

HANGING TYPE PAINTING APPARATUS AND PAINTING SYSTEM

BACKGROUND OF THE INVENTION

5 1. Field of the Invention

 The present invention relates particularly to a hanging type painting apparatus used to paint an inner surface of a cargo tank, for example, an oil tank, provided in an oil tanker, and a painting system having
10 such a painting apparatus.

2. Description of the Related Art

 A cargo tank made of steel plates, for example an oil tank, is formed under a deck of a large-sized and mid-sized ship. The internal space of the cargo tank is
15 relatively large and has a height of approximately 15 to 20 meters, and a width and length of approximately 10 to 20 meters. The painting operation to paint an inner surface of such a cargo tank includes a blasting operation, a cleaning operation and a coating operation.

20 First, the blast operation is carried out wherein an abrasive is injected onto the inner surface of the cargo tank at high speed to remove deposits on the inner surface of the cargo tank. Thereafter, the removal of the deposits is visually inspected, and then, the
25 abrasive is recovered and the cleaning operation is performed to clean the inner surface of the cargo tank. Thereafter, the coating operation including applying a paint to the inner surface of the cargo tank and visually inspecting the coat film applied to the inner surface is
30 carried out. Thus, the painting operation is complete.

 Japanese Patent No. 3607260 discloses a painting apparatus for carrying out such a painting operation. The painting apparatus disclosed in Japanese Patent No. 3607260 is a hanging type apparatus and is
35 comprised of an elevating portion installed on a base plate, and a support post hanging from the elevating portion through an opening formed in the base plate in

the downwardly vertical direction of a hole formed in the lower part of the base plate. The main body of the painting apparatus is moved up and down along the support post.

5 However, the hanging type painting apparatus disclosed in Japanese Patent No. 3607260 is often used in an cargo tank of an oil tanker, and there is a large number of stepped portions, such as angle iron, in the cargo tank. When the hanging type painting apparatus is
10 used in such an environment, the front end of the painting apparatus may contact the inner surface of the cargo tank or the stepped portions.

 If the contact occurs, a separation of a part of the paint applied to the inner surface of the cargo
15 tank or a breakage of the supply portion of the painting apparatus may take place, thus resulting in failure to supply the paint, etc.

 Under these circumstances, it is an object of the present invention to provide a hanging type painting
20 apparatus which can prevent the main body of the painting apparatus from being damaged and can stably perform the painting operation and a painting system having such a painting apparatus.

SUMMARY OF THE INVENTION

25 To achieve the object mentioned above, according to a first aspect of the present invention, there is provided a hanging type painting apparatus comprising a post hanging through an opening formed in an upper surface of a tank, a main body which is movable up and
30 down along the post and is rotatable about the post, a storage portion which stores therein dimensional data of the tank, a calculating portion which calculates the shortest distance between each of a plurality of monitoring points arranged over the entire main body of
35 the painting apparatus and the tank whose data is stored in the storage portion, at a predetermined cycle, and an operation stopping portion which stops the operation of

the main body of the painting apparatus when at least one of the shortest distances calculated by the calculation portion is smaller than a predetermined value.

5 In other words, in the first aspect, when the shortest distance between the monitoring points of the main body of the painting apparatus and the tank is below a predetermined value, the operation of the main body of the painting apparatus is stopped. In other words, the main body of the painting apparatus is stopped before the
10 main body comes into contact with the tank, so it is possible to prevent the main body of the painting apparatus from contacting the tank. Consequently, the stable painting operation can be performed while preventing the inner surface of the tank or the supply
15 portion from being damaged.

According to the second aspect of the invention, the hanging type painting apparatus according to the first aspect further comprises at least one strain detection portion provided at a front end of the main body of the
20 painting apparatus, wherein the operation stopping portion stops the operation of the main body of the painting apparatus when a signal value detected by the strain detecting portion exceeds a predetermined range.

In other words, in the second aspect, when the
25 signal value issued from the strain detecting portion, which is, for example, a strain gauge, exceeds a predetermined range, it is judged that the front end of the supply portion actually contacts the inner surface of the tank, etc. Upon occurrence of such a contact, it is
30 possible to prevent the inner surface of the tank or the supply portion itself from being damaged by stopping the operation of to supply portion of the painting apparatus main body.

According to a third aspect of the invention, the
35 hanging type painting apparatus according to the second aspect further comprises a first paint pipe connected to the front end of the main body of the painting apparatus,

a second paint pipe connecting the first paint pipe to a paint source and having a diameter larger than that of the first paint pipe, and an opening-closing switching valve provided between the first paint pipe and the
5 second paint pipe.

In other words, in the third aspect, when the operation of the supply portion of the main body of the painting apparatus is stopped, the opening-closing switching valve is closed to stop the supply of the
10 paint, etc., as well. The opening-closing switching valve may be closed by the operation stopping portion or by the manual operation of an operator. The opening-closing switching valve is located on the upstream side of the first paint pipe as viewed in the direction of the
15 flow of the paint, and accordingly, if the first paint pipe is damaged, it is possible to prevent the paint from continuously leaking from the damaged portion of the first paint pipe. Note that another opening-closing switching valve is preferably provided between the first
20 paint pipe and the front end of the supply portion to prevent the leakage of the paint, etc., more certainly.

