

AIR LUBRICATION SYSTEM OF A SHIP

FIELD

[0001] The present invention relates to an air lubrication system, and more particularly to an air lubrication system for ships, which can reduce frictional resistance of a ship by ejecting air to a surface of the bottom of a hull.

BACKGROUND

[0002] During navigation, a ship is affected by frictional resistance, which is a kind of friction caused by viscosity of water. In order to reduce frictional resistance affecting navigation of the ship, studies have been made on an air lubrication method.

[0003] In the air lubrication method, a portion of the hull surface dipped in seawater is covered with an air layer in order to reduce frictional resistance caused by viscosity of water by converting contact between the hull surface covered with air and the seawater into contact with air and the seawater.

[0004] An air lubrication system (ALS) adopting the air lubrication method is aimed at generating air bubbles by ejecting air to a surface of the ship bottom through multiple orifices typically formed on the surface of the ship bottom such that frictional resistance due to contact between the hull and seawater can be reduced through such air bubbles.

[0005] In recent years, the air lubrication system has been increasingly applied not only to newly built ships but also to existing ships through modification.

[0006] In application of a typical air lubrication system to ships, one air chamber is disposed to cover the multiple orifices and compressed air is supplied to the surface of the ship bottom through pipes, which communicate with the interior of the air chamber. However, the pipes adopt a structure of supplying air through an upper portion of the air chamber, causing deterioration in efficiency in utilization of the interior space of the ship.

[0007] In particular, in a structure wherein a ballast water pipe and a trolley rail are disposed inside a pipe duct, interference occurs between the pipes configured to supply

air through the upper portion of the air chamber and a structure for supplying air, such as a compressor and the like, thereby causing significant deterioration in efficiency in utilization of the interior space of the ship.

[0008] Therefore, there is a need for development of an air lubrication system, which can avoid interference with other pipes and structures in the pipe duct and can improve efficiency in utilization of the interior space of the ship while allowing sufficient discharge of air through the orifices even in the structure wherein the ballast water pipe and the trolley rail are disposed inside the pipe duct of the ship.

[0009] FIG. 1 is a schematic view of a conventional air lubrication system for ships. Referring to FIG. 1, multiple air-jet orifices 15 formed on a surface of a ship bottom to eject air toward the ship bottom 5 are enclosed by one air chamber 22 such that compressed air can be ejected toward the ship bottom through the multiple air-jet orifices 15 when the compressed air is supplied into the air chamber 22.

[0010] However, such a conventional technique has a problem in that, when hull rolling occurs during navigation of the ship in waves, air supplied to the air chamber 22 is not efficiently discharged toward the surface of the ship bottom.

[0011] In other words, with the structure wherein all of the air-jet orifices disposed in a lateral direction of the hull are enclosed by a single air chamber, the conventional air lubrication system does not allow uniform supply of air towards the surface of the ship bottom contacting seawater upon hull rolling, thereby reducing the effect of reducing frictional resistance.

SUMMARY

[0012] It is an object of the present invention to provide an air lubrication system for ships, which can avoid interference with other pipes and structures in a pipe duct and can improve efficiency in utilization of an interior space of a ship while allowing sufficient discharge of air through air-jet orifices even in a structure wherein ballast water pipes and a trolley rail are disposed inside the pipe duct of the ship.

[0013] It is another object of the present invention to provide an air lubrication system for ships, which can improve workability in application of the air lubrication system

to a ship while allowing uniform supply of air towards a surface of a ship bottom in various navigation conditions such as hull rolling.

[0014] In accordance with one aspect of the present invention, an air lubrication system for ships adapted to generate air bubbles on a ship bottom includes: an air-jet module ejecting air toward the ship bottom; and a pipe part supplying air to the air-jet module, wherein the air-jet module is arranged in plural on the ship bottom in a lateral direction of a ship and each of the multiple air-jet modules includes multiple chamber housings having air-jet orifices disposed on a bottom surface thereof to eject air toward the ship bottom through the air-jet orifices and a longitudinal reinforcing member disposed between the multiple chamber housings, and the pipe part is connected to each of the multiple chamber housings to allow uniform discharge of air upon rolling of the ship.

[0015] The air-jet orifices may be formed in plural on a hull outer plate of the ship; the multiple chamber housings may extend from an inner surface of the hull outer plate to enclose the air-jet orifices; and the pipe part may include a connection line from which air discharged through the air-jet orifices is supplied, a main line extending in a different direction from an extending direction of the connection line to supply air to the chamber housings after receiving the air supplied from the connection line, and branch-off lines connecting the main line to the chamber housings, the branch-off lines being connected to side surfaces of the chamber housings.

[0016] The main line may extend in an installation direction of the chamber housings to supply air to the multiple chamber housings and multiple branch-off lines may be connected to the main line.

[0017] A lower end of the main line may be placed below upper ends of the chamber housings.

[0018] The branch-off lines and the connection line may extend to have sections parallel to each other.

[0019] The main line may extend to have a section perpendicular to the extending direction of the connection line and an extending direction of the branch-off lines.

[0020] The branch-off lines may extend from the side surfaces of the chamber housings to be connected to the main line and may include a curved section.

[0021] The branch-off lines may be connected to a lower portion of the main line.

[0022] In accordance with another aspect of the present invention, an air lubrication system for ships includes: a cover plate provided to a hull outer plate of a ship; multiple air-jet orifices formed on the cover plate; a chamber housing extending from an inner surface of the hull outer plate to surround the cover plate; and a pipe connection part formed at one side of the chamber housing to supply air into the chamber housing, wherein the cover plate is detachably coupled to a cover insertion groove formed on the hull outer plate.

[0023] The cover plate may be formed with a through-hole through which a fastening member is inserted into the cover plate to fasten the cover plate to the hull outer plate, the fastening member being inserted into the cover plate through the through-hole from an outer surface of the hull outer plate toward the inner surface thereof, and the chamber housing may be provided therein with a cover coupling portion into which the fastening member is inserted and secured.

[0024] The cover coupling portion may include a distance maintaining portion into which the fastening member is primarily inserted and an inner flange into which the fastening member is secondarily inserted after passing through the distance maintaining portion, and the inner flange may extend from an inner wall of the chamber housing toward a center of the chamber housing.

[0025] When the cover plate is coupled to the hull outer plate, an edge portion of the cover plate and an inner peripheral surface of the hull outer plate may contact each other in some regions thereof and may be inclined at a predetermined inclination toward the center of the chamber housing.

[0026] When the cover plate is coupled to the hull outer plate, an edge portion of the cover plate and an inner peripheral surface of the hull outer plate may contact each other in some regions thereof, and the inner peripheral surface of the hull outer plate may include an inclined guide guiding the edge portion to be fastened to the hull outer plate and an edge seat curvedly extending from the inclined guide such that the edge portion is placed on the edge seat.

[0027] The cover coupling portion may include a cover support on which at least a portion of an upper surface of the cover plate is placed when the cover plate is coupled to the hull outer plate; an inclined flange extending from an end portion of the cover support to an inner wall of the chamber housing; and a coupling hole through which the fastening member is inserted into a region defined by the cover support and the inclined flange.

