Description

Title: Robot for renovation by stripping and/or coating paint, and/or for inspection of at least one wall having a large curved surface and/or of great height, in particular a structure having circular cross section(s). Use for stripping and painting hulls or bottoms of boats, tanks, such as petroleum tanks, or pipes.

Technical field

The present invention relates to the general field of inspection and/or renovation by surface treatment and painting of large-dimension structures/objects.

It relates more particularly to the field of renovation by surface stripping and, if appropriate, coating a wall with a large surface and/or of great height, more particularly a curved surface, in particular a structure with one or more circular cross section(s), with paint. These may in particular be hulls, bottoms of ships, tanks, such as oil tanks, or pipes.

The phrase "wall with a large surface and/or of great height" is understood to mean any object that cannot be inspected and/or renovated by an individual alone and usually requires at least the use of scaffolding and/or any handling means for moving an individual.

The present invention aims more particularly to propose an autonomous robot intended for renovating and/or inspecting such a wall, in order to reduce service times, the associated costs and the risks for operators and the environment.

Although it is described with reference to an advantageous application for renovating a cylindrical tank, the invention applies to any robot intended for any type of inspection and/or repair work on large-dimension structures.

Prior art

It is necessary to regularly maintain ships' hulls after a period of service; they are generally subjected to a maintenance operation involving a plurality of operations intended to give them/restore the desired esthetic appearance, such as surface preparation such as (water-jet or abrasive) surface stripping and painting.

On account of its mandatory nature, this maintenance operation requires ships to be dry docked.

In essence, this involves removing the existing outer coating as well as any oxidation and replacing it with a new coating.

In general, maintenance or renovation consists in suitably preparing the surface for the application of a new coating of paint. This preparation can, for example, consist in surface stripping with abrasive blasting, also generally referred to as shot blasting, or ultra-high-pressure (UHP) water blasting that makes it possible to create or recover a certain surface roughness for the adhesion and application of a new coating of paint.

Each step of the process of renovating a given ship must be carried out with extreme care in order to avoid the presence of defects that could seriously impair the final esthetic quality.

Despite having numerous and varied constraints and uses, all shipyards carrying out a process of renovation of a ship's hull face the same challenges: high repair costs, large service interruptions, major impact on the ship, personnel safety, and the effectiveness of the repair.

Until now, the various renovation steps have usually been carried out by hand by operators or using several suitable tools for stripping the coatings and spraying the paint onto the desired surface of the hulls.

These manual steps have a certain number of major drawbacks.

First of all, each step requires a long execution time, which has an impact on the final cost of the work. Thus, each step must be relatively precise because the tools used, for example, for surface stripping, ultra-high-pressure (UHP) water lances, at a pressure of around 3000 bar, or shot blasting lances, have a relatively limited area of action and the attention of the operator must be sustained. As a result, these operations can take a considerable amount of time both for the work carried out and for verifications, especially since the surfaces of ships' hulls are very large.

Secondly, the effectiveness of the steps depends heavily on the skill of the operators carrying them out.

In addition, as regards the painting step, this is carried out using a paint spraying tool, which atomizes the paint particles, some of which do not adhere to the surface to be painted and are thus dispersed into the environment. Since the anti-corrosion paints used for these applications typically contain toxic or polluting substances, it is easy to understand how their dispersion can be harmful to the environment and people working near painting areas.

In this regard, recent EU standards include increasingly restrictive measures on the emission of such substances into the environment.

The applicant therefore desired to automate this maintenance or renovation of these ships' hulls and to implement a robot that can carry out these renovation operations.

However, the specifications imposed for such a robot are strict and significant, in particular on account of the strong constraints intrinsic to the dry docking of ships.

The inventors of the present invention have therefore reviewed the existing solutions.

They first of all concluded that none of the existing robotic or mechanized systems were able to meet all of the requirements for renovating ships' hulls.

Certain devices for painting ships' hulls or the like are known from patent documents.

WO01/34309 describes a device for spraying paint onto a ship's hull in a dry dock, comprising a row of spray nozzles housed in a hood mounted at the end of a telescopic arm itself pivotably mounted on a frame that can move in translation on a rail along the hull.

US5398632 proposes a scaffolding system installed on the dock floor around the hull with lifts that can move in elevation and toward/away from the hull and in which painters can take up position.

US4890567 describes a cleaning system with a cleaning head that can move and be fastened to ship's hulls by electromagnetic tracks and that incorporates ultrasonic cleaning means.

EP2090506B1 discloses a platform with two wheelsets and a double scissor aerial lift supporting an elongate table equipped with a travel rail along which a six-axis robot holding a paint gun can slide in order to paint the surface of a ship's hull.

CN105643587 discloses a system for painting ships' hulls using a six-axis robot holding the painting tool mounted at the end of an articulated arm of a lift that moves along the dock floor.

CN2019158233 discloses a painting robot system of the type that moves along ships' hulls using cables, in which the frames supporting the drive motors and cables are installed in-situ in and around the dry dock, the paint spraying nozzles being moved in elevation by the cables while being moved horizontally by a telescopic arm supporting said nozzles.

CN108942897 discloses a system for painting ships' hulls comprising a robotic paint head that moves along the hulls of ships using cables, the cables being fastened to two bogies, one moving on the ground and the other above the ship.

CN108313237 discloses a system for shot-blasting ships' hulls comprising a robot that moves using a winch onboard the ship and is fastened to the surface of the hull by suction using suction cups.

CN107253147 and CN107081771 each describe a sandblasting surface-stripping system comprising a sandblasting robot that rolls along the hull of the ship and is held by permanent magnets, with an anchor point on the hull and a cable winch for moving it.

KR101444392B1 concerns a paint application system with a 6-axis robot mounted at the end of a crane arm.

WO2012/080448 discloses a complete maintenance system (UHP cleaning, painting) with a scaffolding tower in the vicinity of the hull on which a telescopic arm system that supports the work tools can move vertically.

WO2010/057942 discloses a similar system to WO2012/080448, with the essential differences that the scaffolding tower bears a plurality of work cabins, one of which is directly controlled by an individual inside and which bears an articulated arm supporting the work tools.

WO2018/209367 describes a system of rails assembled together to move assemblies for hull maintenance (cleaning, painting) along a ship's hull.

EP2618942B1 discloses the use of a 6-axis robot that carries a paint gun and is supported by the lift of an aerial platform for painting ships' hulls in a dry dock. The lift is equipped with distance sensors for measuring the distance of the lift from the hull surface to be painted, the operation of the sensors being servo-controlled by the unit for commanding and controlling the movement of the platform. Furthermore, the proposed system necessarily comprises an air intake along the surface to be painted and the defined control/command makes it possible to adjust the distance between the lift and the surface to be painted in order to optimize the airflow taken in.

