
115 instruments which can be incorporated in the painting apparatus of the invention are commercially available. The surveying equipment can be capable of various surveying operations, for example measuring
120 the thickness of the hull of a vessel or detecting flaws or depressions in the hull of a vessel. The nature of the surveying equipment will depend on the nature of the survey work to be carried out.
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For a better understanding of the invention and to show how the same may be carried out effect a preferred embodiment of the submersible painting apparatus of the invention will now be described in greater
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detail by reference to the accompanying drawings in which:—

Figure 1 is a perspective view from the port side of a remotely-controllable vehicle for a submersible painting apparatus;

Figure 2 is an underside plan view of the complete submersible painting apparatus having remotely-controllable painting means fastened to the vehicle;

Figure 3 is a top plan view on an enlarged scale of part of the painting means; and

Figure 4 is a vertical cross-section along the line IV—IV of Figure 3

Referring to Figures 1 and 2 of the drawings, the submersible painting apparatus is constituted by a vehicle 1 and painting means 2 fastened to the rear of the vehicle 1. The vehicle is provided with an impeller 3 driven by an electrically-powered motor 7 which is capable of rotating the impeller 3 in a manner such that, when the vehicle is submerged, water is expelled from a chamber defined by a housing of the vehicle to a region below the plane of the paper. The vehicle 1 is provided with a remotely-operable steerable wheel 4 and two support wheels 5 and 6. All three wheels are driven by independent hydraulic motors.

As can be seen from Figures 1 and 2, the vehicle 1 has an outline generally resembling a "D" with the straight edge of the "D" constituting the rear (or stern) of the vehicle as indicated by the reference numeral 8. The vehicle includes a housing 9 which is generally hollow apart from the various mechanical components accommodated therein. The housing 9 is provided with a plurality of stanchions 10 which support a rail 11 on to which ropes for securing the apparatus can be made fast.

When in use the painting apparatus is normally remotely controlled at the water surface from a work boat in which is mounted a control console, a supply of paint and a motor for feeding the paint to the paint brushes of the apparatus. This motor can be an electric positive displacement pump. The control console is attached to the painting apparatus by means of a multi-lead cable which is attached to the junction box 12 which in turn is connected by a further cable 13 to an electrical junction box 14 through which is fed power to operate means for withdrawing the paint brushes 15 from an operative to an inoperative position and to operate the tachometer provided on the control console for each of the paint brushes.

Referring now to Figures 3 and 4 of the accompanying drawings, the painting means for the submersible painting apparatus is provided with nine rotary brushes 15 which are arranged in two rows, one of five brushes and one of four brushes, with the brushes being staggered as can be seen in

Figure 2. The brushes can be made of bristle, nylon or horsehair. Each brush 15 is coupled by bolts 16 to a universal joint 17 which is driven by an hydraulic motor 18 operated by hydraulic fluid which enters by supply pipe 19 and leaves by return pipe 20. Underwater paint can be fed to the brush 15 from a paint manifold 21 through a flexible feed pipe 22 which communicates with the brush 15 through a hollow shaft in the motor 18. Each hydraulic motor 18 is retained in position by two pairs of leaf springs each pair comprising an upper leaf spring 23 and a lower leaf spring 24 fastened respectively to an upper foundation plate 25 and a lower foundation plate 26 both of which are in turn mounted on a steel backplate 27 attached to the vehicle rear 8. Also attached to the backplate 27 are supporting arms 28 for the paint manifold 21. A coil spring 29 extends between the end of the leaf spring 23 which is adjacent to the motor 18 and a ring mounted on an eccentric shaft 30, which can be manually adjusted to vary the tension of spring 29 as and when required. This spring arrangement serves to maintain substantially constant the pressure of the brushes 15 on the surface being painted.

An hydraulically-operated ram 31 (one of a pair the second not being shown in the drawings) is secured at one end to the backplate 27 by a bracket 32 and at its other end to a lever 33 by a hinged bolt 34. The lever 33 transmits movement of the ram 31 to a shaft 35 to which lever 33 is fixed. The supply of hydraulic fluid to the ram 31 by the pipes 36 is controlled by a solenoid valve (not shown) the electrical power for which is supplied via the junction box 14 (see Figure 1). When the solenoid valve is operated, hydraulic fluid is caused to flow through the ram 31 in a direction such as to cause the lever 33 and hence the transverse bar 37 to travel in an upwards direction, so withdrawing the brushes 15 from an operative to an inoperative position. When required, the brushes can be returned to the operative position under the influence of coil spring 29 by allowing hydraulic fluid to flow through the ram 31 in the opposite direction.

If desired to assist the flotation of the submersible painting apparatus, a buoyancy bar (not shown) can be attached so as to be positioned astern of the paint brushes. The buoyancy bar can be made of glass fibre reinforced polyester resin.

WHAT WE CLAIM IS:—

1. A remotely-controllable submersible apparatus for applying paint underwater to a submerged surface, the apparatus comprising a remotely-controllable vehicle capable of being driven along a submerged surface, the vehicle having a housing defining a chamber having an open side and a



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detail by reference to the accompanying drawings in which:—

Figure 1 is a perspective view from the port side of a remotely-controllable vehicle for a submersible painting apparatus;

Figure 2 is an underside plan view of the complete submersible painting apparatus having remotely-controllable painting means fastened to the vehicle;

Figure 3 is a top plan view on an enlarged scale of part of the painting means; and

Figure 4 is a vertical cross-section along the line IV—IV of Figure 3.