[0028] The inclined flange may be inclined at a predetermined inclination in a direction away from the center of the chamber housing.

[0029] In accordance with a further aspect of the present invention, there is provided an air-jet module provided to a ship adopting an air lubrication system, the air-jet module including: a chamber housing defined by a bottom constituting a hull bottom surface of the ship, and a sidewall and a ceiling constituted by partition walls for partitioning an interior of the ship, the air-jet module being provided with air-jet orifices formed on the bottom such that the air lubrication system ejects air toward the hull bottom surface; and a pipe part adapted to supply air to the chamber housings.

[0030] The pipe part may include a connection line connected to the partition wall, a main line connected to the connection line and extending in a direction in which the multiple chamber housings are arranged, and branch-off lines extending from the main line and connected to the chamber housings, respectively.

[0031] The chamber housing may include a lower chamber extending from the hull bottom surface to be gradually narrowed in an upward direction; an ejection amount regulator disposed on the lower chamber and controlling an ejection amount of air to be ejected toward the hull bottom surface; an upper chamber disposed on the ejection amount regulator and receiving air supplied from the pipe part; and a protruding portion protruding from the upper chamber and connected to the pipe part.

[0032] The chamber housing may be secured to the bottom by welding at a location where the lower chamber adjoins the bottom.

[0033] According to embodiments of the present invention, the air lubrication system can avoid interference with other pipes and structures in a pipe duct and can improve efficiency in utilization of an interior space of the ship while allowing sufficient

discharge of air through air-jet orifices even in a structure wherein ballast water pipes and a trolley rail are disposed inside the pipe duct of the ship.

[0034] Further, the air lubrication system can improve workability in application of the air lubrication system to the ship while allowing uniform supply of air through air-jet orifices disposed in a lateral direction in various navigation conditions, such as hull rolling of a ship in waves, thereby enabling continuous reduction in frictional resistance through stable formation of the orifices in various navigation conditions.

DRAWINGS

[0035] The above and other aspects, features, and advantages of the present invention will become apparent from the detailed description of the following embodiments in conjunction with the accompanying drawings:

[0036] FIG. 1 is a schematic view of a conventional air lubrication system for ships.

[0037] FIG. 2 is a schematic view of an air lubrication system for ships according to one embodiment of the present invention.

[0038] FIG. 3 is a partial perspective view of the air lubrication system according to the embodiment of the present invention.

[0039] FIG. 4 is a cross-sectional view taken along line A-A of FIG. 3.

[0040] FIG. 5 is a view of a modification of a pipe part of the air lubrication system according to the embodiment of the present invention.

[0041] FIG. 6 is a cross-sectional view taken along line B-B of FIG. 5.

[0042] FIG. 7 is a sectional view of an inclined inner wall inside a chamber housing of the air lubrication system shown in FIG. 4.

[0043] FIG. 8 is a sectional view of an inclined inner wall inside the chamber housing of the air lubrication system shown in FIG. 6.

[0044] FIG. 9 is a view depicting a result of air ejection simulation in the conventional air lubrication system upon rolling.

[0045] FIG. 10 is a view depicting a result of air ejection simulation in the air lubrication system according to the embodiment of the present invention upon rolling.

[0046] FIG. 11 is a perspective view of a modification of a chamber housing disposed on an inner surface of a hull outer plate inside a hull.

[0047] FIG. 12 is a plan view of an outer surface of the hull outer plate on which the chamber housing is disposed.

[0048] FIG. 13 is a cross-sectional view taken along line A-A of FIG. 12.

[0049] FIG. 14 is a sectional view of a cover plate and fastening members separated from the hull outer plate in FIG. 13.

[0050] FIG. 15 is a sectional view of a modification of a cover plate in the air lubrication system according to the embodiment of the present invention.

[0051] FIG. 16 is a sectional view of the cover plate and the fastening members separated from the hull outer plate in FIG. 15.

[0052] FIG. 17 is a sectional view of a modification of a cover coupling portion in the air lubrication system according to the embodiment of the present invention.

[0053] FIG. 18 is a sectional view of the cover plate and the fastening members separated from the hull outer plate in FIG. 17.

[0054] FIG. 19 is a view of a modification of an air-jet module in the air lubrication system according to the embodiment of the present invention.

[0055] FIG. 20 is an enlarged view of a chamber housing shown in FIG. 19.

[0056] FIG. 21 is a view of a ship adopting an air-jet module according to one embodiment of the present invention.

DETAILED DESCRIPTION

[0057] Hereinafter, embodiments of the present invention will be described in detail. It should be understood that the present invention is not limited to the following embodiments and may be embodied in different ways, and that the embodiments are provided for complete disclosure and thorough understanding of the present invention by those skilled in the art.

[0058] It will be understood that when an element such as a layer, film, region or substrate is referred to as being placed "on" or "under" another element, it can be directly placed on the other element, or intervening layer(s) may also be present. In addition, spatially relative terms, such as "upper" and "lower", are defined from the observer's point

of view, and, when the observer's point of view is changed, "upper (portion)" may mean "lower (portion)", or vice versa.

[0059] It will be noted that like components will be denoted by like reference numerals throughout the specification and the accompanying drawings. In addition, it will be understood that the terms "includes", "comprises", "including", and/or "comprising" when used in this specification, specify the presence of stated features, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, steps, operations, elements, components, and/or groups.

[0060] FIG. 2 is a schematic view of an air lubrication system for ships according to one embodiment of the present invention.

[0061] Referring to FIG. 2, an air lubrication system for ships according to one embodiment of the present invention includes an air-jet module 110 and a pipe part 130 adapted to supply air to the air-jet module 110.

[0062] The air-jet module 110 may include multiple chamber housings 120. Here, each of the multiple chamber housings 120 may be disposed to cover multiple air-jet orifices formed on a surface of a ship bottom.

[0063] Here, at least some of the multiple chamber housings 120 may be disposed in a line in a lateral direction of a hull.

[0064] Details of the chamber housings 120 will be described below.

[0065] The air lubrication system according to the embodiment may further include longitudinal reinforcing members 140 that improve longitudinal strength of the ship while dividing the multiple chamber housings 120 from each other.

[0066] According to this embodiment, the longitudinal reinforcing member 140 may be provided to at least one space between the multiple chamber housings 120 or may be provided to all of spaces between the multiple chamber housings 120 as shown in FIG. 2.

[0067] Here, the longitudinal reinforcing members 140 may have a lower height than the chamber housings 120.

[0068] The pipe part 130 may include a main pipe 131, a branch-off pipe 133, and a connection pipe 135 described below.

[0069] In this embodiment, the pipe part 130 may be further provided with an air flux controller (not shown) and a cut-off valve (not shown) to control pressure of air flowing into the chamber housings 120 or to control flow of air into each of the chamber housings 120.

[0070] That is, to solve the problems of the aforementioned conventional technique in which all of the multiple air-jet orifices formed on the surface of the ship bottom are enclosed by a single air chamber, the inventors of the present invention developed the air lubrication system which includes the air-jet module 110 adapted to allow air to be supplied to each of the multiple chamber housings 120 formed with air-jet orifices 112.

