METHOD AND APPARATUS FOR MODULAR CONSTRUCTION OF A SHIP

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ABSTRACT OF THE DISCLOSURE

A method of assembling a ship is disclosed in which the ship is constructed in a plurality of longitudinal modules. The modules are sequentially constructed, with each module being constructed with its longitudinal axis being substantially vertical. After a module is so constructed, it is rotated 90 degrees, the previously constructed portion of the ship is aligned with the rotated module, and the module is attached to the previously constructed portion of the ship. This portion is then moved forward to provide space for the construction and attachment of the next module. The sequence is repeated until a ship having the desired length is constructed.

This invention relates to an improved method for building ships and, more particularly, to a method for building ships which requires significantly less capital investment and labor than the shipbuilding of the prior art.

The usual method of building a ship is to construct a hull on a way which is at least as big as the ship being constructed, and then to launch the hull into the water and finish construction of the interior of the ship while the ship is tied up to a nearby dock. The hull is constructed on the ways by first forming a suitable framework and then deforming and welding plates of steel to the previously formed framework.

This basic arrangement of constructing ships has been in use for centuries and is essentially the method which was used to construct large wooden vessels in the past. The only major change which has occurred was the substitution of metal for wood in the 19th century.

The disadvantages of this method of construction have also been known for centuries. The method requires a large capital investment in building and maintaining the ways, which for today's ships must sometimes be over 1,000 feet long and 100 feet wide. The method requires many skilled laborers and many thousands of man-hours of skilled labor to build the ship. In addition, the method is extremely slow, typically requiring from many months to as much as several years to construct a large, modern vessel.

From time to time, various modifications in the classic shipbuilding process have been proposed, but these new proposals have, for various economic and practical reasons, not found acceptance in the industry. For example, around the time of World War II, the sudden huge demand for additional shipping capacity led to many proposals for more modern, efficient and speedy shipbuilding procedures. Many such proposals related to means of prefabricating ships or for building ships in some form of modular fashion.

Typical of such proposals of the time is U.S. Patent No. 2,368,441, which proposes a modular method of prefabricating ships. The disadvantages of the method proposed therein include that the hull still has to be formed in the classic manner and that very large and expensive cranes, having sufficient capacity to lift entire sections of the ship, are required to lift and place the modules of the ship into the hull.

A more recent proposal for building ships can be found in U.S. Patent No. 3,011,252, which proposes building the hull of a ship in longitudinal sections, and moving the hull in steps along the ways as each section is completed. The disadvantages of this method include that a way the size of the ship is still required, and that the plates forming the hull must still be welded around a framework in a manner similar to the above described classic method.

It is accordingly an object of the present invention to provide an improved method for building ships which obviates the above described disadvantages of the prior art.

It is another object of the present invention to provide an improved method for building ships which is automated and standardized to a much greater degree than the methods of the prior art.

It is yet another object of the present invention to provide a method for building ships which does not require the heavy capital investment for equipment, such as huge ways, dry docks and large cranes such as are used in the prior art.

It is yet another object of the present invention to provide a method for building ships which requires significantly less labor than the methods of the prior art.

It is yet another object of the present invention to provide a method for building ships in which the ship is constructed in substantially less time than by the prior art methods.

Briefly stated, and in accordance with an embodiment of the present invention, an improved method of constructing ships is provided in which the ship is constructed in a large number of longitudinal modules. Construction occurs on an assembly dock which may be several modules long, but which is substantially shorter than the length of the ship being constructed. Construction may begin from the bow, the stern, or any mid-point of the ship, and as additional modules are completed, the completed portion of the ship is moved out of the assembly dock and into the water, where it floats and supports itself. A watertight seal is provided to keep the construction area dry while construction is underway.

In accordance with a primary feature of the invention, each individual module of the ship is individually constructed on the assembly dock with its longitudinal axis vertical. Prefabricated panels, which are to form the hull, the keel and the longitudinal walls and floors of the ship, are set vertically into place by an overhead crane, and are then welded together along vertical weld lines to form a module of the ship. The module so formed is then rotated ninety degrees and the previously constructed portion is then joined with the module. The completed portion of the ship is then moved one module length further into the water and the next module is constructed on the assembly dock and attached to the ship in the same manner.