All of the solutions proposed lack the ability to quickly, inexpensively and effectively remove stubborn defects from the surface of the hulls, more particularly those resulting from corrosion of the latter and the ability to apply a homogeneous coating over the entire surface of a ship's hull regardless of its profile (planar, concave, convex).

Furthermore, the proposed solutions do not allow sufficiently precise localization in space to guarantee homogeneous renovation treatment over the entire surface of a ship's hull to be renovated.

Finally, it is far from certain that among all of the proposed solutions, at least one could be implemented completely autonomously over the entire surface of a ship's hull, i.e. without any human intervention.

To overcome these drawbacks, in particular in order to considerably reduce intervention times and associated costs, to reduce the complexity of the work, and to increase the effectiveness and homogeneity of the surface treatments over the entire surface of the walls to be renovated, the inventors of the present invention have proposed a robot according to patent application WO2021/074327. This robot is realized on the base of an aerial lift, which may be standard, equipped with a plurality of sensors that precisely compensate for the lack of equipment provided by the lift manufacturers, in order to be able to provide the control/command unit with information useful for determining the very precise location in space, in real time, of the platform of the lift and therefore of the tool holder mounted on the platform.

While this robot is completely satisfactory for most configurations of surfaces to be renovated, the inventors have observed that some other surface configurations could not be treated, at least with a suitable intervention time, on account of being physically impossible for the robot to access and/or of a complex surface, in particular with a significant curvature and/or with an overhang to be reached. Such a specific configuration is encountered, for example, in the case of hulls or bottoms of ships.

There is therefore a need to improve robots intended for renovation by surface stripping and/or by painting walls with a large surface and/or of great height, more particularly walls with complex surfaces, such as hulls or bottoms of ships in a dry dock or overhanging mechanical assemblies to be reached.

The aim of the invention is to at least partially meet this need.

Summary of the invention

To this end, the invention relates, in one of its aspects, to a robot for renovating by surface stripping and/or coating with paint, and/or inspecting at least one wall of a structure with a curved surface, in particular a structure with circular cross section(s), comprising:

- a scissor lift comprising the following components:

  • a movable base comprising at least one steering axle defining a first axis (Axis 1) and a translational-movement motor defining a second axis (Axis 2),

• a platform mounted so as to move in vertical translation on the movable base along a third axis (Axis 3),

- a Cartesian robot comprising:

• a load-bearing structure mounted so as to move in horizontal translation on the platform along a fourth axis (Axis 4),

• a tool-holder assembly, designed to hold a renovation and/or inspection tool, the tool-holder assembly being mounted so as to move in rotation on the load-bearing structure about a fifth axis (Axis 5) orthogonal to the fourth axis (Axis 4), in horizontal translation on the load-bearing structure along a sixth axis (Axis 6) orthogonal to the fifth axis (Axis 5), in rotation on the load-bearing structure about a seventh axis (Axis 7) parallel to the sixth axis (Axis 6) and in translation on the load-bearing structure along an eighth axis (Axis 8) orthogonal to the seventh axis (Axis 7);

- a plurality of sensors comprising:

• at least one linear-movement sensor, designed to measure the vertical deployment of the platform with respect to the movable base along the third axis (Axis 3),

• at least one angular-measurement sensor, designed to measure the angular position of the tool-holder assembly with respect to the load-bearing structure about the fifth axis (Axis 5),

• at least two distance measuring sensors designed to each measure a distance of a point on the tool-holder assembly from the wall to be renovated and/or inspected;

• at least two distance measuring sensors designed to measure an inclination of the tool-holder assembly with respect to the wall to be renovated and/or inspected;

- a control/command unit connected to the plurality of sensors and to the means for moving the components of the lift and the Cartesian robot along/about the first to eighth axes, the control/command unit being designed to automatically move the components of the lift and the Cartesian robot along/about one and/or another of the first to eighth axes, on the basis of the information provided by the plurality of sensors and according to a predefined sequence of renovating and/or inspecting areas of the wall without the movable base of the lift having to be moved.

According to one advantageous embodiment, the tool-holder assembly comprises:

- a first support mounted so as to move in rotation on the load-bearing structure about the fifth axis (Axis 5),

- a second support mounted so as to move in translation on the first support along the sixth axis (Axis 6),

- a third support mounted so as to move in rotation on the second support about the seventh axis (Axis 7),

- a fourth support mounted so as to move in translation on the third support along the eighth axis (Axis 8) and to which the renovation and/or inspection tool is intended to be fastened.

With these supports, the tool-holder assembly is mechanically robust and very precise and reliable when moving the tool. Furthermore, these supports may consist of assembled-together profiled elements, thus reducing the weight of the tool-holder assembly.

According to this embodiment and one advantageous variant, the robot comprises an electric motor, which is fastened to the load-bearing structure and the output shaft of which defining the fifth axis (Axis 5) is fastened to the first support in order to drive it in rotation.

According to this embodiment and another advantageous variant, the robot comprises:

- an electric motor, which is fastened to the first support;

- a ball screw defining the sixth axis (Axis 6), which is fastened to the first support so as to be rotated by the electric motor of the first support;

- a nut, which forms, with the ball screw, a nut system for driving the second support in translation.

According to this embodiment and another advantageous variant, the robot comprises:

- an electric motor, which is fastened to the second support;

- a shaft defining the seventh axis (Axis 7), which is fastened to the third support so as to be rotated by the electric motor of the second support in order to drive the third support in rotation.

According to this embodiment and another advantageous variant, the robot comprises a cylinder, which is fastened to the third support and the rod of which defining the eighth axis (axis 8) is fastened to the fourth support in order to drive it in translation.

Thus, the dynamics of the various axes of the tool-holder assembly can be realized with a small number of robust, precise and reliable electrical components.

According to another advantageous embodiment, the robot comprises:

- an electric motor, which is fastened to the platform of the lift;

- a ball screw defining the fourth axis (Axis 4), which is fastened to the load-bearing structure so as to be rotated by the electric motor of the platform;

- a nut fastened to the load-bearing structure and forming, with the ball screw, a nut system for driving the load-bearing structure in translation. Here too, the dynamics of the movement of the load-bearing structure relative to the lift can be realized with a screw-nut system coupled to an electric motor that is robust, reliable and precise.