[0071] That is, the air lubrication system according to the embodiment of the present invention is provided with the air-jet modules 110 each realized by a group of the multiple chamber housings 120 arranged in the lateral direction of the hull such that air can be supplied to each of the groups, that is, each of the air-jet modules 110.

[0072] The inventors of the present invention developed the arrangement structure of the air-jet modules 110 and the chamber housings 120 described below in order to solve the problem of significant deterioration in utilization of the interior space of the ship while improving workability in application of the air-jet modules 110 to the ship and allowing uniform supply of air through the air-jet orifices disposed in the lateral direction in a hull rolling state, which occur upon navigation of the ship in waves.

[0073] Here, the air-jet module 110 may have a total width A of 5 m or less and each of the chamber housings 120 constituting the air-jet module 110 may have a height C of 500 mm to 1,000 mm and a maximum width B (a section having the maximum length with reference to a width direction) of 300 mm to 600 mm.

[0074] FIG. 3 is a partial perspective view of the air lubrication system according to the embodiment of the present invention and FIG. 4 is a cross-sectional view taken along line A-A of FIG. 3.

[0075] Referring to FIG. 3, the air lubrication system according to the embodiment may include the multiple air-jet orifices 112 disposed on a hull outer plate 111, the multiple chamber housings 120 each being disposed to cover at least one of the

multiple air-jet orifices 112, and the pipe part 130 connecting the multiple chamber housings 120 to an air supply pipe (not shown) disposed inside the hull.

[0076] In this embodiment, the hull outer plate 111 may mean a horizontal ship bottom-outer plate constituting a bottom surface of the ship and a ship side-outer plate slanted or perpendicular to the ship bottom-outer plate. Here, an inner surface 111a of the hull outer plate 111 refers to an interior space of the ship corresponding to a space into which the chamber housings 120 extend to be installed therein, and an outer surface (not shown) of the hull outer plate 111 refers to a space to which air is discharged.

[0077] The air-jet orifices 112 provide a space through which air generated by a compressor disposed inside the ship is discharged to a region outside the ship, for example, to the ship bottom to generate air bubbles on the ship bottom through the air supply system of the air lubrication system. The air lubrication system according to the present invention can reduce frictional resistance to the ship by forming an air layer through generation of the air bubbles on the ship bottom. For example, the air-jet orifice 112 may be provided in plural and multiple groups of the air-jet orifices 112 may be provided.

[0078] The chamber housings 120 extend upwards from the inner surface 111a of the hull outer plate 111 and are disposed to enclose the air-jet orifices 112.

[0079] For example, the chamber housings 120 may have a cylindrical shape having a predetermined diameter.

[0080] For example, the chamber housings 120 may have a conical shape having a constantly changing diameter.

[0081] For example, as shown in FIG. 4, each of the chamber housings 120 may include a lower chamber extending along a diameter changing portion 123, which has a gradually decreasing diameter on the inner surface 111a of the hull outer plate 111, and an upper chamber extending from the diameter changing portion 123 and having the same diameter as a diameter of an upper end of the diameter changing portion 123.

[0082] For example, the multiple chamber housings 120 may be disposed to be adjacent each other and each of the chamber housings 120 may include a group of air-jet orifices 112.

[0083] In other words, according to this embodiment, each of the chamber housings 120 includes the upper chamber and the lower chamber, in which the upper

chamber has a hollow cylindrical shape (or a cylinder) open at upper and lower sides thereof and includes an upper plate 121 coupled to an upper end thereof to cover the open upper side of the chamber housing 120, and the lower chamber may be formed with the diameter changing portion 123 to surround at least one air-jet orifice 112.

[0084] Referring to FIG. 4, the multiple air-jet orifices 112 are arranged in a line on the hull outer plate 111 in one direction (that is, in the lateral direction). However, it should be understood that the present invention is not limited thereto. That is, the size, location and angle of each of the multiple air-jet orifices 112 may be determined in various ways in light of the size of the chamber housings 120 and the flow rate of compressed air to be ejected toward the surface of the ship bottom.

[0085] The air lubrication system according to the embodiment may include the pipe part 130 connected to an air supply unit (not shown) adapted to generate compressed air inside the hull and supplying air to each of the multiple chamber housings 120.

[0086] Specifically, as shown in FIG. 2, the pipe part 130 may include a main line 131, which extends in the lateral direction of the hull, and a connection line 135, which connects the air supply unit to the main line 131.

[0087] In addition, referring to FIG. 4, the pipe part 130 may further include branch-off lines 133 branched off from one main line 131 and connected to the multiple chamber housings 120, respectively.

[0088] That is, in the pipe part 130 according to this embodiment, the branch-off lines 133 connecting the multiple chamber housings 120 are branched off from one main line 131, whereby, even when one of the multiple chamber housings 120 malfunctions or is damaged, air can be efficiently ejected toward the surface of the ship bottom through the other chamber housings 120.

[0089] The main line 131 receives air from the connection line 135.

[0090] For example, the main line 131 may extend in a different direction from a direction in which the connection line 135 extends a predetermined distance from the main line 131. Here, the predetermined distance may refer to a distance from a point at which the connection line 135 is connected to the main line 131 to a point at which the connection line 135 extends in a different shape. By way of example, the connection line

135 may extend in a curved shape and may extend in a linear shape by a predetermined distance from the point at which the connection line 135 is connected to the main line 131.

[0091] For example, the main line 131 may extend in a direction in which the multiple chamber housings 120 are arranged adjacent each other, and the multiple branch-off lines 133 may branch off from the main line 131 and be connected to the chamber housings 120.

[0092] That is, air having flown from the connection line 135 to the main line 131 is divided by the branch-off lines 133 to be supplied to the multiple chamber housings 120. Here, the main line 131 may extend in a different direction from the direction in which the connection line 135 extends the predetermined distance, so as to allow air to be supplied to the chamber housings 120 after efficient distribution inside the main line 131 and division into each of the branch-off lines 133.

[0093] The branch-off lines 133 may connect the main line 131 to the chamber housings 12.

[0094] In the air lubrication system according to the embodiment, the branch-off lines 133 may be connected to side surfaces of the chamber housings 120, respectively. Accordingly, a lower end 131a of the main line may be placed below an upper end of the chamber housing, that is, below the upper plate 121. By way of example, there is a predetermined height difference h between the lower end 131a of the main line and the upper plate 121.

[0095] That is, in a conventional air lubrication system in which pipes are disposed above the chamber housings 120, there occurs significant interference between the pipes and a ballast water pipe and a trolley rail, which may be disposed inside a pipe duct, thereby causing significant deterioration in efficiency in utilization of the interior space of the ship, or an unnecessary curved portion is formed on the pipe, thereby causing inefficient flow of air discharged through the air-jet orifices. However, the present invention can solve such problems.

[0096] Furthermore, as described above, the chamber housing 120 may include the diameter changing portion 123 formed on the lower chamber and the upper chamber extending therefrom and having the same diameter as the diameter changing portion 123, and each of the branch-off lines 133 is connected to the side surface of the corresponding

chamber housing 120 at an upper portion thereof such that adjacent groups of the air-jet orifices 112 are disposed close to each other while allowing other pipes and structures to pass through a space between the upper portions of the chamber housings 120, thereby achieving significant improvement in efficiency in utilization of the interior space of the ship.