The attached drawings and their following descriptions show specific details of the invention. Other objects and advantages of the invention are apparent from these drawings and their descriptions.

In the drawings:

FIGURE 1 shows a perspective view of a ship which is constructed in accordance with the present invention;

FIGURE 2 shows an exploded view of a typical module in the ship of FIGURE 1;

FIGURE 3 through FIGURE 6 show sequential views illustrating the assembly of an individual module and the attachment of the module to the previously constructed portion of the ship;

FIGURE 7 shows a perspective view of a module under construction and a completed portion of the ship, and
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illustrates a preferred method of welding the module together and details on the interior of the completed portion of the ship;

FIGURE 8 schematically illustrates the manner of formation of the panel assemblies from which the modules are constructed;

FIGURE 9 shows an exploded view of the preferred embodiment of an assembly dock on which the ship may be constructed;

FIGURE 10 shows an exploded view of a tanker ship, and illustrates how it could be constructed in accordance with the present invention;

FIGURE 11 shows a perspective view of a typical module for the tanker of FIGURE 10;

FIGURE 12 shows an exploded view of a container type freighter, and illustrates how it could be constructed in accordance with the present invention; and

FIGURE 13 shows a perspective view of a typical module and bulkhead assembly for the container ship of FIGURE 12.

In the following description of the drawings, the same reference numeral is used to designate the same element in the different figures whenever practical.

FIGURE 1 shows a perspective view of a ship 10 which has been constructed in accordance with the method of the present invention. The ship illustrated is an ore carrying boat such as is used to haul iron ore from ore ranges to steel plants. Typically, the ship might be 1,000 feet long, have a beam of 100 feet and a displacement of 50,000 tons. Although, as will be shown later in more detail, the invention is readily adaptable to the construction of any of the various types of ships, such an ore boat has been chosen to illustrate the invention because the inventors were originally made in connection with the construction of such an ore boat, and because the ore boat particularly lends itself to the illustration of the invention.

The ship 10, which is an integral unit when completed, is constructed of a bow section 12, a stern section 14 and a plurality of intermediate modules 16. In the particular ship 10 illustrated in FIGURE 1, there are sixteen such intermediate modules, the ends of which are designated by the dashed lines around the ship 10. Of course, the number of modules selected is solely a function of the length of each module and the desired overall length of the ship.

The particular details of construction of the bow section 12 and stern section 14 form no part of the present invention. Accordingly, this specification does not go into any details on how these sections are made. They may be made by any of the conventional methods known to those in the shipbuilding art.

FIGURE 2 shows an exploded view of a typical module 16 of the ship 10 of FIGURE 1. As shown therein, the module is constructed from a keel box section 18, two bottom panels 20, two side panels 22, two deck panels 24, four panels 26 which define the ore hopper on the interior of the ship, and two panels 28 which help support the panels 26 and which form the bottom of the ballast tanks, the details of which will later be shown at FIGURE 7.

FIGURES 3 through 6 show perspective views illustrating the manner in which the module 16 is constructed and attached to the already completed portion of the ship. In the preferred embodiment of the present invention, construction generally occurs on a floating assembly dock 30, details of which are described later in connection with the description of FIGURE 9. At the stage of construction shown in FIGURE 3, the constructed portion 31 of the ship consists of two modules attached to the bow section and a third module is being constructed. The construction portion 31 of the vessel, as illustrated in FIGURE 4, the final deck panel 24 is being lowered by the crane onto the assembly dock 30 to complete the illustrated module. The seams between all adjacent panels at this point are welded together, preferably by a single pass vertical welding method such as the well-known electrodeslag or electrogas welding methods, to thereby form an integral unit. The module 16 is then rotated ninety degrees, as shown in FIGURE 5, and is aligned with the previously constructed portion 31 of the ship. Details of the preferred manner of rotating the module are illustrated later in connection with the description of FIGURE 9.