According to a fourth aspect of the invention, the hanging type painting apparatus according to any one of the first to the third aspects further comprises a
25 modifier which modifies an operation program of the hanging type painting apparatus, based on a deviation between a measured position of the post in the tank and a target position of the post determined in accordance with the position of the opening depending on the dimensional
30 data of the tank.

In other words, in the fourth aspect, as the program is modified in accordance with the deviation between the measured value of the position of the post and the target value, the operation of the hanging type painting
35 apparatus can be carried out more accurately.

According a fifth aspect of the present invention, the hanging type painting apparatus according to the

first aspect further comprises a gondola which is rotatable about an axis parallel with the post.

In other words, the operator on the gondola can move very close to an object to be inspected or repaired,
5 etc., to perform the inspection or repair, etc.

According to a sixth aspect of the invention, there is provided a painting system comprising a first hanging type painting apparatus having a first post hanging through a first opening formed in an upper surface of a
10 tank, and a first main body which is movable up and down along the first post and is rotatable about the first post, a second hanging type painting apparatus having a second post hanging through a second opening formed in the upper surface, and a second main body which is
15 movable up and down along the second post and is rotatable about the second post, a first control portion which controls the first hanging type painting apparatus, a second control portion which controls the second hanging type painting apparatus, and host control portion
20 to which the first control portion and the second control portion are connected, wherein the first control portion transmits position signals of a plurality of first monitoring points at least arranged entirely over the first main body of the first hanging painting apparatus
25 to the host control portion at a predetermined cycle, said second control portion transmits position signals of a plurality of second monitoring points at least arranged over the entire second main body of the second hanging painting apparatus to the host control portion at the
30 predetermined cycle, the host control portion comprises a calculation portion which calculates the distance between each of the first monitoring points and each of the second monitoring points at the predetermined cycle, and an operation stopping portion which stops the operation
35 of the first and second main bodies of the painting apparatus when the shortest distance among the distances calculated by the calculation portion is smaller than a

predetermined value.

5 In the sixth aspect, when the shortest distance
between the monitoring point of the first main body of
the first painting apparatus and the monitoring point of
the second main body of the second painting apparatus is
smaller than a predetermined value, the first main body
of the first painting apparatus and the second main body
of the second painting apparatus are stopped. In other
words, the first main body of the first painting
10 apparatus and the second main body of the second painting
apparatus are stopped before they come into contact with
each other, no contact of the first and second main
bodies takes place. Consequently, it is possible to
carry out a stable painting operation while preventing
15 the first main body of the first painting apparatus and
the second main body of the second painting apparatus
from being damaged. When both the first main body and
the second main body have been operated, the operation of
both may be stopped, and when one of the first and second
20 main bodies has been operated, the operation of the one
main body may be stopped.

Alternatively, it is possible to additionally
provide a third hanging type painting apparatus having a
third main body, wherein when any of the shortest
25 distances between the monitoring point of the first main
body of the first hanging type painting apparatus and the
monitoring point of the second main body of the second
hanging type painting apparatus, between the monitoring
point of the second main body of the second hanging type
30 painting apparatus and the monitoring point of the third
main body of the third hanging type painting apparatus,
and between the monitoring point of the third main body
of the third hanging type painting apparatus and the
monitoring point of the first main body of the first
35 hanging type painting apparatus is smaller than a
predetermined value, the first, second and third main
bodies of the first, second and third hanging type

painting apparatuses are stopped.

These and other objects, features, and advantages of the present invention will be more apparent in light of the detailed description of exemplary embodiments thereof
5 as illustrated by the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partial sectional view of a ship in which a hanging type painting apparatus according to the present invention is installed.

10 FIG. 2 is an enlarged view of a main body and an elevator of a hanging type painting apparatus.

FIG. 3 is a perspective view of a main body of a hanging type painting apparatus.

FIG. 4a is an enlarged view of a blast hose winding portion connected to a main body of a hanging type
15 painting apparatus according to the present invention.

FIG. 4b is a sectional view of the blast hose winding portion shown in FIG. 4a.

FIG. 5 shows a paint mixing and supplying portion of a hanging type painting apparatus according to the
20 present invention.

FIG. 6a is a plan view showing a model of a cargo tank, etc.

25 FIG. 6b is a partial enlarged view of the model shown in FIG. 6a.

FIG. 7 is a flow chart showing the monitoring operation of a hanging type painting apparatus according to the present invention.

30 FIG. 8a is a side view of an injection nozzle provided in a supply portion.

FIG. 8b shows an injection nozzle a part of which is in contact with a cargo tank.

FIG. 8c is a partial enlarged view of the injection nozzle shown in FIG. 8a.

35 FIG. 9a is a view of a first paint pipe and a second paint pipe, extending from an injection nozzle.

FIG. 9b is an enlarged view of a second opening-

closing switching valve.

FIG. 10a is a side view of another main body of a hanging type painting apparatus.

5 FIG. 10b is an end view of another main body of a hanging type painting apparatus.

FIG. 11 is a block diagram of a painting system having a plurality of hanging type painting apparatuses according to the present invention.

10 FIG. 12a is a plan view of another model of a painting system.

FIG. 12b is a side view of a model of a painting system.

FIG. 13 is a flow chart showing the operation of the painting system.

15 FIG. 14 is a flow chart showing an installation method of a post used in a hanging type painting apparatus.

DETAILED DESCRIPTION

20 Embodiments of the present invention will be discussed below with reference to the accompanying drawings. In the drawings, the same components are assigned like reference numerals. For sake of easy understanding, the scale of the drawings has been appropriately changed.