[0097] The connection line 135 supplies compressed air generated by the air supply unit to the interior of each of the multiple chamber housings 120 and may be connected to a compressor (not shown) to supply air at a predetermined pressure.

[0098] For example, the connection line 135 may extend in a liner shape or in a curved shape. By way of example, the connection line 135 may be disposed to extend in a curved shape and to extend a predetermined length in a linear shape from a location at which the connection line 135 is connected to the main line 131.

[0099] That is, to improve efficiency in utilization of the internal structure of the ship, the connection line 135 may be disposed to extend in a linear shape and/or in a curved shape and to extend a predetermined length in a linear shape from a location at which the connection line 135 is connected to the main line 131, thereby enabling supply of air to the main line 131 under a sufficient air pressure.

[00100] The branch-off lines 133 and the connection line 135 may extend to include sections parallel to each other, with the main line 131 interposed therebetween. For example, the main line 131 may include a section perpendicular to the extending direction of the connection line 135 and the extending direction of the branch-off lines 133. With this structure, the main line can minimize interference obstructing the flow of air to allow air supplied through the connection line 135 to be efficiently supplied to the chamber housings 120 through the branch-off lines 133.

[00101] In this embodiment, the main line 131 may be disposed in plural in a direction in which the multiple chamber housings 120 are arranged adjacent each other, and the multiple branch-off lines 133 may be branched off from each of the main lines 131 such that the multiple chamber housings 120 can be grouped.

[00102] That is, in the air lubrication system according to the embodiment, each of the multiple chamber housings 120 may be disposed to cover at least one of the multiple air-jet orifices 112 formed on the surface of the ship bottom and the multiple chamber

housings 120 may be grouped such that air can be supplied to each group, that is, each of the air-jet modules 110, thereby enabling uniform supply of air to the surface of the ship bottom through the air-jet modules 110 even upon occurrence of hull rolling.

[00103] Here, the main lines 131 may be connected to the multiple connection lines 135, respectively.

[00104] FIG. 5 is a view of a modification of the pipe part of the air lubrication system according to the embodiment of the present invention and FIG. 6 is a cross-sectional view taken along line B-B of FIG. 5.

[00105] Referring to FIG. 5 and FIG. 6, the pipe part has a different shape from the air lubrication system and the branch-off lines shown in FIG. 3 and FIG. 4. For other structures of the pipe part, refer to the description of the structures described with reference to FIG. 3 and FIG. 4.

[00106] The pipe part according to this modification includes a main line 151, branch-off lines 153, and a connection line 155.

[00107] Referring to FIG. 5 and FIG. 6, the branch-off lines 153 may extend from a side surface of the chamber housing 120 to be connected to the main line 151. Specifically, the branch-off line 153 may include a curved section connected to a lower portion of the main line 151.

[00108] Accordingly, the pipe part allows air having flown into the main line 151 to be discharged to the branch-off lines 153 through the lower portion of the main line 151, for example, through the lowermost point of the main line 151, thereby maximizing efficiency in utilization of the interior space of the ship, and allows air to be supplied to the side surfaces of the chamber housings 120 through the branch-off lines 153 each including the curved section to improve efficiency in air flow, thereby improving supply efficiency of air to the chamber housings 120.

[00109] FIG. 7 and FIG. 8 are sectional views of an inclined inner wall inside the chamber housing of the air lubrication system according to the embodiment of the present invention. Specifically, FIG. 7 is a sectional view of an inclined inner wall inside the chamber housing of the air lubrication system shown in FIG. 4 and FIG. 8 is a sectional view of an inclined inner wall inside the chamber housing of the air lubrication system shown in FIG. 6.

[00110] Referring to FIG. 7 and FIG. 8, the air lubrication system has the same configuration as the air lubrication system described with reference to FIG. 4 and FIG. 6 except for the inclined inner wall 125.

[00111] The inclined inner wall 125 is provided to improve efficiency in discharge of air through the air-jet orifices 112 by controlling the flow of air supplied to the chamber housing 120 through the branch-off line 133; 153.

[00112] For example, to prevent air from flowing above a predetermined height at the upper portion of the chamber housing 120, the inclined inner wall 125 is disposed in an inner space defined by the chamber housing 120. For example, the inclined inner wall 125 may have an elliptical shape.

[00113] For example, when the branch-off line 133; 153 is connected to one side of the upper portion of the chamber housing 120, the inclined inner wall 125 may extend at a negative inclination from the one side of the upper portion of the chamber housing 120 to the other side of the upper portion of the chamber housing 120.

[00114] Here, the lowermost end of a point on the other side of the upper portion of the chamber housing 120 to which the inclined inner wall 125 is connected may have a lower height than the lowermost end of a point on the one side of the upper portion of the chamber housing 120 to which the branch-off lines 133; 153 are connected, thereby providing, for example, a height difference d (d' in FIG. 8).

[00115] Accordingly, the pipe part allows air having flown into the chamber housings 120 to be discharged through the air-jet orifices 112 at a lower portion of each of the chamber housings 120 after efficiently flowing in terms of fluid dynamics.

[00116] FIG. 9 is a view depicting a result of air ejection simulation in the conventional air lubrication system upon rolling and FIG. 10 is a view depicting a result of air ejection simulation in the air lubrication system according to the embodiment of the present invention upon rolling.

[00117] Referring to FIG. 9, it can be seen that the conventional air lubrication system does not allow air to be ejected through the air-jet orifices F at a distal end due to difference in internal pressure of an air chamber upon hull rolling.

[00118] Referring to FIG. 10, it can be seen that the air lubrication system according to the embodiment allows uniform supply of air to the air-jet orifices arranged

in the lateral direction upon hull rolling, thereby enabling continuous reduction in frictional resistance through stable formation of the orifices in various navigation conditions.

[00119] The air lubrication system according to the embodiment of the present invention can avoid interference with other pipes and structures, such as a compressor and the like, in the pipe duct and can improve efficiency in utilization of the interior space of the ship while allowing sufficient discharge of air through the air-jet orifices even in the structure wherein ballast water pipes and a trolley rail are disposed inside the pipe duct of the ship.

[00120] In addition, the air lubrication system according to the embodiment of the present invention can improve workability in installation of the air-jet modules on the ship while allowing uniform supply of air to the air-jet orifices arranged in the lateral direction in various navigation conditions, for example, hull rolling of the ship in waves, thereby enabling continuous reduction in frictional resistance through stable formation of the orifices even in various navigation conditions.

[00121] On the other hand, in the conventional air lubrication system, since the housing is disposed on the outer plate formed with the air-jet orifices, it is very difficult to perform maintenance and repair of the interior of the housing when the air-jet orifices are blocked or the interior of the housing is damaged or filled with foreign matter.

[00122] In order to solve such problems, the conventional air lubrication system is provided with a cover detachably coupled to an upper portion of the housing to allow maintenance and repair of the interior of the housing.

[00123] However, the air lubrication system is provided with many pipes for supply of air, making it very difficult to attach or detach the cover. In particular, in the structure wherein the ballast water pipes and the trolley rail are disposed inside the pipe duct of the ship, the cover cannot be detachably coupled to the housing due to interference between the pipes for supplying air through the upper portion of the housing and structures such as a compressor for supplying air.