FIGURE 6 shows the module assembly 16 completely rotated and the previously constructed portion 31 of the ship aligned with the module. The module 16 is then attached to the ship, preferably by welding, and by using a single pass vertical welding method as described above whenever practical. Preferably, the previously constructed portion 31 of the ship is aligned with the rotated module 16 by flooding the interior of the assembly dock 30 so that the constructed portion may be floated into alignment with the rotated module. To effect this alignment, the interior of assembly dock 30 is flooded, the watertight seal 32 is broken, and the constructed portion 31 of the ship is floated into alignment with the rotated module 16. After so aligning the module and the constructed portion, the watertight seal 32 is restored and the interior of the assembly dock 30 is pumped dry to provide a dry area for welding the module to the constructed portion. A temporary dam (not shown) is provided across the open rear section of the constructed portion 31 of the ship so that the interior is not flooded when the assembly dock 30 is flooded.

After the module is welded to the constructed portion of the ship, the interior of the assembly dock 30 is again flooded and the watertight seal 32 is broken so that the constructed portion 31 of the ship may be floated forward one module length to allow for the construction of the next module. Additional details of these portions of the method are also explained in connection with FIGURE 9 which follows.

FIGURE 7 shows a perspective view of a module 16 being welded into an integral unit and of the constructed portion 31 of the ship. For clarity, details of the floating assembly dock have been omitted from FIGURE 7.

As shown therein, the various panels which comprise the module 16 have been lowered vertically onto the assembly dock and are supported in any suitable manner while they are being welded together. Four electrogas single pass vertical welding units 34 are shown in the process of welding the various panel assemblies together.

Each of the welding units 34 includes a welding head 36 supported on a vertical column 38, which is in turn mounted on tracks 40 on the floor of the assembly dock. However, the floating assembly arrangement of the welding units is not critical to the invention, and other suitable means, such as supporting the welded unit from the top of the panel by a suitable support arrangement, could be used instead. After each welding unit 34 completes a vertical pass to weld a desired seam, it is moved to the next welded seam and the previously constructed portion 31 of the module 16 have been welded. Module 16 is then rotated ninety degrees as shown in FIGURES 6 and 9, aligned with the constructed portion 31 and welded thereto. The vertical seams between the module 16 and the constructed portion 31 may...
also be welded by the electrogas method and the horizontal seams may be welded by any desired suitable means.

One of the primary advantages of the present invention lies in the use of the single pass vertical welding method, such as the electroclad or electrogas welding techniques. These welding techniques are well known to be extremely efficient and economical, but their use is limited to vertical welds and also requires a backing shoe to be located on the opposite side of the welded seam from the welding unit. As can readily be appreciated, if the ship were constructed in the conventional manner, most seams would be vertical instead of vertical welds and even those seams that are vertical could not be welded by these methods because it would be practically impossible to control the backing shoe on the interior of the hull as the welding unit moved about the exterior of the hull. By using the vertical modular construction method of the present invention, most of the primary welds in the ship can be made by these efficient, modern welding techniques, which readily lend themselves to automation and standardization.

Still referring to FIGURE 7, this drawing also affords an interior view of the constructed portion 31 of the ship, and shows how additional crossing and supporting beams 42 may be added to the interior after the module 16 is connected to the constructed portion 31. These braces 42, and any desired splicing plates, may then be added according to the strength requirements of any particular design.

FIGURE 8 schematically illustrates a manner in which the various panels which form the module may conveniently be manufactured. As shown therein, metal plates 44, of a desired size, are reinforced with stringers 46, which may be welded by any desired method to the plates 44 to form sub-panel assemblies 48. A number of such sub-panel assemblies 48 may be attached together to form a panel assembly 50. As will later be described, the sub-panels are not yet welded together, but are instead held together at this time by a suitable jig fixture or the like (not shown).