Advantageously, the linear-movement sensor for measuring the vertical deployment of the platform is an absolute wire-draw encoder comprising an encoder fastened to the platform and to a cable mechanism comprising a drum fastened to the movable base and around which a cable is wound, the free end of the cable being fastened to the platform.

Further advantageously, the angular-measurement sensor comprises two first laser rangefinders fastened at a distance from one another on the tool-holder assembly.

Further advantageously, the at least one linear-movement sensor for measuring the horizontal movement of the tool-holder assembly with respect to the load-bearing structure comprises a plurality of inductive sensors fastened to the load-bearing structure.

Further advantageously, the at least two sensors for measuring the distance between the tool holder and the wall to be renovated and/or inspected are two second laser rangefinders fastened at a distance from one another on the tool-holder assembly.

Further advantageously, the at least two sensors for measuring the inclination of the tool-holder assembly with respect to the wall to be renovated and/or to be inspected are two second laser rangefinders fastened at a distance from one another on the tool-holder assembly.

The movable base preferably comprises at least one further steering axle defining a ninth axis (Axis 9).

According to one advantageous embodiment, the control/command unit comprises a control/command PLC connected to each of the plurality of sensors, preferably via CAN bus, a lift PLC connected to the control/command PLC, preferably via Ethernet connection,

the control/command PLC being designed to transmit its command instructions, on the one hand, to the lift PLC, which commands the movement of the components of the lift along/about one and/or another of the first to third axes, and, if appropriate, about the ninth axis and, on the other hand, to the Cartesian robot for moving the load-bearing structure and/or the tool-holder assembly along/about one and/or another of the fourth to eighth axes.

Preferably, the control/command unit is designed to automatically move the movable base along/about one and/or another of the first and second axes and, if appropriate, about the ninth axis, once the predefined sequence has been completed.

According to one advantageous embodiment, the robot comprises a cabinet that houses all of the electrical components and the control/command unit, said cabinet being fastened to the lift platform, at the opposite longitudinal end to the end at which the Cartesian robot is arranged.

Advantageously, the tool-holder assembly is designed to hold a shot-blasting nozzle fitted with a suction hood for recycling shot or a high-pressure water-blasting nozzle with a hood for re-suction of blasted water or a paint-spraying nozzle with a device for re-suction of paint that is not deposited on the wall of the structure.

The invention also relates to a method for operating a robot as described above, along a wall of a structure with a curved surface, in particular a structure with circular cross section(s), comprising the following steps carried out automatically by the control/command unit:

i/ positioning the lift, if appropriate by remote operation, and therefore the tool-holder assembly holding the renovation tool, opposite a given point on the wall around a first work area;

ii/ measuring the distance using at least two measuring sensors and calculating using the control unit so as to position the tool-holder assembly parallel to the wall and centered around the first work area;

iii/ renovating the first work area by moving the load-bearing structure relative to the lift and/or the tool-holder assembly along a first curved strip of limited height along the wall;

iv/ once the renovation of the first work area is finished, automatically sliding the load-bearing structure of the robot toward the platform of the lift and retracting the lift away from the wall;

v/ repeating steps i/ and iv/ in one or more working areas in addition to the first, until a first curved strip of the entire wall height has been renovated;

vi/ moving the robot parallel to the wall, by one increment, to repeat steps i/ to v/ so as to renovate at least one second curved strip of the entire wall height, in the continuity of the first strip.

In other words, the operating method of the invention is sequential, on the basis of the information provided by the sensors installed with calibration or correction thereof, in order to produce a vertical curved work (cleaning, surface stripping or painting in the case of a hull or bottom of a ship) strip, over a limited height and then over the entire height of a strip and to repeat this operation along the wall to be renovated.

By allowing remote operation for the movements of the movable base of the lift, the base and lift can be constantly under the control of an operator, thereby limiting the safety constraints of using the robot.

Once the scissor lift has been positioned, preferably so as to be perpendicular to the longitudinal axis of the curved wall, and the Cartesian robot has been positioned with respect to the wall, on the basis of the measurements from additional distance sensors and calculations, the control/command unit can execute the movement commands for the different axes of the tool-holder assembly according to the precise real-time knowledge of the position in space.

The invention finally relates to the use of the robot as described above, for renovation with surface stripping, preferably by abrasive blasting or water-jet surface stripping, and, if appropriate, with coating a hull or a bottom of a ship or a cylindrical tank, such as an oil tank, or a pipe, in particular a pressure pipe, with paint.

Thus, the invention essentially consists of an autonomous robot realized on the base of a scissor lift, which may be standard, on which there is installed a Cartesian robot, a load-bearing structure of which is able to slide on the platform of the lift and which supports a robust, precise and reliable tool-holder assembly.

Because it can be implemented starting from a standard scissor lift, the robot according to the invention is not specific to a given application. A standard scissor lift can thus typically be raised from the ground to heights of up to 18 m above the ground.

The robot is perfectly suited for renovating walls with curved surfaces, even with great curvature that in particular starts at a relatively low height from the ground.

Typically, the robot according to the invention is perfectly suited to renovating ships' hulls in a dry dock, which may have a large minimum radius of curvature, typically from 3 to 4 m, and the low point of which is at a height of 2 m above the ground and the high point of which is up to a height of 10 m above the ground.

The compact footprint of the robot with scissor lifts and a Cartesian robot is perfectly suited to the very reduced accessibility around a ship under renovation, in particular on account of the presence of scaffolding, tools, etc. Furthermore, this compact footprint enables numerous activities, in particular maintenance activities around the work area in which the robot according to the invention operates.

The invention has numerous advantages, including:

- the possibility of renovating, in particular by surface stripping, cleaning or painting, a curved wall, in particular a large-dimension and/or large-curvature circular wall, the low point of which may be very close to the ground, such as a ship's hull in dry dock with a minimum radius of curvature of 3.8 meters, from a height of 2 m up to a height of 10 m above the ground;
- a robot that can be easily realized from a standard scissor lift;
- a robot with a very small footprint that allows renovations to be carried out even in environments with restricted accessibility and/or that require simultaneous operations around it, such as a shipyard.
- the possibility of remote operation for the movement of the scissor lift, thereby making the robot safer to use;
- movement of the Cartesian robot that can be fully automated with the control/command unit, thereby making the renovation operations performed by the tools held by the tool-holder assembly of the Cartesian robot very precise and reliable.

Other advantages and features of the invention will become more clearly apparent upon reading the detailed description of embodiments of the invention, which is provided by way of non-limiting illustration, with reference to the following figures.