[00124] Accordingly, when a space for maintenance and repair of the interior of the housing is formed at the upper portion of the housing, arrangement of the pipes and the structures is changed, thereby causing significant deterioration in efficiency in utilization of the interior space of the ship.

[00125] The present invention provides the air lubrication system for ships, which can improve efficiency in utilization of the interior space of the ship while allowing maintenance and repair of the interior of the chamber housings without being affected by the pipes and the structures disposed inside the ship.

[00126] FIG. 11 and FIG. 12 show modifications of the chamber housing of the air lubrication system according to the embodiment of the present invention. FIG. 11 is a perspective view of a chamber housing disposed on an inner surface of a hull outer plate inside a hull and FIG. 12 is a plan view of an outer surface of the hull outer plate on which the chamber housing is disposed.

[00127] Next, a chamber housing 220 according to the modification will be described with different reference numerals from the above embodiment.

[00128] Referring to FIG. 11 and FIG. 12, the chamber housing 220 extends from an inner surface 211a of a hull outer plate 211 and is disposed to enclose air-jet orifices 262 described below.

[00129] The chamber housing 220 according to the modification may include a housing body 221 and an upper plate 223 fastened to an upper portion of the housing body 221.

[00130] The upper plate 223 may be coupled to the upper portion of the housing body 221 by welding or may be detachably coupled thereto through fastening members, such as a bolt and a nut.

[00131] For example, the housing body 221 may have a cylindrical shape having a predetermined diameter.

[00132] For example, the housing body 221 may have a conical shape having a constantly changing diameter.

[00133] For example, the housing body 221 may have a diameter gradually decreasing from the inner surface 211a of the hull outer plate 211.

[00134] For example, the chamber housings 220 may be disposed in plural to be adjacent each other and each of the multiple the chamber housing 220 may include a group of air-jet orifices 262.

[00135] A pipe connecting portion 223a serves to allow air generated by a compressor to be supplied to the interior of the chamber housing 220 and may be provided

to the upper plate 223 or to a side surface of the chamber housing 220, as in the above embodiment.

[00136] FIG. 13 is a cross-sectional view taken along line A-A of FIG. 12 and FIG. 14 is a sectional view of a cover plate and fastening members separated from the hull outer plate in FIG. 13.

[00137] Referring to FIG. 13 and FIG. 14, the air lubrication system according to this embodiment may include a cover plate 260 coupled to the hull outer plate 211, multiple air-jet orifices 262 formed on the cover plate 260, the chamber housing 220 extending from the inner surface 211a of the hull outer plate 211 to surround the cover plate 260, and the pipe connecting portion 223a formed at one side of the chamber housing 220 to supply air to the chamber housing 220.

[00138] Here, the cover plate 260 may be detachably coupled to a cover insertion groove 216 formed on the hull outer plate 211.

[00139] That is, the air lubrication system according to this embodiment can improve efficiency in utilization of the interior space of the ship while allowing maintenance and repair of the interior of the chamber housing 220 without being affected by pipes and structures disposed inside the ship.

[00140] In this embodiment, the cover plate 260 may be formed with through-holes 261 into which fastening members 270 for coupling the cover plate 260 to the hull outer plate 211 are inserted. For example, the through-holes 261 may be disposed closer to an edge portion 260a (see FIG. 14) than the center of the cover plate 260.

[00141] The cover plate 260 may have the same or similar thickness to the hull outer plate 211 and may have a size corresponding to an inner periphery of a lower end of the chamber housing 220.

[00142] Further, the cover plate 260 may be formed with multiple through-holes 261 for fastening multiple fastening members 270 along the periphery thereof.

[00143] The fastening members 270 may be inserted into the through-holes 261 in a direction from an outer surface 211b of the hull outer plate 211 to the inner surface 211a thereof. For example, the fastening members 270 may include bolt members.

[00144] The chamber housing 220 may be provided therein with a cover coupling portion 225 to be coupled to the cover plate 260, in which the cover coupling

portion 225 may be formed with coupling holes 225c to which the fastening members 270 are coupled.

[00145] For example, each of the fastening member 270 and the cover coupling portion 225 may be formed with screw threads (not shown) and screw grooves corresponding to the screw threads such that the fastening member 270 presses the cover plate 260 on the cover coupling portion 225 to secure the cover plate 260 to the hull outer plate 211 through engagement with the cover coupling portion 225 inside the chamber housing 220.

[00146] That is, according to this embodiment, the cover plate 260 may be coupled to the cover coupling portion 225 protruding from an inner peripheral surface of the chamber housing 220 through bolt fastening.

[00147] The cover coupling portion 225 may include a distance maintaining portion 225a into which the fastening member 270 is primarily inserted and an inner flange 225b into which the fastening member is secondarily inserted after passing through the distance maintaining portion 225a

[00148] The inner flange 225b may extend from an inner wall of the chamber housing 220 toward the center of the chamber housing 220, and the distance maintaining portion 225a may have a flat shape to be attached to a lower side of the inner flange 225b such that an upper surface of the cover plate 260 can be seated thereon.

[00149] For example, the distance maintaining portion 225a and the inner flange 225b may be realized in a secured structure.

[00150] For example, the distance maintaining portion 225a may extend beyond the inner flange 225b towards the center of the chamber housing 220.

[00151] For example, a predetermined space may be formed between the distance maintaining portion 225a and an inner wall of the chamber housing 220.

[00152] With this structure, the cover coupling portion 225 can increase a mounting area of the cover plate 260 without occupying a large space inside the chamber housing 220, thereby stably securing the cover plate 260 to the hull outer plate 211 while reducing costs for installation of the air lubrication system.

[00153] Here, the cover plate 260 is provided with an edge portion 260a and the hull outer plate 211 is provided with an inner peripheral surface 213.

[00154] When the cover plate 260 is coupled to the hull outer plate 211, the edge portion 260a and the inner peripheral surface 213 may contact each other in some regions thereof and may be inclined at a predetermined inclination toward the center of the chamber housing 220.

[00155] With this structure, not only the cover coupling portion 225 but also the inner peripheral surface 213 can resist compressive force from the fastening members 270, whereby the cover plate 260 can be stably secured to the hull outer plate 211.

[00156] FIG. 15 is a sectional view of a modification of the cover plate in the air lubrication system according to the embodiment of the present invention and FIG. 16 is a sectional view of the cover plate and the fastening members separated from the hull outer plate in FIG. 15.

[00157] In this modification, the air lubrication system has the same configuration and effects as the air lubrication system described with reference to FIG. 11 to FIG. 14 except for the configuration of a cover plate 280.

[00158] Next, the cover plate 280 according to the modification will be described with different reference numerals from the above embodiment.

[00159] Referring to FIG. 15 and FIG. 16, when the cover plate 280 is coupled to the hull outer plate 211, an edge portion 280a of the cover plate 280 and an inner peripheral surface 213 of the hull outer plate may contact each other in some regions thereof, and the inner peripheral surface 213 may include an inclined guide 214 and an edge seat 215.