25 FIG. 1 is a partial sectional view of a ship in which a hanging type painting apparatus according to the present invention is installed. As can be seen from FIG. 1, a ship 900 has therein a cargo tank 800, and an elevator 70 of a hanging type painting apparatus 10
30 according to the present invention is installed on a deck 910 of the ship 900. Generally, the deck 910 is provided with a plurality of openings 920, i.e., butterworth machine holes which are used when the cargo tank is cleaned and a manhole (not shown) through which an
35 operator enters the cargo tank.

The opening 920 in the present invention has a circular shape whose diameter is approximately 40 cm.

The manhole has, for example, a rectangular shape of approximately 100 cm x 80 cm or an elliptical shape having a major diameter of 100 cm and a minor diameter of 80 cm. The cargo tank 800 of the ship 900 has a height of approximately 15 m to 20 m and width and length of approximately 10 m to 20 m. After the elevator 70 is positioned on the opening 920 of the deck 910 and the post 11 of the hanging type painting apparatus 10 is suspended in the cargo tank 800 from a part of the elevator 70 through the opening 92 of the deck 910.

FIG. 2 is an enlarged view of the main body of the hanging type painting apparatus and the elevator. As can be seen from Fig. 2, the post 11 extends through the opening 920 of the deck 910 and is anchored at its upper end 13 by a hanger, e.g., a chain 72, which extends from a part of the elevator 70, e.g., frame 71. Thus, the post 11 is suspended from the frame 71. The total weight of the main body 12 of the hanging type painting apparatus 10 and the post 11 is approximately 10 tons.

When the main body 12 and the post 11 are hung, it is possible to enhance the stability, compared with the support structure in which the main body 12 and the post 11 are vertically supported only on and by the doubled bottom surface 810 of the cargo tank 800. The support of the post 11 by hanging can reduce the load against the bottom surface 810 of the cargo tank 800.

It is preferable that the post 11 be supported at its lower end 14 by a swing prevention damper support 89 which is positioned in advance on the bottom surface 810 of the cargo tank 800. A large part of the total weight of the main body 12 and the post 11, of the hanging painting apparatus 10, for example, 80% of the total weight is supported by the frame 71 and the remaining part of the weight, for example 20% is supported by the damper support 89 on the bottom surface 810 as shown in FIG. 1 and FIG. 3, which is a perspective view of a main body of the hanging type painting apparatus.

Consequently, it is possible to prevent the post 11 from swinging during the operation of the hanging type painting apparatus 10.

5 The main body 12 of the hanging type painting apparatus 10 is carried into the cargo tank 800 through the manhole (not shown) of the deck 910 in a disassembled state. In other words, each of the components of main body 12 (which will be discussed hereinafter) of the hanging type painting apparatus 10 is small enough to
10 pass through the manhole of the deck 910. Thus, in the present invention, it is not necessary to form a dedicated hole for introducing the assembled main body 12 of the hanging type painting apparatus 10 into the cargo tank 800. The components are assembled together with the
15 post 11 in the cargo tank 800 to form the main body 12 of the hanging type painting apparatus 10 according to the present invention.

As can be seen from FIGS. 2 and 3, the main body 12 of the hanging type painting apparatus 10 is comprised of
20 a sleeve 29 which is rotatably attached to the post 11 and annular driving portions 21 and 22 connected to the sleeve 29 on the upper and lower portions of the sleeve 29, respectively. As shown in FIG. 3, the post 11 of the hanging type painting apparatus 10 is provided with a key
25 way 15 extending in the longitudinal direction of the post 11. The annular driving portions 21 and 22 have therein projections (not shown) which are fitted in the key way 15. The engagement of the projections in the key way 15 easily prevents the rotation of the annular
30 driving portions 21 and 22 per se about the post 11.

The sleeve 29 includes motors 23 and 24 having small gears which are engaged by gears 25 and 26 of the annular driving portions 21 and 22, respectively. As shown in
FIGS. 2 and 3, the gears 25 and 26 are identical in shape
35 and are coaxially positioned. When the motors 23 and 24 are driven, the motors 23 and 24 revolve around the peripheral surfaces of the gears 25 and 26, so that the

sleeve 29 can be rotated around the post 11.

5 The elevator 70 has, as shown in FIG. 2, an elevator driving portions 79 around which wires 73 are wound. The wires 73 extend at their one end into the cargo tank 800 through the pulleys 78 within the elevator 70 and the opening 920 of the deck 910. As can be seen from FIGS. 2 and 3, the upper annular driving portion 21 located above the sleeve 29 is provided on its upper surface with hangers 28 to which the one end of each wire 73 is
10 connected.

Therefore, the main body 12 of the hanging type painting apparatus 10 can be moved up and down by winding or unwinding the wires 73 through the elevator driving portions 79 of the elevator 70. In FIG. 2, there are
15 provided two wires 73, but at least one wire 73 is necessary to elevate or lower the main body 12 of the hanging type painting apparatus 10. In the present invention, the use of the wires 73 makes it possible to precisely position the sleeve 29 in the vertical
20 direction.

The annular driving portions 21 and 22 include therein bearings, as indicated by dotted lines in FIG. 2, so that the main body 12 of the hanging type painting apparatus 10 can be easily moved up and down through the
25 bearings. Moreover, encoders (not shown) are provided in the elevator driving portions 79 of the elevator 70 to detect the height position (coordinate Z) of the main body 12 of the hanging type painting apparatus 10.