Next, a frame assembly, consisting of a frame member 52 and a frame cap 54, are placed across the panel assembly perpendicular to the stringers and welded thereto to hold the panel assembly together during the construction process until the individual sub-panels are welded together and, more importantly, to provide additional strength to the panels after the ship is completed. The completed panel 56 shown in FIGURE 8 consists of five sub-panel assemblies connected by seven frame assemblies. In the preferred embodiment of the invention, the sub-panel assemblies are still not welded together at their seams, such as 58, until the complete panel 56 is lowered onto the assembly dock, such as was described in the previous figures. The seams 58 are then also welded by the electrogas welder.

The panel assemblies schematically illustrated in FIGURE 8 are essentially flat panels. Sometimes it may be desirable to use panel assemblies which have curved or complex surfaces. Although the manner for forming the particular panel assembly forms no part of the present invention, and any such desired manner as convenient may be used with the invention, such curved panels can be readily formed by deforming and holding the plates 44 in suitable jig fixtures which define the desired curve surface, and then welding the stringers 46 and frame 52 to the plates 44 and panel assembly 50 while these elements are being held in the desired shape by the jig or other desirable method. If desired or necessary, stringers and frames having curved shapes may be welded to the plates and panel assembly.

FIGURE 9 shows an exploded view of a floating assembly dock 30 which may conveniently be used in accordance with the present invention. The dock 30 includes a plurality of ballast tanks 62 which are connected into a unitary structure by suitable beams such as 64. As later will be described in detail, suitable pumps (not shown) are provided to pump water into and out of ballast tanks 62. Dock 30 also includes a floor 66, supported on beam 64, upon which the ship assembly actually occurs.

The construction of the modules of the ship actually occurs on a pivoting mounted cradle 68. When welding is completed on a particular module and it is desired to rotate the module ninety degrees for alignment with the previously constructed portion of the ship (as previously described), side 70 of the cradle 68, which is hinged to side 72, is rotated about the hinge and brought into contact with the bottom side of the completed module. Side 73 is then securely fastened to crane 68 to support the module as it is rotated into position. A plurality of hydraulic cylinder 74 are provided to rotate cradle 68, and thus the completed module, into the desired aligned position.

Floor 66 also supports a large plurality of assembly rests 76, upon which rests the bottom of the hull of the completed portion of the ship under construction. In the case of the ore boat, such as has been heretofore described, the bottom is essentially flat and horizontal, so all of the assembly rests 76 may be of the same length. In the case of ships having more complex or varying hull shapes, as will later be described in FIGURES 10 through 13, assembly rests of any desired length may be provided in different portions of dock 30. Alternatively, adjustable assembly rests of variable lengths may be provided to accommodate the more complex shapes which may be under construction.

A watertight gate is provided at each end of assembly dock 30 which comprises two seal gates 78 and 80 which are pivoting mounted on hinges 82 on the outer side of end beam 64. These seal gates make a watertight seal with the hull of a ship under construction to maintain a dry assembly area while construction is in progress.

The preferred manner of operating assembly dock 30 is as follows:

Assume that a portion of the ship has been completed and projects out of assembly dock 30 into the water, thereby being buoyantly self-supported in the completed portion, and that a module has just been attached to the completed portion and it is desired to move the completed portion forward one modular length to allow for construction and attachment of the next module. A temporary dam is constructed across the bottom of the open end of the ship so that it will float freely and water is pumped from the ballast tanks 62 into the interior of assembly dock 30 until the water level inside dock 30 is the same as that outside. The seal gates are then opened and water from outside the dock is pumped into ballast tanks 62 to decrease the net buoyancy of assembly dock 30 and to cause it to sink in the water away from the bottom of the hull of the ship, which is then floated one modular length forward. Water is next pumped out of ballast tanks 62, thus causing assembly dock 30 to float higher in the water. This out-pumping is continued until the assembly rests 76 barely touch the bottom of the hull of the completed portion of the ship. The seal gates are now closed and a watertight seal is effected between assembly dock 30 and the hull of the ship. At this time, the water trapped inside assembly dock 30 is completely isolated from the water outside the dock. The ship and dock are now freely floating with no stress between the ship and dock at their junction point. The water inside assembly dock 30 is now pumped into ballast tanks 62. This pumping operation renders the interior of the dock dry for additional construction without changing the net buoyancy of the bottom and thus not causing stresses to be generated within the hull, such as might cause if the water were pumped out into the open water. The interior of the dock 30 is now dry and ready for the construction of the next module and thereafter for the next repetitive step of the present invention.