[00160] The inclined guide 214 serves to guide the edge portion 280a to the hull outer plate 211 when the cover plate 280 is disposed on the hull outer plate 211.

[00161] The edge seat 215 refers to a portion on which the edge portion 280a of the cover plate 280 is placed, and may extend after being bent at the inclined guide 214 towards the center of the chamber housing 220.

[00162] For example, the inclined guide 214 may be perpendicular to the edge seat 215.

[00163] With this structure, not only the cover coupling portion 225 but also the edge seat 215 can resist compressive force from the fastening members 270, whereby the cover plate 280 can be stably secured to the hull outer plate 211.

[00164] In FIG. 15 and FIG. 16, reference numeral 282 indicates air-jet orifices 282, and in FIG. 16, reference numeral 281 indicates through-holes 281 into which the fastening members 270 are inserted. The air-jet orifices 282 and the through-holes 281 are the same as those described above and detailed description thereof will be omitted.

[00165] FIG. 17 is a sectional view of a modification of the cover coupling portion in the air lubrication system according to the embodiment of the present invention and FIG. 18 is a sectional view of the cover plate and the fastening members separated from the hull outer plate in FIG. 17.

[00166] In this modification, the air lubrication system has the same configuration and effects as the air lubrication system described with reference to FIG. 11 to FIG. 14 except for the configuration of a cover coupling portion 227.

[00167] Next, the cover coupling portion 227 according to the modification will be described with different reference numerals from the above embodiment. Although the cover plate 260 shown in FIG. 13 and FIG. 14 is described as being coupled to the cover coupling portion 227 in this modification, it should be understood that the cover plate 280 shown in FIG. 15 and FIG. 16 may be coupled thereto.

[00168] Referring to FIG. 17 and FIG. 18, the cover coupling portion 227 may include a cover support 227a, an inclined flange 227b, and a coupling hole 227c.

[00169] The cover support 227a serves to provide a region in which at least a portion of an upper surface of the cover plate 260 is seated when the cover plate 260 is coupled to the hull outer plate 211. The cover support 227a may have the same shape as the upper surface of the cover plate 260 and may include, for example, a flat section.

[00170] The inclined flange 227b extends from a distal end of the cover support 227a to an inner sidewall of the chamber housing 220 and defines a surface of the cover coupling portion 227 inside the chamber housing 220. That is, the shape of the cover coupling portion 227 is defined by the cover support 227a, the inclined flange 227b and the inner sidewall of the chamber housing 220.

[00171] The coupling hole 227c refers to a space into which the fastening member 270 is inserted, and may be formed in a region defined by the cover support 227a and the inclined flange 227b.

[00172] The inclined flange 227b may be inclined at a predetermined inclination in a direction away from the center of the chamber housing 220. That is, air can flow along the inclined flange 227b to the air-jet orifices 262.

[00173] Accordingly, the air lubrication system allows air having flown into the chamber housing 220 through a pipe connecting portion 223a to be efficiently discharged through the air-jet orifices 262 without being accumulated inside the chamber housing 220.

[00174] For example, the inclined flange 227b may extend to one end of a through-hole 261.

[00175] Accordingly, the air lubrication system can improve efficiency in discharge of air having flown into the chamber housing 220 through the air-jet orifices 262.

[00176] The air lubrication system according to the can improve efficiency in utilization of the interior space of the ship while allowing maintenance and repair of the interior of the chamber housings without being affected by pipes and structures disposed inside the ship.

[00177] On the other hand, a ship including such an air lubrication system is provided with multiple air injectors, air-jet orifices, air supply pipes, and the like in a closed space in which components are disposed in the longitudinal direction of the hull, providing poor workability.

[00178] The present invention provides an air lubrication system for ships, in which air-jet modules previously manufactured in a modular form are integrally provided to a lower portion of a ship to improve workability.

[00179] FIG. 19 is a view of a modification of the air-jet module in the air lubrication system according to the embodiment of the present invention, FIG. 20 is an enlarged view of a chamber housing shown in FIG. 19, and FIG. 21 is a view of a ship adopting an air-jet module according to one embodiment of the present invention.

[00180] First, referring to FIG. 19 and FIG. 20, according to this modification, an air-jet module 310 has a space defined by a bottom 311, a sidewall 313 and a ceiling 315.

[00181] The bottom 311 constitutes a hull bottom surface 301 of the hull when the air-jet module 310 is provided to a ship 300 (see FIG. 21).

[00182] Each of the sidewall 313 and the ceiling 315 is constituted by a partition wall for partitioning the interior of the ship 300 when the air-jet module 310 is provided to the ship 300.

[00183] That is, according to this embodiment, the air-jet module 310 may include the bottom 311 connected to the hull bottom surface 301, the sidewall 313 extending upwards from an edge of the bottom 311 and having a predetermined height, and the ceiling 315 connected to an upper end of the sidewall 313, in which the bottom 311, the sidewall 313, and the ceiling 315 may be formed of the same material as the hull bottom surface 301.

[00184] The air-jet module 310 may be provided therein with multiple chamber housings 320 on the bottom 311, longitudinal reinforcing members 340 disposed between the multiple chamber housings 320, and a pipe part 330 supplying air to the chamber housings 320.

[00185] Here, each of the multiple chamber housings 320 may cover multiple air-jet orifices 312 and may extend upwards from the bottom 311, and at least some of the multiple chamber housings 320 may be arranged in a line in the lateral direction of the hull.

[00186] Referring to FIG. 19, although the air-jet orifices 312 are formed on the bottom 311 in this embodiment, it should be understood that the present invention is not limited thereto. Like the embodiments described above, the chamber housing 320 may be provided with a separate hatch plate (not shown) on an inner peripheral surface of a lower end thereof, and the multiple air-jet orifices may be formed on the separate hatch plate.

[00187] According to this embodiment, the longitudinal reinforcing members 340 may be disposed between the multiple chamber housings 320 to allow efficient utilization of the interior space of the ship 300 while improving longitudinal strength of the ship 300.

[00188] Here, the chamber housings 320 and the longitudinal reinforcing members 340 may be secured to the bottom 311 by, for example, welding.

[00189] The pipe part 330 may be connected to the partition wall, that is, at least one of the sidewall 313 and the ceiling 315 to allow air to flow from the outside of the air-jet module 310, more specifically from an air supply unit 303 (see FIG. 21) disposed inside the hull, to the chamber housings 320.

[00190] Specifically, as shown in FIG. 19, the pipe part 330 may include a main line 331 extending in the lateral direction of the hull in the interior space of the air-jet module 310 and multiple branch-off lines 333 branched off from the main line 331 to the multiple chamber housings 320, respectively.

[00191] That is, in the interior space of the air-jet module 310, the branch-off lines 333 connecting the multiple chamber housings 320 are branched off from one main line 331, whereby, when one of the multiple chamber housings 320 malfunctions or is damaged, efficient injection of air can be achieved through the other chamber housings 320.

[00192] In a conventional technique, all of the air-jet orifices 15 (see FIG. 1) are enclosed by one air chamber and it is difficult to achieve uniform supply of air to the surface of the ship bottom contacting seawater upon hull rolling. On the contrary, according to the present invention, the air-jet modules 310 are arranged in the lateral direction inside the hull to allow uniform supply of air to the surface of the ship bottom through the air-jet orifices 312 in each of the chamber housings 320 upon hull rolling.