As shown in FIGS. 2 and 3, a beam 30 is attached to
30 the sleeve 29. The illustrated beam 30 is secured to the sleeve 29. The beam 30 shown in FIGS. 2 and 3 is provided on its upper surface with a first sliding portion 31. In addition, the beam 30 includes a guide rail 33 provided on the upper surface thereof and a motor
35 32 positioned in the beam 30.

The first sliding portion 31 is slid by the motor 32 in the longitudinal direction of the beam 30 while being

guided by the guide rail 33. Furthermore, in FIGS. 2 and 3, a second sliding portion 39 is shown at a distal end of the first sliding portion 31. The first sliding portion 31 has a guide rail 34 provided on the upper surface thereof and a rack (not shown) provided on the side surface of the first sliding portion 31. The second sliding portion 39 has a motor 38 with a rotating shaft to which a pinion is attached. The pinion of the motor 38 engages with the rack, so that the second sliding portion 39 is slid in the longitudinal direction of the first sliding portion 31 together with the motor 38 while being guided by the guide rail 34 on the first sliding portion 31.

A spacer 41 is connected to the second sliding portion 39 so as to rotate about the horizontal rotation axis V in the second sliding portion 39. The spacer 41 is also rotatable about the longitudinal axis thereof in the direction θ in FIG. 3. The spacer 41 has at its distal end a multi-axis arm 42 which is in turn provided on its distal end with a supply portion 50, e.g., an automatic gun.

It can be understood that with this structure, the supply portion 50 is movable up and down along the post 11, is rotatable about the post 11, and is movable in the horizontal direction as well. Thus, it is possible to appropriately move the supply portion 50 of the hanging type painting apparatus 10, depending on the shape of the object to be painted.

In FIGS. 2 and 3, the cables, for example, the cables for driving the motor 38 are accommodated in the Cableveyor (registered trademark) 35.

As illustrated in FIGS. 2 and 3, the sleeve 29 has a weight support beam 51 on the opposite side to the beam 30. A counter weight 52 is provided at the distal end of the weight support beam 51. The counter weight 52 defines a counter to the beam 30, etc., of the hanging type painting apparatus 10, on the opposite side with

respect to the sleeve 29 and functions to prevent the post 11 from being deformed or deflected when the sleeve 29 moves up and down relative to the post 11 or rotates about the post 11.

5 As shown in FIG. 3, the monitoring camera 55 is mounted on a part of the main body 12, e.g., the counter weight 52. The monitoring camera 55 is adapted to monitor the state of the object to be painted in the cargo tank 800 after each operation and the operation
10 state of the main body of the hanging type painting apparatus 10 and display them on a monitor in the control chamber. Furthermore, the weight support beam 51 is provided with a control box 53 which includes therein a controller for controlling the elevator 70 and/or the
15 main body 12 and a controller for controlling the monitoring camera 55, etc.

FIG. 4a is an enlarged view of a blast hose winding portion connected to the main body of the hanging type painting apparatus according to the present invention.
20 FIG. 4b is a sectional view of the blast hose winding portion shown in FIG. 4a. In the hanging type painting apparatus 10 of the present invention, as shown in FIG. 2 and 4a, the blast hose winding portion 80 is installed on the deck 910 of the ship 900.

25 One end of the blast hose 81 extends from the blast hose winding portion 80 through an appropriate pulley 82 into the cargo tank 800 through the opening 920 of the deck 910. In the cargo tank 800, the blast hose 81 is connected to the vicinity of the annular driving portion
30 21 of the hanging type painting apparatus 10 and is also connected to the supply portion 50 of the multi-axis arm 42 (blast hose 81 between the supply portion 50 and the annular driving portion 21 is not shown).

35 As can be seen from FIG. 4b, the blast hose 81 is wound and/or unwound by driving the motor 83 of the blast hose winding portion 80. In FIG. 4b, the number of turns of the blast hose 81 is 8. The other end of the blast

hose 81 extends to a continuing blast portion 85 through a swivel joint 84 provided on the blast hose winding portion 80.

5 As shown in FIG. 1, the other end of the blast hose 81 extending from the blast hose winding portion 80 is connected to the continuing blast portion 85. In FIG. 1, the continuing blast portion 85 is installed outside of the ship 900, for example, on a quay but may be installed on the deck 910 of the ship 900. Abrasives are charged
10 in a hopper 86 of the continuing blast portion 85. The abrasives are made of, for example, steel grit having a diameter of approximately 0.5 mm to 2.0 mm. A level sensor (not shown) is provided in the hopper 86 of the continuing blast portion 85 to monitor the amount of the
15 abrasives in the hopper 86.

FIG. 5 shows a paint mixing and supplying portion of the hanging type painting apparatus according to the present invention. The paint mixing and supplying
portion 90 is comprised of two paint containers 91 and 92
20 in the illustrated embodiment. In the illustrated embodiment, the paint container 91 is a container for a base material and the paint container 92 is a container for a curing agent. The base material and the curing agent supplied from the paint containers 91 and 92 are
25 mixed in the mixing portion 93.

By mixing the base material from the paint container 91 and the curing agent from the paint container 92 in the mixing portion 93, a two-component paint, for example, a two-component epoxy paint is obtained. The
30 supply amount and the mixing ratio of the paint can be optionally set in the mixing portion 93. The paint produced in the mixing portion 93 is temporarily stored in a paint pot 94.