Brief description of the drawings

[Fig 1] Figure 1 is a schematic perspective view of a robot according to the invention intended for inspecting and renovating a wall with large curved surfaces, in particular circular surfaces of great height, in particular of a cylindrical tank, figure 1 showing the scissor lift of the robot in its fully folded position.

[Fig 2] Figure 2 is a perspective detail view of the robot according to figure 1, figure 2 showing the load-bearing structure of the Cartesian robot and its means for movement relative to the platform of the lift.

[Fig 3] Figure 3 is a perspective view of the Cartesian robot according to the invention.

[Fig 4] Figure 4 repeats the perspective view of figure 3 but only showing the load-bearing structure.

[Fig 5] Figure 5 is a perspective view of a first support of the tool-holder assembly of the robot, which is mounted so as to move in rotation on the load-bearing structure and supports laser rangefinders as well as means for moving a second support of the tool-holder assembly in translation.

[Fig 6] Figure 6 is a perspective view showing the load-bearing structure and the means for rotational movement on a first support on the load-bearing structure.

[Fig 7] Figure 7 is a perspective view showing the first support mounted so as to move in rotation on the load-bearing structure as well as the second support mounted so as to move in translation on the first support.

[Fig 8] Figure 8 is a perspective view showing the second support and the means for moving a third support of the tool-holder assembly in rotation.

[Fig 9] Figure 9 is a perspective view of the third support and of the laser rangefinders borne by this third support.

[Fig 10] Figure 10 is a perspective view of the second, third and fourth supports mounted so as to move in translation on the third support and to which the renovation and/or inspection tool is intended to be fastened.

[Fig 11] Figure 11 is a perspective view of the fourth support mounted so as to move in translation on the third support and to which the renovation and/or inspection tool is intended to be fastened.

[Fig 12] Figure 12 is a perspective view of the fourth support to which the renovation and/or inspection tool is intended to be fastened.

[Fig 13] Figure 13 is a schematic side view of a robot according to the invention, showing the scissor lift of the robot in its fully deployed position as well as the electrical cabinet it supports and a wire-draw encoder as a linear movement measuring sensor for measuring the vertical deployment of the platform with respect to the movable base.

[Fig 14] Figure 14 is a schematic view showing a renovation area of a cylindrical tank that can be reached by a robot according to the invention, which corresponds to the least favorable position for the stability of the robot.

[Fig 15] Figure 15 is an overview of the connections between the position and distance sensors of the robot according to the invention with the PLCs of the control/command unit as well as between the latter.

[Fig 16A], [Fig 16B], [Fig 16C] Figures 16A to 16C are schematic views showing various renovation areas of a cylindrical tank that can be reached by a robot according to the invention.

[Fig 17] Figure 17 is a block diagram of a method for operating the robot according to the invention to carry out an automatic cycle of renovating a curved wall, in particular a structure with a circular cross section such as a cylindrical tank.

[Fig 18A], [Fig 18B] Figures 18A and 18B are schematic views showing the steps of withdrawing the robot according to the invention from the wall, before the automatic cycle is carried out.

[Fig 19A], [Fig 19B], [Fig 19C] Figures 19A to 19C are schematic views showing various steps of positioning the Cartesian robot relative to a work area, i.e. an area to be renovated of a wall, before the automatic cycle is initiated.

[Fig 20] Figure 20 schematically illustrates the various automatic cycle and movement sequences in adjacent renovation strips that are envisioned to be carried out according to the method for operating the robot according to the invention.

Detailed description

It is specified here that throughout the present application, the terms "below", "above", "bottom", "top", "lower" and "upper" refer to an operating configuration of a scissor lift of a robot according to the invention. Thus, for example, the uppermost position of the platform of the lift is the highest elevation it can reach by maximum deployment with respect to the movable base.

It should also be specified that in all of the figures in which they are shown, the wheels supported by the fourth support of the tool-holder assembly should not be considered to be a renovation tool. These wheels are used for tests for tracking the curvature of a wall, such as a wall of a cylindrical tank, in order to enable work in contact with the wall without

damaging it. These wheels should not be taken into consideration for the fourth support to which an inspection tool (camera) or renovation tool (surface stripping, cleaning, painting) is directly fastened. They will therefore not be detailed hereinbelow.

Figure 1 shows a robot 1 according to the invention intended to carry out an inspection using a camera and/or a renovation with surface stripping by shot blasting or high-pressure water-blasting followed, if appropriate, by coating a wall C of a cylindrical tank, or of a ship's hull, with paint as part of maintenance.

A tank or ship's hull may have a plurality of circular cross sections typically of at least 3.5 m and from a height of 2 meters to a height of 10 meters above the ground.

As shown in figure 1, the robot 1 first comprises a scissor lift 2. This scissor lift 2 comprises, in a manner known per se, a movable base 20 with two axles 21, 22, at least one of which is a pivoting axle forming a steering axle defining a first axis "Axis 1", and a motor, not shown, for movement in translation defining a second axis "Axis 2", and a platform 23 mounted so as to move in vertical translation on the movable base along a third axis "Axis 3".

The lift 2 used may be a standard lift that is already marketed, and in particular may be remotely operated, i.e. controlled using a wired or wireless remote control. Typically, when its platform 23 is in the fully deployed position, the lift 2 can reach a height of 12 meters. The platform 23 can be raised by means of hydraulic cylinders arranged in the scissor structure.

The movable base 20 can be equipped with stabilizers that make it possible to distribute its mass uniformly over the ground and to ensure it is highly stable when fully deployed.

According to the invention, the robot according to the invention comprises a Cartesian robot 3 mounted on the scissor lift 2.

More precisely, the Cartesian robot 3 comprises a load-bearing structure 30 mounted so as to move in horizontal translation on the platform along a fourth axis "Axis 4" and a tool-holder assembly 31 designed to hold a renovation and/or inspection tool. The tool (not shown) may be a shot-blasting nozzle fitted with a suction hood for recycling shot or a high-pressure water-blasting nozzle with a hood for re-suction of blasted water or a paint-spraying nozzle with a device for re-suction of paint that is not deposited on the wall of the structure.

Translation along Axis 4 makes it possible to bring the tool-holder assembly 31 closer to the hull C to be renovated. The translation travel can typically be of the order of 800 mm and limited to a value of less than 600 mm for safety reasons. As illustrated, the load-bearing

structure 30 advantageously consists of profiled elements with a square cross section, in particular made of steel, that are welded together.

As shown in more detail in figure 2, this translation along Axis 4 can be ensured by an electric motor 24 that is fastened to the platform and drives in rotation, in particular by means of a remote transmission, for example using a belt, a screw 25 of a screw-nut system, the nut (not visible) being fastened to the load-bearing structure 30. The platform 23 is also provided with a pair of rails 230 on which at least one pair of sliders 300, for example two sliders, fastened to the load-bearing structure 30 can slide.