[00193] That is, instead of adopting the structure wherein air is ejected into one air chamber 22 having the air-jet orifices 15 arranged in the lateral direction and is discharged through the air-jet orifices 15 of the air chamber 22, the air-jet module 310 according to this embodiment adopts the structure wherein the multiple chamber housings 320 each including a small group of air-jet orifices 312 are arranged in the lateral direction of the hull inside the air-jet module 310 and the main line 331 is connected to the multiple chamber housings 320 in the arrangement direction of the multiple chamber housings 320, thereby suppressing occurrence of rolling even in a harsh marine environment while remarkably improving utilization of the interior space of the ship 300 and manufacturing workability through integral installation of the air-jet modules 310, which are previously manufactured in a modular form, to a lower portion of the ship 300.

[00194] In this embodiment, the interior space of the air-jet module 310 is additionally provided with an air supply pipe 302 (see FIG. 21) and a separate connection line 315 connected to the main line 331 to receive air from the air supply unit 303 disposed inside the hull.

[00195] As shown in FIG. 20, each chamber housing 320 may include an upper chamber 321, an ejection amount regulator 323, and a lower chamber 325.

[00196] According to this embodiment, the chamber housing 320 may include the lower chamber 325 extending from the bottom 311 to be gradually narrowed in an upward direction and the upper chamber 321 disposed on the lower chamber 325 and receiving air from the pipe part 330, and may further include the ejection amount regulator 323 disposed between the lower chamber 325 and the upper chamber 321 to control the ejection amount of air.

[00197] That is, after air is supplied to the chamber housing 320, the ejection amount of air to be discharged toward the bottom 311 is regulated through the ejection amount regulator 323, thereby enabling uniform generation of air bubbles on the hull bottom surface 301 without being affected by a marine environment.

[00198] For example, the ejection amount of air of each of the multiple chamber housings 320 is controlled by a controller 304 described below, thereby reducing frictional resistance by maintaining generation of air bubbles in a harsh marine environment.

[00199] Here, the chamber housing 320 may further include a protruding portion 321a protruding from the upper chamber 321 and connected to the pipe part 330, and the lower chamber 325 may be secured to the bottom 311 by welding W at adjoining sites thereof.

[00200] As such, the chamber housings 320, the longitudinal reinforcing members 340, and the pipe part 330 may be integrally formed with one another inside the air-jet module 310, and the air-jet module 310 previously manufactured in a modular form may be integrally provided to the lower portion of the ship 300, thereby improving manufacturing workability.

[00201] Next, referring to FIG. 21, a method of manufacturing a ship 300 adopting the air lubrication system according to the embodiment of the present invention will be described.

[00202] The method of manufacturing a ship 300 adopting the air lubrication system including an installation region 305 of the air-jet module 310 may include: manufacturing a ship including the installation region 305 in which the air-jet module 310 previously manufactured in a modular form will be installed; installing the air-jet module

310 in the installation region 305; and connecting the pipe part 330 to the air supply pipe 302 connected to the air supply unit 303 of the ship 300.

[00203] The installation region 305 is defined by an empty space and is determined to have a volume corresponding to the size of the air-jet module 310, and the previously manufactured air-jet module 310 is fitted into the installation region 305 and secured thereto in manufacture of the ship 300, thereby remarkably improving manufacturing workability.

[00204] The air-jet module 310 may further include an inner connecting portion 335a and an outer connecting portion 302a to shield a connection site between the air supply pipe 302 and the pipe part 330 in the course of installing the previously manufactured air-jet module 310 in the installation region 305.

[00205] The inner connecting portion 335a may be provided to at least one of a partition wall, the sidewall 313 and the ceiling 315 to be placed in the interior space of the air-jet module 310, and the outer connecting portion 302a may be placed at a location corresponding to the inner connecting portion 335a in the installation region 305.

[00206] For example, the inner connecting portion 335a and the outer connecting portion 302a are fastened to joining sites by bolt fastening, thereby preventing air leakage at the joining sites.

[00207] By way of example, the inner connecting portion 335a and the outer connecting portion 302a may be fastened to the joining sites by bolt fastening through previous calculation of accurate locations for bolt fastening at the joining sites after simulation in consideration of minute variation in angle due to bolt fastening upon coupling the previously manufactured air-jet module 310 to the installation region 305, thereby fundamentally preventing air leakage at the joining sites.

[00208] After connecting the pipe part 330 to the air supply pipe 302 connected to the air supply unit 303 of the ship 300, air leakage is monitored by the controller 304.

[00209] For example, the controller 304 may determine whether air leakage occurs at a connection site between the air-jet module 310 and the installation region 305 by driving the air supply unit 303 to generate air, followed by measuring air pressure through an air pressure sensor (not shown) provided to the inner connecting portion 335a.

[00210] For example, the controller 304 may determine whether uniform supply of air to each of the chamber housings 320 is achieved after installation of the air-jet module 310 by driving the air supply unit 303 to generate air, followed by measuring air pressure through an air pressure sensor (not shown) provided to each of the chamber housings 320.

[00211] The air lubrication system according to the embodiment allows the air-jet module previously manufactured in the modular form to be integrally coupled to the lower portion of the ship, thereby achieving remarkable improvement in manufacturing workability, and allows simple installation of the air-jet module in the installation region, thereby reducing a manufacturing schedule upon modification of the ship.

[00212] On the other hand, for application of the air lubrication system to a typical ship, installation of the air-jet module having the multiple air-jet orifices on a lower surface thereof is performed with the ship lifted in a dry dock (not shown).

[00213] Specifically, with the ship lifted in the dry dock, punching and welding for installation of air floating modules inside a double bottom ballast tank and a pipe duct of the ship are repeated, causing deterioration in longitudinal strength of the hull due to punching on the bottom surface of the hull.

[00214] In order to reinforce longitudinal strength of the hull, a separate operation for local reinforcement is required, thereby complicating the corresponding process and requiring excessive time consumption for the operation performed with the ship lifted in the dry dock.

[00215] The present invention is aimed at remarkable reduction in work time in the dry dock by simplifying a process for application of the air lubrication system to an existing ship in modification of the ship.

[00216] In this embodiment, the bottom 311 of the air-jet module 310 may be formed to have a greater thickness than the hull bottom surface 301, specifically a 10% to 20% greater thickness than the hull bottom surface 301.

[00217] Further, the air-jet module 310 according to this embodiment may be welded to the hull such that a lower surface of the bottom 311 is coplanar with the hull bottom surface 301.

[00218] Here, multiple air-jet modules 310 may be arranged on the hull in the lateral direction of the hull to allow uniform supply of air to the air-jet orifices 312 in each of the air-jet modules 310 even upon occurrence of hull rolling.

[00219] Further, the bottom 311 of the air-jet module 310 may be formed to have a greater thickness than the hull bottom surface 301 and at least one longitudinal reinforcing member 340 is provided to at least one space between the multiple chamber housings 320 to omit an additional operation for local reinforcement, thereby enabling remarkable reduction in work time in the dry dock.