A level sensor (not shown) is provided in the paint
35 pot 94 to prevent the paint from overflowing from the paint pot 94. Thereafter, the paint is sucked by an airless painting machine 95 and fed by pressure to the

supply portion 50 of the main body 12 of the hanging type painting apparatus 10. In FIG. 5, the paint mixing and supplying portion 90 is installed on the deck 910 of the ship 900 but may be installed outside of the ship 900, e.g., on a quay.

With reference to FIG. 3 again, the controller 100 connected to the control box 53 includes a storage portion 101 which stores the dimensional data of the cargo tank 800. The dimensional data of the cargo tank 800 includes the data of the inner surface of the cargo tank 800 as well as data of the stepped portions 850 (see FIG. 1, etc.) projecting from the inner surface of the cargo tank 800.

Furthermore, the controller 100 includes a calculation portion 102 which calculates the shortest distance between each of a plurality of monitoring points (which will be discussed hereinafter) distributed over the entire main body 12 and the position of the cargo tank 800 stored in the storage portion 101, at a predetermined cycle. The controller 100 may be contained in the control box 53 or arranged in the control chamber. Furthermore, the controller 100 has an operation stopping portion 103 which stops the operation of the main body 12 when at least one of the shortest distances calculated by the calculation portion 102 is smaller than a predetermined value. The operation stopping portion 103 stops not only the movement of the main body 12 but also the operation of the supply of the paint, etc., to the supply portion 50. The controller 100 also has a modifier 104 which modifies an operation program of the hanging type painting apparatus 10 in accordance with the deviation between the measured position of the post 11 in the cargo tank 800 and the target position of the post 11 determined based on the position of the opening 920 contained in the dimensional data of the cargo tank 800.

FIG. 6a shows a model of the cargo tank, etc., as viewed from above, and FIG. 6b is a enlarged partial view

of the model shown in FIG. 6a. These models are displayed in a display (not shown), such as a liquid crystal monitor, connected to the controller 100. As can be seen from FIG. 6b, a plurality of monitoring points B
5 are arranged on the main body 12 of the hanging type painting apparatus 10. The monitoring points B are located at equal distances in a grid like arrangement over the entire outer surface of the main body 12. The distance between the adjacent monitoring points B is
10 indicated by "A". The distance "A" is equal to, for example, 200 mm.

FIG. 7 shows a flow chart of the monitoring operation of the hanging type painting apparatus according to the present invention. With reference to
15 FIGS. 6a, 6b, and 7, the monitoring operation of the hanging type painting apparatus 10 according to the present invention will be discussed below. The monitoring operation shown in FIG. 7 is carried out at a predetermined control cycle during the painting operation
20 of the hanging type painting apparatus 10.

First, at step 111 in FIG. 7, the dimensional data of the cargo tank 800, in which the hanging type painting apparatus 10 is installed, is read out from the storage portion 101. After that, at step 112, the current
25 positions of a plurality of monitoring points B distributed over the main body 12 are obtained.

The position of the post 11 in the cargo tank 800 is determined based on the location of opening 920 when the hanging type painting apparatus 10 is installed. The
30 current position of the main body 12 of the hanging type painting apparatus 10 is detected from the positions of the output shafts of the motors 23, 24, 32, 38, etc., and the dimensional data of the hanging type painting apparatus 10 itself. Therefore, the respective current
35 positions of a plurality of monitoring points B can be obtained from the positions of the monitoring points B on the main body 12.

Thereafter, at step 113, the calculation portion 102 calculates the shortest distances C between the respective monitoring points B and the cargo tank 800. As shown in FIG. 6a, a plurality of stepped portions 850 are provided on the inner surface of the cargo tank 800 and, accordingly, the distance between a certain monitoring point B1 and the stepped portion 850 may be smaller than the shortest distance between the monitoring point B1 and the inner surface of the cargo tank 800. In this case, the distance between the monitoring point B1 and the stepped portion 850 is selected as the shortest distance C.

At step 114, it is judged as to whether or not at least one of the shortest distances C regarding the plurality of monitoring points B is smaller than a predetermined value. The predetermined value is equal to, for example, "A", as shown in FIG. 6b, but may be a value other than "A".

If at least one of the shortest distances C is smaller than a predetermined value, the control proceeds to step 115. At step 115, the operation stopping portion 103 stops the operation of the main body 12. Furthermore, at step 116, the supply of the paint, etc. to the supply portion 50 is stopped. Note that if at least one of the plurality of shortest distances C is not smaller than a predetermined value, the operation ends.

As may be understood from the foregoing, according to the present invention, the main body 12 is stopped before it comes into contact with the inner surface or the stepped portion 850 of the cargo tank 800. Consequently, it is possible to prevent the main body 12 and particularly, the supply portion 50 of the main body 12 from contacting the cargo tank 800, etc. Therefore, it is possible to stably carry out the painting operation while preventing the inner surface of the cargo tank 800 or the main body 12 from being damaged.

FIG. 8a shows side view of an injection nozzle

provided in the supply portion. As can be seen from FIG. 8a, the injection nozzle 121 is provided with a bent metal pipe 123 which has at its distal end an injector 122 from which the paint, etc., is injected.