Referring to Figures 1 and 2 of the drawings, the submersible painting apparatus is constituted by a vehicle 1 and painting means 2 fastened to the rear of the vehicle 1. The vehicle is provided with an impeller 3 driven by an electrically-powered motor 7 which is capable of rotating the impeller 3 in a manner such that, when the vehicle is submerged, water is expelled from a chamber defined by a housing of the vehicle to a region below the plane of the paper. The vehicle 1 is provided with a remotely-operable steerable wheel 4 and two support wheels 5 and 6. All three wheels are driven by independent hydraulic motors.

As can be seen from Figures 1 and 2, the vehicle 1 has an outline generally resembling a "D" with the straight edge of the "D" constituting the rear (or stern) of the vehicle as indicated by the reference numeral 8. The vehicle includes a housing 9 which is generally hollow apart from the various mechanical components accommodated therein. The housing 9 is provided with a plurality of stanchions 10 which support a rail 11 on to which ropes for securing the apparatus can be made fast.

When in use the painting apparatus is normally remotely controlled at the water surface from a work boat in which is mounted a control console, a supply of paint and a motor for feeding the paint to the paint brushes of the apparatus. This motor can be an electric positive displacement pump. The control console is attached to the painting apparatus by means of a multi-lead cable which is attached to the junction box 12 which in turn is connected by a further cable 13 to an electrical junction box 14 through which is fed power to operate means for withdrawing the paint brushes 15 from an operative to an inoperative position and to operate the tachometer provided on the control console for each of the paint brushes.

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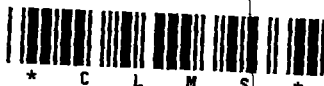
An hydraulically-operated ram 31 (one of a pair the second not being shown in the drawings) is secured at one end to the backplate 27 by a bracket 32 and at its other end to a lever 33 by a hinged bolt 34. The lever 33 transmits movement of the ram 31 to a shaft 35 to which lever 33 is fixed. The supply of hydraulic fluid to the ram 31 by the pipes 36 is controlled by a solenoid valve (not shown) the electrical power for which is supplied via the junction box 14 (see Figure 1). When the solenoid valve is operated, hydraulic fluid is caused to flow through the ram 31 in a direction such as to cause the lever 33 and hence the transverse bar 37 to travel in an upwards direction, so withdrawing the brushes 15 from an operative to an inoperative position. When required, the brushes can be returned to the operative position under the influence of coil spring 29 by allowing hydraulic fluid to flow through the ram 31 in the opposite direction.

If desired to assist the flotation of the submersible painting apparatus, a buoyancy bar (not shown) can be attached so as to be positioned astern of the paint brushes. The buoyancy bar can be made of glass fibre reinforced polyester resin.

WHAT WE CLAIM IS:—

1. A remotely-controllable submersible apparatus for applying paint underwater to a submerged surface, the apparatus comprising a remotely-controllable vehicle capable of being driven along a submerged surface, the vehicle having a housing defining a chamber having an open side and a

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- pressure-reducing device capable in use of continuously maintaining a reduced pressure inside the chamber relative to the pressure outside the chamber so as to cause the vehicle to adhere to the submerged surface with the open side of the chamber facing the submerged surface, and located at the rear of the vehicle remotely-controllable painting means capable of applying by rotary brush means underwater paint to the submerged surface.
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2. An apparatus as claimed in Claim 1, wherein the remotely-controllable painting means is detachably mounted on the remotely-controllable vehicle.
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3. An apparatus as claimed in Claim 1 or 2, and further comprising a device for surveying submerged structures.
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4. An apparatus as claimed in Claim 1, 2 or 3, wherein the vehicle further comprises a steerable driven wheel mounted so that the vehicle can be driven along the submerged surface, a remotely-operable steering device for steering the steerable wheel, and a motor for driving the steerable wheel.
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5. An apparatus as claimed in Claim 4, wherein the vehicle is provided with a junction box to which can be connected in use one end of a control cable, the other end of which can be connected to a control console positioned on a work boat floating near the submerged surface.
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6. An apparatus as claimed in any preceding claim, wherein the remotely-controllable painting means comprises a plurality of rotary paint brushes, means for rotating the brushes and means for feeding underwater paint to each of said brushes.
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7. An apparatus as claimed in Claim 6, wherein each rotary brush is formed with bristles which are substantially parallel to
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the axis about which the brush is rotatable.

8. An apparatus as claimed in Claim 6 or 7, wherein the painting means is provided with resilient suspension means for ensuring that each brush can move in a direction substantially at right angles to the submerged surface to be painted and can maintain a substantially constant pressure on said surface.

9. An apparatus as claimed in Claim 6, 7 or 8, wherein the painting means is provided with remotely-operable hydraulic means for withdrawing the plurality of brushes from an operative to an inoperative position and, when desired, for allowing the brushes to return to the operative position.

10. An apparatus as claimed in Claim 6, 7, 8 or 9, wherein the plurality of brushes are arranged in two parallel rows with the brushes staggered so that in use the areas covered by adjacent brushes will overlap.

11. An apparatus as claimed in Claim 10, wherein one row of brushes is arranged to rotate in a direction opposite to that of the other row.

12. A submersible painting apparatus substantially as hereinbefore described with reference to, and as shown in, the accompanying drawings.

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