As shown in more detail in figure 3, the tool-holder assembly 31 is mounted so as to move in rotation on the load-bearing structure 30 about a fifth axis "Axis 5" orthogonal to Axis 4, which is in horizontal translation on the load-bearing structure along a sixth axis "Axis 6" orthogonal to "Axis 5", in rotation on the load-bearing structure about a seventh axis "Axis 7", which is parallel to "Axis 6" and in translation on the load-bearing structure along an eighth axis "Axis 8" orthogonal to the seventh axis at Axis 7.

A tool (not shown) for renovating and/or inspecting the wall to be renovated is fastened to the end of the tool-holder assembly 3. Preferably, for surface-stripping operations, the tool is a shot-blasting nozzle fitted with a suction hood for recycling shot or a high-pressure water-blasting nozzle with a hood for re-suction of blasted water.

The rotation about Axis 5 enables the tool-holder assembly 31 to be oriented parallel to the hull with an angle of travel that can typically range from -30 to +30°.

The translation along Axis 6 will enable the tool to be moved horizontally in order to carry out renovation in a strip with horizontal movement, typically at most 610 mm, which can be limited to 500 mm for safety reasons.

The rotation along Axis 7 will allow the tool to be oriented parallel to the hull with an angle that can typically range from -45 to +90°.

The translation along Axis 8 will allow the tool to be moved in or out relative to the hull C over a distance typically of 200 mm. This translation will thus allow the tool to be pressed against the hull during a renovation operation.

According to one advantageous variant, as illustrated in figure 1, the movable base 20 may comprise at least one further steering axle 22 defining a ninth axis (Axis 9). An additional steering axle can make it easier to maneuver the scissor lift 2, in particular in a congested

environment, which may be the case for a renovation site, in particular if other operations are being carried out around it, in particular operations requiring scaffolding.

Several embodiments can be envisioned for producing the tool-holder assembly 31 on the load-bearing structure 30 of the Cartesian robot 3.

According to an embodiment illustrated in figures 3 to 12, the tool-holder assembly 31 consists of four supports 32, 33, 34, 35 mounted so as to move with respect to one another along/about the various Axes 5 to 8.

More precisely, the first support 32 is mounted so as to move in rotation on the load-bearing structure about Axis 5.

To this end, as shown in figures 4 to 6, an electric motor 320, which is fastened to the load-bearing structure and the output shaft 321 of which defines Axis 5, is fastened to the first support 32 in order to drive it in rotation. This output shaft 321 can be mounted through a bushing stop 322 and a shaft support 323, which are both mounted in mounting plates 324 at a distance from one another and fastened directly to the load-bearing structure 30. As illustrated, the second support 33 may consist of a folded metal sheet, in particular made of aluminum, with reinforcements made of profiled elements, in particular made of aluminum.

The second support 33 is mounted so as to move in translation on the first support 32 along Axis 6. To this end, as shown in figures 7 to 9, an electric motor 330 is fastened to the first support 32 and a ball screw 331 defining Axis 6 is fastened to the first support 32 so as to be rotated by the electric motor 330. A nut 332, such as a ball bearing, forms, with the screw 331, a nut system for driving the second support 33 in translation. An elastic coupling 333 may advantageously be provided between the output of the shaft of the electric motor 330 and the screw 331.

For the translation of the second support 33 on the first support 32, it is possible for the first support 32 to be provided with a pair of rails 325 on which at least one pair of sliders 333, advantageously two sliders, of the second support 33 can slide. As illustrated, this second support may consist of two metal plates, in particular made of aluminum, with reinforcements, spaced apart from one another and connected to one another by another metal plate, in particular made of aluminum.

The third support 34 is mounted so as to move in rotation on the second support 33 about Axis 7. To this end, as shown in figures 8 and 9, an electric motor 340 is fastened to the second support 33, which can drive a shaft 341 defining Axis 7 in rotation, said shaft being

fastened to the third support 34. This shaft 341 can be mounted so as to move in rotation in a ball bearing 334 fastened in the second support 33.

The fourth support 35 is mounted so as to move in translation on the third support 34 along Axis 8. To this end, as shown in figures 9 to 12, a cylinder 350 fastened to the third support and the rod 351 of which defines Axis 8 is fastened to the fourth support 35 in order to drive it in translation. For robust guidance of the fourth support 35 in translation, the latter may comprise guide rods 352 fastened to a mounting plate 353 of the fourth support 35 and mounted so as to slide, parallel to the rod 351 of the cylinder 350, in ball bushings 342 fastened in the third support 34. As illustrated, the third support 34 may be in the form of a protective cage for the cylinder 350, which cage may consist of two metal plates, in particular made of aluminum, and four metal profile bars, in particular made of aluminum, in order to ensure the rigidity of the cage while reducing the weight of the tool-holder assembly 31.

In order to optimize the ability of the fourth support 35 and therefore ultimately of the tool that it will support, to conform to the curvature of the wall to be renovated, provision is advantageously made for this support 35 to be in the form of two mounting plates 353, 354, which are articulated with respect to one another by means of at least one universal-joint device 355. Provision may also be made for return means 356 for returning to a rest position in which the two mounting plates 353, 354 are parallel to one another. These return means 356 may consist of compression springs, for example three compression springs distributed at 120° from one another. Thus, with this articulated system with a universal joint 355 and return means 356, the fourth support 35 and therefore the tool that it will support for a renovation operation will follow the curvature of the wall to be renovated C as closely as possible. In other words, the return means 356 make it possible to damp the forces absorbed by the tool, to absorb the surface irregularities of the wall, and, with the universal joint 355, make it possible to guarantee that the tool conforms to the curvature to a certain extent. As illustrated, the mounting plates 353, 354 may be metal plates, in particular made of aluminum.

The inventors carried out calculations to verify that the robot 1 according to the invention was stable in any working position, i.e. renovation position around a wall with a curved section C.

This verification was thus carried out in the most unfavorable use case, which is that in which the robot 1 is positioned with the Cartesian robot 3 in a working position at -90° with the support structure 30 fully deployed, as illustrated in figure 14.

The input data considered were as follows:

- the mass m of the entire Cartesian robot 3, namely that of the load-bearing structure and of the tool-holder assembly 31 and all of the components it supports (motors, mechanical components, sensors), was set at 170 kg;
- the distance d1 of the center of gravity of the assembly from the center of the front wheel 21 of the lift was set at 1840 mm;
- the application force F of the cylinder 350 was set at 483 N;
- the distance d2 to the point of application of the cylinder 350 was set at 2455 mm.