An assembly dock of about two hundred and fifty feet
is a convenient length in which to build a one thousand foot long ship. The width of the dock is made sufficiently wider than the beam at the widest point of the ship to allow access around the hull during construction.

It will be readily appreciated by those skilled in the art that a floating assembly dock, such as described in FIGURE 9 above, can be built and maintained far more economically than can a full-sized dry dock or conventional ways upon which ships have previously been built. Use of such a dock has been found to be greatly advantageous in the practice of the present invention. However, if a conventional dry dock or conventional ways are available, there may be times in which it is more economical to use such existing facilities rather than to provide a new floating assembly dock. In such instances, those skilled in the art will readily appreciate that the modular shipbuilding method, as previously described in FIGURES 1 through 8, can readily be used in existing shipbuilding facilities, and that the practice of the present invention is not restricted to the use of a floating assembly dock as described in FIGURE 9 above.

It will also be appreciated by those skilled in the art that the assembly dock disclosed in FIGURE 9 may also be used to repair or inspect portions of the hull of a previously constructed ship. It is noted from FIGURE 9 that watertight seals are provided at each end of assembly dock 30. Thus, the seal at each end may be broken and the dock 30 sunk into the water to a sufficient depth to allow a ship to be floated over the dock until that portion of the ship which requires inspection or repair is positioned over dock 30. Water is then pumped out of the ballast tanks 62, thus causing the buoyancy of dock 30 to increase and the position of the dock to rise in the water. This is continued until assembly rests 76 are barely in contact with the hull of the ship. Watertight seals are then effected at each end of dock 30 with the hull of the ship, thereby isolating the remaining water in the dock from the outside water. This remaining water is then pumped into the ballast tanks 62 to keep the same net buoyancy of the ship and dock while, at the same time, providing a completely dry area around that portion of the hull of the ship within the assembly dock. The hull can then be conveniently inspected or repaired while the ship is still floating in the water.

The invention has thus far been described in connection with an ocean-going vessel which has a relatively consistent and simple cross-section, but the invention is not restricted to the construction of such ships. Instead, it can be readily adapted to construct any of the various types of ships. For example, FIGURE 10 shows an exploded perspective view of a tanker ship and illustrates how it can be constructed in accordance with the present invention. The various modules of the tanker now take varying hydrodynamic cross-sections to provide the desired hull shape. In this case, some of the panels from which the modules are constructed are made to desired curved shapes, as was discussed above, and the assembly dock of FIGURE 9 is provided with assembly rests which can be of variable lengths to support the different sections of the hull as it progressively moves along the assembly dock. The individual modules are still constructed with their longitudinal axes vertical and then rotated ninety degrees and attached to the constructed portion of the hull in a manner similar to that previously described.

FIGURE 11 shows a schematic view of a typical module which is used in the tanker ship of FIGURE 10.

FIGURE 12, similar to FIGURE 11, shows an exploded view of a container ship freighter, and illustrates how it is constructed in accordance with the teachings of the present invention. Again, the modifications mentioned in connection with the practice of the present invention. FIGURE 10 are employed to form the various shaped modules.

FIGURE 13 shows a typical module used in the container ship of FIGURE 12, and also illustrates how bulkheads might be provided between the modules, if desired.

An alternate embodiment of the invention for constructing ships having more complex hull shapes, such as the case in FIGURES 10 through 13, is to construct the ship upside down and to invert the ship to its proper position after it is floating in the water. In this modification of the invention, the module is constructed in a vertical position similar to that previously described but the deck of the module, rather than the bottom of the hull, faces the direction that the module is to be rotated. The module, after welding, is then rotated into a horizontal position with the deck of the module resting on the assembly rests in the floating assembly dock. The advantages gained by this modification of the invention include the use of simpler fixed length assembly rests to support the planar deck of the hull after a completed module has been rotated from its vertical position to its horizontal position.