5 A sudden change in the direction or sudden stop of the movement of the supply portion 50 may take place during the painting operation of the hanging type painting apparatus 10. If the supply portion suddenly changes the movement direction or suddenly stops, a small
10 amount of further movement of the supply portion may occur due to inertia, so that the injection nozzle 121 may come into contact with the inner surface of the cargo tank 800. Alternatively, if, for example, a projection which is not indicated in a draft drawing is provided in
15 the cargo tank 800, there is a possibility that the injection nozzle 121 comes into contact with the projection. If such a contact occurs, the metal pipe 123 of the injection nozzle 121 may be forcedly bent and broken or the paint may partly peel off from the painted
20 surface.

 Therefore, in the present invention, as can be seen from FIG. 8c, strain gauges 124 are mounted on the peripheral surface of the metal pipe 123. The strain gauges 124 are connected to the controller 100 which is
25 in turn connected to the control box 53 through terminal board 125.

 When the injection nozzle 121 contacts the cargo tank 800, a slight deformation of the strain gauge 124 occurs, whereby the signal value of the strain gauge 124,
30 e.g., the electric resistance of the strain gauge 124 varies. Therefore, in this embodiment, it can be judged that an actual contact of the injection nozzle 121 with the inner surface of the cargo tank 800, etc., occurs when the signal value of the strain gauge 124 exceeds a
35 predetermined range.

 If such a judgment is made, the operation stopping portion 103 immediately stops the operation of the main

body 12 and the supply of the paint to the supply portion 50. Thus, it is possible to minimize the occurrence of the breakage of the injection nozzle 121 and the damage of the painted surface. Furthermore, when the signal
5 value of the strain gauge remains above the predetermined range, it can be easily judged that the injection nozzle 121 has been broken. In this case, the replacement of the broken injection nozzle 121 with a new injection nozzle can prevent the occurrence of painting failure.
10 Note that in FIG. 8c, two strain gauges 124 are mounted to the upper and lower surface portions of the metal pipe 123, but it is possible to provide a larger number of strain gauges 124 on the peripheral surface of the metal pipe 123 at equal pitches in the circumferential
15 direction, whereby the contact of the injection nozzle 121 can be detected over the circumferential direction of the metal pipe 123.

FIG. 9a shows a first paint pipe and a second paint pipe, extending from the injection nozzle. In the
20 embodiment illustrated in FIG. 9a, the first paint pipe 131 extends from the injection nozzle 121 and is connected to the second paint pipe 132. Note that the second paint pipe 132 is connected to the airless painting machine 95 (see FIG. 5).

25 The second paint pipe 132 is larger in diameter than the first paint pipe 131 which is more flexible than the second paint pipe 132. Due to this relationship of the diameter and the flexibility between the first and second paint pipes, a smooth operation of the multi-axis arm 42
30 can be ensured. The first paint pipe 131 is long enough to provide a universal movement of the multi-axis arm 42. In an embodiment, the first paint pipe 131 has a length of approximately 7 meters.

As shown in FIG. 9a, a first opening-closing
35 switching valve 133 is provided in the first paint pipe 131 in the vicinity of the injection nozzle 121 and a second opening-closing switching valve 134 is provided

between the first paint pipe 131 and the second paint pipe 132. The first and second opening-closing switching valves 133 and 134 are connected to the control box 53, and are actuated to open or close by the controller 100
5 connected to the control box 53.

With reference to FIG. 7 again, at step 116, when at least one of the plurality of shortest distances C is smaller than a predetermined value, the supply of the paint, etc., to the supply portion 50 is stopped. In
10 this connection, normally, only the first opening-closing switching valve 133 is closed to stop the supply of the paint.

However, as the first paint pipe 131 is flexible, the first paint pipe 131 tends to be damaged during the
15 movement of the multi-axis arm 42. Consequently, if the first paint pipe 131 is damaged, the paint continues being injected from the damaged portion of the first paint pipe 131 even after the first opening-closing switching valve 133 is closed. In addition thereto, the
20 first opening-closing switching valve 133 itself may be damaged.

To prevent this, in the present invention, the first opening-closing switching valve 133 and the second opening-closing switching valve 134 are both closed when
25 the supply of the paint is stopped. As can be seen from FIG. 9b which is an enlarged view of the second opening-closing switching valve 134, the latter is a kind of a ball valve wherein the second opening-closing switching valve 134 is rotated to close the same as shown in the
30 drawing. Thus, the supply of the paint can be stopped on the upstream side of the first paint pipe 131.

Therefore, when the first paint pipe 131 is damaged, it is possible to prevent the paint from continuously leaking from the damaged portion of the first paint pipe
35 131. Note that, actually, a small amount of paint in the first paint pipe 131 can be discharged from the damaged portion due to the residual pressure, but the discharge

flow is relatively weak, and thus the scattering range of the paint can be minimized.

FIGS. 10a and 10b respectively show a side view and an end view of another embodiment of the main body of the hanging type painting apparatus. A gondola 135 shown in
5 FIGS. 10a and 10b is movable in the horizontal direction through a sliding portion 31 and is rotatable about the post 11 through the sleeve 29. The gondola 135 is provided with a rotating shaft 136 on the bottom of one
10 end of the gondola 135. As can be seen from FIG. 10a, the rotating shaft 136 is parallel with the post 11. In other words, the gondola 135 is rotatable about the rotating shaft 136. Thus, an operator on board on the gondola 135 can come very close to the object to be
15 inspected and repaired, etc., and perform the inspection or repair, etc.