Thus, the torque C1 generated by the weight of the Cartesian robot 3 applied to the center of the wheel 21 is equal to m x d1, i.e. 3100 Nm.

The torque C2 generated by the cylinder 350 on the hull is equal to F x d2, i.e. 1186 Nm.

Thus, the Cartesian robot 3 generates on the lift 2 a total torque Ct equal to 4286 Nm.

On the basis of data from a scissor lift manufacturer indicating a lift mass of 2940 kg and a distance between the center of gravity of the lift and the center of the front wheel 21 equal to 1015 mm, the torque Cnac generated by the weight of the lift 2 is equal to 29 274 Nm, i.e. a value equal to approximately 6.8 times the torque Ct, i.e. a safety factor of the same value.

It is specified that, for the calculation, the inventors assumed that the center of gravity of the lift is at the physical center of the lift 2.

Thus, the moment generated by the weight of the scissor lift is large enough for it alone to be able to support the weight of the Cartesian robot 3 when its load-bearing structure 30 is fully deployed. It is therefore not necessary to add a counterweight to the lift.

The robot 1 according to the invention is also equipped with a plurality of sensors 5 that, on the one hand, precisely compensate for the lack of equipment provided by the scissor lift manufacturers and, on the other hand, measure all of the movements of the Cartesian robot in order to position the various components of the Cartesian robot 3 and therefore the tool in space with great precision.

Thus, at least one linear-movement sensor 50 makes it possible to measure the vertical deployment of the platform 23 with respect to the movable base 20 along Axis 3. As illustrated in Fig. 13, this sensor 50 is preferably in the form of an absolute wire-draw encoder making it possible to measure, in real time, the height of the platform 23 with respect to the movable base 20. This type of sensor continuously changes as the scissor lift is raised

and makes it possible to calibrate this measurement with respect to the reality of the deployment of the platform 23. Furthermore, a wire-draw encoder enables precise measurement while being mechanically robust.

The absolute wire-draw encoder 50 comprises an encoder 500 fastened to the platform and to a cable mechanism comprising a drum 501 fastened to the movable base 20 and around which a cable 502 is wound, the free end of the cable being fastened to the platform 23.

At least one angular-measurement sensor 51 makes it possible to measure the angular position of the tool-holder assembly with respect to the load-bearing structure about Axis 5. As illustrated in figures 4 and 6, this may advantageously be a plurality of inductive sensors 51, which are fastened to a mounting plate 322 of the load-bearing structure. These inductive sensors 51 arranged at a distance from one another make it possible to initialize and follow the course of the rotation about Axis 5 with great precision.

At least two sensors 52, 53 make it possible to measure the distance between the tool-holder assembly 31 and the wall C to be renovated and/or inspected. As illustrated in figures 5 and 7, these may advantageously be two second rangefinders 52, 53 fastened at a distance from one another on the first second support 33 of the tool-holder assembly, i.e. along Axis 6.

At least two distance measuring sensors 54, 55 make it possible to measure the inclination of the tool-holder assembly 31 with respect to the wall to be renovated and/or inspected. As illustrated in figures 9 and 10, these may be two second rangefinders 54, 55 fastened at a distance from one another on the third support 34 of the tool-holder assembly, i.e. so as to move in rotation about Axis 7.

All of the sensors 50 to 55 that have just been described and are installed in the scissor lift 2 and the Cartesian robot 3 make it possible to supply the dedicated PLC of the control/command unit of the robot according to the invention with useful information for determining the location of the tool in space.

The robot 1 according to the invention finally comprises a control/command unit 10 connected to the plurality of sensors 50 to 53 and to the means for moving the components of the lift and for moving the tool-holder Cartesian robot along/about the first to eighth axes, the control/command unit being designed to automatically move the components of the lift and the Cartesian robot along/about one and/or another of the first to eighth axes, on the basis of the information provided by the plurality of sensors and according to a predefined

sequence of renovating and/or inspecting areas of the wall without the movable base 20 of the lift having to be moved.

Fig. 15 illustrates an advantageous embodiment of the architecture of the control/command unit 12: it comprises a main PLC 10 connected to each of the plurality of sensors 5. These connections are preferably CAN bus connections.

The main PLC 10 is also connected to the lift PLC 11 already integrated into the lift 2, to the plurality of means for moving the Cartesian robot and to the renovation tool that is installed.

During operation of the robot, the main PLC 10 communicates with the PLC 11 of the lift 2 so as to control the vertical deployment or folding of the platform 23 with respect to the movable base 20 on the basis of the renovation work area selected beforehand on the wall C.

The main PLC 10 also controls the five axes of the Cartesian robot 3, i.e. Axes 4 to 8, on the basis of the feedback from the various sensors 50 to 55 and the work area selected.

Finally, the main PLC 10 controls each renovation tool O as well as the associated stations on the basis of the trajectories and the tooling specificities (surface stripping by shot blasting, water jet, painting, etc.).

The electrical network of the robot 1 can be grouped together within a single electrical cabinet 24 containing all of the electrical components. This cabinet 24 is advantageously fastened to the platform 23 of the lift 2, preferably on the opposite side to the Cartesian robot 3 for reasons of both mass distribution and footprint, as illustrated in figure 3. This cabinet 24 can house in particular the main PLC 10 and the associated input and output boards, which are used for controlling the robot, the variators and the motor starter used for controlling the various motors, in particular the electric motors 320, 330, 340 and the cylinder 320, the power supply and a transformer making it possible to obtain the different voltages needed to supply power to the components. Furthermore, the cabinet 24 can house a radio controller connected to the PLC that can take control of the robot, if necessary. Finally, various components used for protecting the equipment such as circuit breakers and fuses or relays and safety relays can be installed in the cabinet 24.

The operation of a robot 1 that has just been described makes it possible to follow the profile of the wall C by moving from the top to the bottom of the wall, in all possible configurations, such as the following positions:

- the robot 1 is in an upper working position with the tool oriented at -45° (figure 16A);

- the robot 1 is in a vertical working position with the tool oriented at 0° (figure 16B);

- the robot 1 is in a lower working position with the tool oriented at +90° (figure 16C).

The work area Z covered by the Cartesian robot 3 corresponds to a vertical strip of width l defined by Axis 6 (horizontal movement) and of height H, which is based on the extension along Axis 4 (translation of the load-bearing structure 30) and the travel along Axis 3 (deployment of the platform 23). Work is carried out from top to bottom in horizontal passes. By way of indication, the width l may be equal to 200 mm and the height H of the order of 610 mm.