[00220] Although some embodiments have been described herein, it should be understood that these embodiments are provided for illustration only and are not to be construed in any way as limiting the present invention. The scope of the present invention should be defined by the appended claims and equivalents thereto.

[00221] For example, the drawings schematically show each component as a subject to aid understanding, and the thickness, length, number, and the like of each component shown in the drawings may be different from the actual ones depending on the procedure of creating the drawings. In addition, the material, shape, dimensions, and the like of each component described in the above embodiments are given for illustration only and are not to be construed in any way as limiting the present invention, and various changes can be made by those skilled in the art without substantially departing from the spirit and scope of the present invention.

[00222] <List of Reference numeral>

110, 310: Air-jet module	111: Hull outer plate
111a, 211a: Inner surface	112, 262, 282, 312: Air-jet orifice
120, 220, 320: Chamber housing	121, 223: Upper plate
123: Diameter changing portion	125: Inclined inner wall
130: Pipe part	131, 151: Main line
131a, 151a: Lower end of main line	133, 153: Branch-off line
135, 155: Connection pipe	140: Longitudinal reinforcing member
211: Hull outer plate	211b: Outer surface
213: Inner peripheral surface	214: Inclined guide
215: Edge seat	216: Cover insertion groove
221: Body of housing	223a: Pipe connecting portion
225: Cover coupling portion	225a: Distance maintaining portion
225b: Inner flange	225c: Coupling hole
260, 280: Cover plate	260a, 280a: Edge portion
261, 281: Through-hole	270: Fastening member
300: Ship	
301: Hull bottom surface	302: Air supply pipe
303: Air supply unit	304: Controller
311: Bottom	313: Sidewall
315: Ceiling	321: Upper chamber
321a: Protruding portion	323: Ejection amount regulator
325: Lower chamber	W: Welding

What is claimed is:

1. An air lubrication system adapted to generate air bubbles on a ship bottom, comprising:

- multiple air-jet orifices formed on a hull outer plate of a ship;
- a chamber housing extending from an inner surface of the hull outer plate and enclosing the air-jet orifices;
- a connection line from which air discharged through the air-jet orifices is supplied;
- a main line extending in a different direction from an extending direction of the connection line to supply air to the chamber housing after receiving the air supplied from the connection line; and
- a branch-off line connecting the main line to the chamber housing,
the branch-off line being connected to a side surface of the chamber housing.

2. The air lubrication system according to claim 1, wherein the chamber housing comprises multiple chamber housings, the main line extends in an installation direction of the multiple chamber housings to supply air to the multiple chamber housings, and the branch-off line comprises multiple branch-off lines connected to the main line.

3. The air lubrication system according to claim 1, wherein a lower end of the main line is placed below an upper end of the chamber housing.

4. The air lubrication system according to claim 1, wherein the branch-off line and the connection line extend to have sections parallel to each other.

5. The air lubrication system according to claim 4, wherein the main line extends to have a section perpendicular to the extending direction of the connection line and an extending direction of the branch-off line.

6. The air lubrication system according to claim 1, wherein the branch-off line extends from the side surface of the chamber housing to be connected to the main line and comprises a curved section.

7. The air lubrication system according to claim 6, wherein the branch-off line is connected to a lower portion of the main line.

8. An air lubrication system for ships adapted to generate air bubbles on a ship bottom, the air lubrication system comprising:

multiple air-jet modules arranged on the ship bottom in a lateral direction of a ship and ejecting air toward the ship bottom; and

a pipe part supplying air to the air-jet modules,

wherein each of the multiple air-jet modules comprises multiple chamber housings each disposed to enclose air-jet orifices formed on a hull outer plate of the ship; and

wherein the pipe part comprises:

a connection line from which air discharged through the air-jet orifices is supplied;

a main line extending in a different direction from an extending direction of the connection line to supply air to the chamber housings after receiving the air supplied from the connection line; and

branch-off lines connecting the main line to the chamber housings, the branch-off line being connected to side surfaces of the chamber housings.

9. The air lubrication system according to claim 1 or 8, further comprising:

a cover plate detachably coupled to a cover insertion groove formed on the hull outer plate,

wherein the air-jet orifices are formed on the cover plate and each of the chamber housings is disposed to surround the cover plate.

10. The air lubrication system according to claim 9, wherein:

the cover plate is formed with a through-hole through which a fastening member is inserted into the cover plate to fasten the cover plate to the hull outer plate, the fastening

member being inserted into the cover plate through the through-hole from an outer surface of the hull outer plate toward the inner surface thereof; and

each of the chamber housings is provided therein with a cover coupling portion into which the fastening member is inserted and secured.

11. The air lubrication system according to claim 10, wherein the cover coupling portion comprises a distance maintaining portion into which the fastening member is primarily inserted and an inner flange into which the fastening member is secondarily inserted after passing through the distance maintaining portion,

the inner flange extending from an inner wall of the chamber housing toward a center of the chamber housing.

12. The air lubrication system according to claim 11, wherein:

when the cover plate is coupled to the hull outer plate, an edge portion of the cover plate and an inner peripheral surface of the hull outer plate contact each other in some regions thereof; and

the edge portion of the cover plate and the inner peripheral surface of the hull outer plate are inclined at a predetermined inclination toward the center of the chamber housing.

13. The air lubrication system according to claim 11, wherein:

when the cover plate is coupled to the hull outer plate, an edge portion of the cover plate and an inner peripheral surface of the hull outer plate contact each other in some regions thereof; and

the inner peripheral surface of the hull outer plate comprises an inclined guide guiding the edge portion to be fastened to the hull outer plate and an edge seat curvedly extending from the inclined guide such that the edge portion is placed on the edge seat.

14. The air lubrication system according to claim 11, wherein the cover coupling portion comprises:

a cover support on which at least a portion of an upper surface of the cover plate is placed when the cover plate is coupled to the hull outer plate;

an inclined flange extending from an end portion of the cover support to an inner wall of the chamber housing; and

a coupling hole through which the fastening member is inserted into a region defined by the cover support and the inclined flange.

15. The air lubrication system according to claim 14, wherein the inclined flange is inclined at a predetermined inclination in a direction away from the center of the chamber housing.

16. The air lubrication system according to claim 8, wherein each of the air-jet modules has a space defined by a bottom constituting a hull bottom surface of the ship, and a sidewall and a ceiling constituted by partition walls for partitioning an interior of the ship.

17. The air lubrication system according to claim 8, wherein each of the air-jet modules further comprises a longitudinal reinforcing member disposed between the multiple chamber housings.

18. The air lubrication system according to claim 16, wherein each of the chamber housings comprises:

a lower chamber extending from the hull bottom surface to be gradually narrowed in an upward direction;

an ejection amount regulator disposed on the lower chamber and controlling an ejection amount of air to be ejected toward the hull bottom surface;

an upper chamber disposed on the ejection amount regulator and receiving air supplied from the pipe part; and

a protruding portion protruding from the upper chamber and connected to the pipe part.

19. The air lubrication system according to claim 18, wherein each of the chamber housings is secured to the bottom by welding at a location at which the lower chamber adjoins the bottom.