FIG. 11 shows a block diagram of a painting system having a plurality of hanging type painting apparatuses according to the present invention. In the painting
20 system 600 shown in FIG. 11, three hanging type painting apparatuses 10a through 10c are indicated. The hanging type painting apparatuses 10a through 10c are connected to the controllers 100a through 100c, respectively. Note that the painting system 600 may include a larger number
25 of hanging type painting apparatuses 10 and a larger number of controllers 100. However, the painting system 600 has to include at least two hanging type painting apparatuses 10 and controllers 100 associated therewith.

As can be seen from FIG. 11, a single host
30 controller 500 is connected to the controllers 100a through 100c. The host controller 500 is a digital computer and includes a storage portion 501 and an operation stopping portion 503, as in the above-mentioned embodiment. Note that another storage portion 501' may
35 be provided outside of the host controller 500, e.g., on a data server. Moreover, the host controller 500 includes a calculation portion 502 which calculates the

distances between a plurality of first monitoring points provided on the main body 12 of one hanging type painting apparatus 10 and a plurality of second monitoring points provided on another hanging type painting apparatus 10, at a predetermined cycle.

FIG. 12a shows a plan view of another model of a painting system viewed from above, and FIG. 12b shows a side view of the model of the painting system. These models are displayed in a display (not shown), such as a liquid crystal monitor, connected to the host controller 500. Note that the positions of the posts 11a, 11b, and 11c of the model shown in FIG. 12b correspond to the positions of the openings 920 of the cargo tank 800.

FIG. 13 shows a flow chart of the operation of the painting system. The operation of the painting system 600 including the first hanging type painting apparatus 10a and the second hanging type painting apparatus 10b will be discussed below with reference to FIGS. 11, 12a, 12b, and 13. Note that the operations shown in FIG. 13 are carried out at a predetermined control cycle during the painting operation of the painting system 600. As discussed above with reference to FIG. 6b, the first main body 12a of the first hanging type painting apparatus 10a and the second main body 12b of the second hanging type painting apparatus 10b are equally provided with a plurality of monitoring points B.

First, at step 211 in FIG. 13, the position of each monitoring point B of the first main body 12a of the first hanging type painting apparatus 10a is obtained, and at step 212, the position of each monitoring point B of the second main body 12b of the second hanging type painting apparatus 10b is obtained. Obtaining the positions of the monitoring points B are carried out by the controllers 100a and 100b, as in the previous embodiment, and the positions of the monitoring points B are transmitted to the host controller 500. Thereafter, at step 213, the calculation portion 502 calculates the

distances between each monitoring point B of the first main body 12a and each monitoring point B of the second main body 12b, respectively, based on these positions of the monitoring points B.

5 After that, whether or not the shortest distance among the plurality of distances is smaller than a predetermined value, e.g., the distance "A" is checked at step 214. If the shortest distance is smaller than the predetermined value, the process proceeds to step 215 and
10 if the shortest distance is not smaller than the predetermined value, the process ends.

 At step 215, the operation stopping portion 503 stops the operations of the first main body 12a and the second main body 12b. Note that when both the first and
15 second main bodies 12a and 12b operate, the operations of the first and second main bodies are stopped, and when one of the first and second main bodies 12a and 12b operates, only the operating main body is stopped. Then, at step 216, the operation stopping portion 503 stops the
20 supply of the paint, etc., to the supply portion 50 of the first main body 12a and/or the second main body 12b whose operation has been stopped. The operation of the operation stopping portion 503 is the same as the operation stopping portion 103 mentioned above and no
25 detailed explanation therefor will be given herein.

 As can be seen from the foregoing, in the painting system 600, the first main body 12a of the first hanging type painting apparatus 10a and the second main body 12b of the second hanging type painting apparatus 10b are
30 stopped before the first hanging type painting apparatus 10a and the second hanging type painting apparatus 10b contact with each other. Therefore, in the present invention, it is possible to prevent the first hanging type painting apparatus 10a and the second hanging type
35 painting apparatus 10b from contacting each other. Thus, in the painting system 600 according to the present invention, it is possible to carry out a stable painting

operation while preventing the first main body 12a and the second main body 12b from being damaged.

5 Note that as shown in FIG. 11, etc., if the painting system 600 includes three hanging type painting apparatuses 10, the shortest distance between the monitoring points of the first main body 12a and the monitoring points of the second main body 12b, the shortest distance between the monitoring points of the second main body 12b and the monitoring points of the third main body 12c, the shortest distance between the monitoring points of the third main body 12c and the monitoring points of the first main body 12a may be calculated, and if any one of the shortest distances is smaller than a predetermined value, the first main body 12a, the second main body 12b and the third main body 12c may be stopped. It is apparent that the same effect can be brought about in such a painting system 600 having three hanging type painting apparatuses.

20 It is necessary to correctly install the post 11 of the hanging type painting apparatus 10 in the cargo tank 800 in order to obtain correct positions of the monitoring points B of the main body 12 in FIGS. 7 and 13. The installation method of the post will be discussed below with reference to FIG. 14 which shows a flow chart of the installation operation of the post used in the hanging type painting apparatus.

25 First, at step 221 in FIG. 14, the damper support 89 (FIG. 1) is placed on the bottom surface 810 of the cargo tank 800 in parallel with the bottom surface. To this end, it is possible to use an appropriate shape of spacer or support (not shown). Thereafter, at step 222, the position of the damper support 89 is determined so that the center thereof is coincidental with the center of the opening 920.