The operation of the robot 1 can be carried out automatically by the control/command unit 10 to follow the profile of a wall C, starting from its upper part and moving down to the lowest part of the wall.

An operator can remotely operate the robot solely in order to move the lift 2 closer to or further away from the hull between two cycles limited by the deployment of the load-bearing structure 30 along Axis 4.

Manual control is also provided to enable the user to move the lift 2 and the Cartesian robot 3 as they desire. Two manual control modes may be selected, for example, using a dual-position selector, implemented on a remote control:

- what is referred to as local control, which is carried out with the original remote control of the lift 2 and takes over all of the basic commands of the lift;
- what is referred to as remote control, which is carried out from a radio controller connected to the main PLC 10.

This remote control mode makes it possible to operate the Cartesian robot 3 and can also make it possible to directly control the lift 2.

The fully automatic operating cycle of the Cartesian robot 3 enables the robot 1 to carry out a complete renovation cycle (surface stripping, cleaning, painting) autonomously, the block diagram of which is illustrated in figure 17.

This cycle takes place according to the sequence of the following steps:

(0) Initialization step: the PLC 10 is waiting for the operator to start automatic mode.

(1) Step of selecting the work area Z: the operator indicates the work area Z where they desire to be placed in order to enable correct initialization of the positioning of the axes to cover the largest possible surface area. There are two possible scenarios:

- if the work area is located on the upper part of the hull C, Axis 5 will be completely extended and will have to retract as the platform 23 of the lift is lowered;

- if the work area is located on the lower part of the hull C, the load-bearing structure 30 (Axis 4) is completely folded and has to be deployed as the platform 23 of the lift descends.

(2) Operator guidance step (optional): the operator can correctly position the lift 2 and the Cartesian robot 3 before the start of the renovation work.

(3) Calculate the position of the Cartesian robot 3: the calculations make it possible to return positioning setpoints and thus for the Cartesian robot to position itself correctly with respect to the hull C and the selected work area Z.

(4) Verify reachable position setpoints: the position setpoints returned by the calculations are verified to ensure that they are physically reachable by the Cartesian robot 3. If this is not the case, the cycle stops and the lift 2 has to be repositioned to enable the robot 3 to renovate the desired area.

(5) Position the robot: the robot 3 is correctly positioned facing the selected work area Z.

(6) Start the operating cycle of the robot 3: the Cartesian robot 3 carries out the renovation work, extending the tool O and moving it at a constant speed along the horizontal translation X, parallel to the central axis of the hull C, in order to cover a strip Z of width l.

(7a) Fold (optional) the load-bearing structure 30: when the robot 1 is in a position as illustrated in figure 16A, the tool O has to be retracted before lowering the platform 23 to the next work area. This step is ignored if it is not necessary to retract the load-bearing structure 30 in order to save cycle time.

(7b) Move the lift 2 away from the hull C: if it is necessary to retract the load-bearing structure 30 and the latter reaches the end of its travel, then the cycle stops and the operator has to manually control the lift 2 to move it away from the hull C.

(8a) Lower the lift 2: until the lift is completely lowered or has reached the stopping point, the robot 3 descends until it reaches the next work area Z.

(8b) End of the cycle: this end is activated when the platform 23 of the lift 2 is completely lowered. The operator has to reset the program to continue using the robot and the initialization step (0) is activated until the next automatic cycle is started.

As indicated above, the operator has to select a work area Z at the start of the cycle in order to correctly initialize the axes of the robot 1. This step makes it possible to indicate to the

PLC that it is necessary to retract (figure 18A) or extend (figure 18B) the load-bearing structure 30 (Axis 4), at the start of the cycle.

The optional operator guidance step enables the operator to correctly position the robot 1 so that the cycle can start under the right conditions. Thus, the operator has to be able to control the robot 1 axis by axis by indicating in particular the desired characteristics and positioning distances: the robot has to be placed facing the work area Z and the operator has to orient the tool O so that it is parallel to the wall C. Operator guidance may be performed from an independent HMI, such as a monitor or from a monitor of the radio controller.

The step of calculating the positioning of the robot makes it possible to correctly position the latter with respect to its work area so that the strip l x H is treated uniformly over the entire working length requested.

Figures 19A, 19B and 19C show the intermediate steps of repositioning the robot facing the work area requested.

Since the diameter of curvature of a wall C is of the order of several meters, this wall C can therefore be regarded as a planar surface at the scale of a work area that is of the order of a decimeter, as illustrated.

The positioning calculations are based solely on the information returned by the rangefinders 54, 55, at the top and bottom, respectively, and on the orientation of Axis 7, which is known in the cycle. These data make it possible to determine the gradient of the hull C and therefore the orientation setpoint of Axis 7.

Next, the vertical and horizontal offsets are determined using trigonometric equations. The positioning results returned by these calculations are satisfactory since the accuracy of the positioning facing the work area is of the order of one centimeter.

Once the robot is correctly positioned facing the work area, the cycle of the Cartesian robot 3, which consists in treating a horizontal strip l x H, can begin.

The calculations required to move the robot to the next work area then follow the same logic as those performed for positioning the robot facing the work area Z.

The automatic cycle ends once all of the desired areas have been treated or once the platform 23 of the lift has lowered to its minimum height.

The operator then controls the lift 2 to move it longitudinally along the hull C, so as to position the renovation tool at the edge of the space that has already been renovated. A laser pointer can, for example, be used for visual validation of the movement increment.

The tool is then moved without changing the orientation of the movable base 20 of the lift 2.

The operator then starts the automatic cycle as specified above.

Figure 20 shows the sequence of the treatment (renovation) and movement steps of the robot 1 along the hull C.

Other variants and modifications may be contemplated for the robot according to the invention without otherwise departing from the scope of the invention.

For example, other types of sensors than those described may be used as equipment for measuring the various axes of movement of the components of a scissor lift and the Cartesian robot.

Claims

1. A robot (1) for renovating by surface stripping and/or coating with paint, and/or inspecting at least one wall of a structure with a curved surface, in particular a structure with circular cross section(s), comprising:

- a scissor lift (2) comprising the following components:

  - a movable base (20) comprising at least one steering axle defining a first axis (Axis 1) and a translational-movement motor defining a second axis (Axis 2),

  - a platform (23) mounted so as to move in vertical translation on the movable base along a third axis (Axis 3),

- a Cartesian robot (3) comprising:

  - a load-bearing structure (30) mounted so as to move in horizontal translation on the platform along a fourth axis (Axis 4),

  - a tool-holder assembly (31), designed to hold a renovation and/or inspection tool (O), the tool-holder assembly being mounted so as to move in rotation on the load-bearing structure about a fifth axis (Axis 5) orthogonal to the fourth axis (Axis 4), in horizontal translation on the load-bearing structure along a sixth axis (Axis 6) orthogonal to the fifth axis (Axis 5), in rotation on the load-bearing structure about a seventh axis (Axis 7) parallel to the sixth axis (Axis 6) and in translation on the load-bearing structure along an eighth axis (Axis 8) orthogonal to the seventh axis (Axis 7);

- a plurality of sensors (5) comprising:

  - at least one linear-movement sensor (50) designed to measure the vertical deployment of the platform with respect to the movable base along the third axis (Axis 3),

  - at least one angular-measurement sensor (51), designed to measure the angular position of the tool-holder assembly with respect to the load-bearing structure about the fifth axis (Axis 5),

  - at least two distance measuring sensors (52, 53) designed to each measure a distance of a point on the tool-holder assembly from the wall to be renovated and/or inspected;

  - at least two distance measuring sensors (54, 55) designed to measure an inclination of the tool-holder assembly with respect to the wall to be renovated and/or inspected;

- a control/command unit (10) connected to the plurality of sensors and to the means for moving the components of the lift and the Cartesian robot along/about the first to eighth axes, the control/command unit being designed to automatically move the components of the lift and the Cartesian robot along/about one and/or another of the first to eighth axes, on the basis of the information provided by the plurality of sensors and according to a predefined sequence of renovating and/or inspecting areas of the wall without the movable base of the lift having to be moved.

2. The robot (1) as claimed in claim 1, the tool-holder assembly comprising:

- a first support mounted so as to move in rotation on the load-bearing structure about the fifth axis (Axis 5),

- a second support (33) mounted so as to move in translation on the first support along the sixth axis (Axis 6),

- a third support mounted so as to move in rotation on the second support about the seventh axis (Axis 7),

- a fourth support mounted so as to move in translation on the third support along the eighth axis (Axis 8) and to which the renovation and/or inspection tool is intended to be fastened.

3. The robot (1) as claimed in claim 2, comprising an electric motor, which is fastened to the load-bearing structure and the output shaft of which defining the fifth axis (Axis 5) is fastened to the first support in order to drive it in rotation.

4. The robot (1) as claimed in claim 2 or 3, comprising:

- an electric motor, which is fastened to the first support;

- a ball screw defining the sixth axis (Axis 6), which is fastened to the first support so as to be rotated by the electric motor of the first support;

- a nut, which forms, with the ball screw, a nut system for driving the second support in translation.

5. The robot (1) as claimed in one of claims 2 to 4, comprising:

- an electric motor, which is fastened to the second support;

- a shaft defining the seventh axis (Axis 7), which is fastened to the third support so as to be rotated by the electric motor of the second support in order to drive the third support in rotation.

6. The robot (1) as claimed in one of claims 2 to 5, comprising a cylinder, which is fastened to the third support and the rod of which defining the eighth axis (Axis 8) is fastened to the fourth support in order to drive it in translation.

7. The robot (1) as claimed in one of the preceding claims, comprising:

- an electric motor, which is fastened to the platform of the lift;

- a ball screw defining the fourth axis (Axis 4), which is fastened to the load-bearing structure so as to be rotated by the electric motor of the platform;

- a nut fastened to the load-bearing structure and forming, with the ball screw, a nut system for driving the load-bearing structure in translation.

8. The robot (1) as claimed in one of the preceding claims, the linear-movement sensor for measuring the vertical deployment of the platform being an absolute wire-draw encoder comprising an encoder fastened to the platform and to a cable mechanism comprising a drum fastened to the movable base and around which a cable is wound, the free end of the cable being fastened to the platform.

9. The robot (1) as claimed in one of the preceding claims, the angular-measurement sensor comprising two first laser rangefinders fastened at a distance from one another on the tool-holder assembly.

10. The robot (1) as claimed in one of the preceding claims, the at least one linear-movement sensor for measuring the horizontal movement of the tool-holder assembly with respect to the load-bearing structure comprising a plurality of inductive sensors fastened to the load-bearing structure.

11. The robot (1) as claimed in one of the preceding claims, the at least two distance measuring sensors for measuring two distances between the tool holder and the wall to be renovated and/or inspected being two second laser rangefinders (52) fastened at a distance from one another on the tool-holder assembly.

12. The robot (1) as claimed in one of the preceding claims, the at least two distance measuring sensors (53) for measuring an inclination of the tool-holder assembly with respect to the wall to be renovated and/or to be inspected being two second laser rangefinders (53) fastened at a distance from one another on the tool-holder assembly.

13. The robot (1) as claimed in one of the preceding claims, the movable base (20) comprising at least one further steering axle defining a ninth axis (Axis 9).

14. The robot (1) as claimed in one of the preceding claims, the control/command unit comprising a control/command PLC (10) connected to each of the plurality of sensors, preferably via CAN bus, a lift PLC (11) connected to the control/command PLC, preferably via Ethernet connection, the control/command PLC being designed to transmit its command instructions, on the one hand, to the lift PLC, which commands the movement of the components of the lift along/about one and/or another of the first to third axes, and, if appropriate, about the ninth axis and, on the other hand, to the Cartesian robot for moving the load-bearing structure and/or the tool-holder assembly along/about one and/or another of the fourth to eighth axes.

15. The robot (1) as claimed in one of the preceding claims, the control/command unit being designed to automatically move the movable base along/about one and/or another of the first and second axes and, if appropriate, about the ninth axis, once the predefined sequence has been completed.

16. The robot (1) as claimed in one of the preceding claims, comprising a cabinet that houses all of the electrical components and the control/command unit (10), said cabinet being fastened to the lift platform, at the opposite longitudinal end to the end at which the Cartesian robot is arranged.

17. The robot (1) as claimed in one of the preceding claims, the tool-holder assembly being designed to hold a shot-blasting nozzle fitted with a suction hood for recycling shot or a high-pressure water-blasting nozzle with a hood for re-suction of blasted water or a paint-spraying nozzle with a device for re-suction of paint that is not deposited on the wall of the structure.

18. The use of the robot as claimed in any one of the preceding claims for renovation with surface stripping, preferably by abrasive blasting or water-jet surface stripping, and, if appropriate, with coating a hull or a bottom of a ship or a cylindrical tank, such as an oil tank, or a pipe, in particular a pressure pipe, with paint.