35 In this positioning operation, it is preferable that a laser beam be irradiated from the damper support 89 toward the opening 920 to align the damper support 89

with the opening 920. After that, at step 223, the damper support 89 is secured to the bottom surface 810 of the cargo tank 800 by welding or by the use of bolts and nuts, etc.

5 After that, the components such as the supply portion 50 are carried into the cargo tank 800 through the manhole. Thereafter, at step 224, the post 11 is inserted through the opening 920 and the upper end 13 of the post 11 is suspended from the frame 71. The lower
10 end 14 of the post 11 is supported by the damper support 89. To this end, the damper support 89 may be provided with a recess in which the lower end 14 can be partly inserted. After that, the main body 12 is attached to the post 11 so that the hanging type painting apparatus
15 10 is formed in the cargo tank 800.

 As a result of the above mentioned operations, the center of the damper support 89 and the center of the opening 920 are substantially coaxial, but there is a possibility of a small error, such as a design error. In
20 view of this possibility, at step 226, a non-contact type distance meter, such as a laser distance meter is mounted on the supply portion 50. The hanging type painting apparatus 10 is driven to move the supply device 50, so that the distance between the target point of the cargo
25 tank 800, e.g., the stepped portion 850 and the non-contact type distance meter is measured. The measurements are performed for a plurality of target points, for example, 40 target points. Thus, the calculation portion 102 can calculate the position of the
30 post 11 relative to the cargo tank 800. The calculated value regarding the position of the post 11 is stored in the storage portion 101.

 Thereafter, at step 227, the target position of the post 11 which is determined in accordance with the
35 position of the opening 920 in the dimensional data of the cargo tank 800 stored in the storage portion 101 is obtained. The modifier 104 calculates the deviation

between the measurement of the position of the post 11 and the target position and stores the same in the storage portion 101. After that, the modifier 104 corrects the target coordinates within the operation
5 program of the hanging type painting apparatus 10, based on the calculated deviation. As a result, the actual positional relationship of the post 11, etc., and the positional relationship on the drawing are identical, so that the painting operation can be carried out with
10 higher precision.

As a matter of course, combinations of some of the embodiments mentioned above are included in the present invention. Note that although the hanging type painting apparatus 10 is used in the cargo tank 800 in the
15 illustrated embodiments, it can be understood that the hanging type painting apparatus can be used in other places, for example, in a gas tank.

Although the invention has been shown and described with exemplary embodiments thereof, it should be
20 understood by those skilled in the art that the foregoing and various other changes, omissions and additions may be made therein and thereto without departing from the scope of the invention.

CLAIMS

1. A hanging type painting apparatus comprising
a post hanging through an opening formed
in an upper surface of a tank,
5 a main body which is movable up and down
along the post and is rotatable about the post,
a storage portion which stores therein
dimensional data of the tank,
a calculation portion which calculates the
10 shortest distance between each of a plurality of
monitoring points arranged entirely over the main body of
the painting apparatus and the tank whose data is stored
in the storage portion, at a predetermined cycle, and
an operation stopping portion which stops
15 the operation of the main body of the painting apparatus
when at least one of the shortest distances calculated by
the calculation portion is smaller than a predetermined
value.
2. A hanging type painting apparatus according to
20 claim 1, further comprising
at least one strain detection portion
provided at a front end of the main body of the painting
apparatus,
wherein said operation stopping portion
25 stops the operation of the main body of the painting
apparatus when a signal value detected by the strain
detecting portion exceeds a predetermined range.
3. A hanging type painting apparatus according to
claim 2, further comprising
30 a first paint pipe connected to the front
end of the main body of the painting apparatus,
a second paint pipe connecting the first
paint pipe to a paint source and having a diameter larger
than that of the first paint pipe, and
35 an opening-closing switching valve
provided between the first paint pipe and the second
paint pipe.

4. A hanging type painting apparatus according to any one of claims 1 to 3, further comprising

5 a modifier which modifies an operation program of the hanging type painting apparatus, based on a deviation between a measured position of the post in the tank and a target position of the post determined in accordance with the position of the opening depending on the dimensional data of the tank.

10 5. A hanging type painting apparatus according to claim 1, further comprising a gondola which is rotatable about an axis parallel with the post.

6. A painting system comprising
15 a first hanging type painting apparatus having a first post hanging through a first opening formed in an upper surface of a tank, and a first main body which is movable up and down along the first post and is rotatable about the first post,

20 a second hanging type painting apparatus having a second post hanging through a second opening formed in the upper surface, and a second main body which is movable up and down along the second post and is rotatable about the second post,

a first control portion which controls the first hanging type painting apparatus,

25 a second control portion which controls the second hanging type painting apparatus, and

an host control portion to which the first control portion and the second control portion are connected,

30 wherein said first control portion transmits position signals of a plurality of first monitoring points at least arranged entirely over the first main body of the first hanging painting apparatus to the host control portion at a predetermined cycle,

35 said second control portion transmits position signals of a plurality of second monitoring points at least arranged entirely over the second main

body of the second hanging painting apparatus to the host control portion at said predetermined cycle,

5 said host control portion comprises a calculation portion which calculates the distance between each of the first monitoring points and each of the second monitoring points at said predetermined cycle, and an operation stopping portion which stops the operation of the first and second main bodies when the shortest distance among the distances calculated by the
10 calculation portion is smaller than a predetermined value.