Thus, the invention is disclosed and several particular embodiments described in detail. However, the invention is obviously not limited to these described embodiments. Instead, many modifications will occur to those skilled in the art which clearly lie within the scope of the invention.

What is claimed:

1. A method of constructing a ship which includes the steps of assembling on a vertically-mounted structure a module of the ship with the longitudinal axis of said module substantially vertical, pivoting said structure and aligning said module and the previously constructed portion of the ship and attaching said module to said previously constructed portion of the ship.

2. The method of claim 1 which further includes the steps of assembling said module by placing and supporting a plurality of panels in a vertical position into the desired configuration of said module, and welding said plurality of panels into an integral unit.

3. The method of claim 2 which further includes the steps of pivoting said assembled module substantially ninety degrees, aligning said module with said previously constructed portion of the ship with the longitudinal axis thereof collinear with the longitudinal axis of said previously constructed portion, and welding said module to said previously constructed portion of the ship.

4. The method of claim 2 in which said welding is effected by single pass vertical welding method.

5. The method of claim 4 in which said welding method is the electrogas welding method.

6. The method of claim 4 in which said welding method is the electroslag welding method.

7. A method of constructing a ship which comprises the steps of assembling on a vertically-mounted structure a module of the ship with the longitudinal axis of said module substantially vertical; pivoting said structure and module until the longitudinal axis of the module is substantially horizontal, aligning said module and a previously constructed portion of the ship; attaching said module to said previously constructed portion of the ship; and constructing and attaching additional such modules to said completed portion of the ship until a ship having a desired size is constructed.

8. The method of claim 7 in which the ship is constructed on an assembly dock shorter than the desired length of the ship being constructed, and which further includes the steps of advancing the completed portion of the ship off the said assembly dock and into the water as additional modules are constructed and attached, such that the completed portion of the ship is buoyantly self-supported during the construction of the ship.

9. The method of claim 8 which includes the steps of maintaining a watertight seal between said assembly dock and said completed portion of the ship, such that said assembly dock is kept dry for construction of additional modules while said completed portion of the ship is buoyantly self-supported.

10. A method of constructing a ship which comprises
the steps of assembling the ship in modules on an assembly dock, advancing the completed portion of the ship off of said assembly dock and into the water as additional modules are constructed and attached to said ship, such that the completed portion of the ship is buoyantly self-supported during the construction of the ship, and maintaining a watertight seal between said assembly dock and said completed portion of the ship during the construction and attachment of said additional modules.

11. The method of claim 10 which further includes the steps of flooding said assembly dock after a module is attached to the completed portion of said ship, breaking the watertight seal between said assembly dock and the completed portion of said ship, floating said completed portion of said ship forward in said assembly dock a predetermined distance, re-establishing the watertight seal between said assembly dock and said completed portion of said ship, and pumping the water out of the interior of said assembly dock to again provide a dry construction area for the construction and attachment of an additional module to the completed portion of said ship.

12. The method of claim 11 in which said assembly dock is a floating assembly dock including ballast tanks and in which the water from the interior of said assembly dock is pumped into said ballast tanks.

13. An assembly dock in which a ship may be constructed and having at least one end in contact with the water comprising a first area in which a module of the ship may be constructed, a second area for supporting completed portions of the ship, and means at the end of said dock adjacent the water and having one surface thereof in contact with the water for maintaining a watertight seal between said assembly dock and a portion of the sides and the bottom of the hull of a ship under construction.

14. The assembly dock of claim 13 in which said first area comprises a cradle upon which said module is constructed with its longitudinal axis substantially vertical, and means for rotating said cradle to align the axis of said module with the axis of previously constructed portions of said ship.

15. The assembly dock of claim 13 in which said second area includes a plurality of assembly rests having their lengths conformal to the shape of the hull of the ship being constructed.

16. The assembly dock of claim 13 which further includes a plurality of ballast tanks for buoyantly supporting said assembly dock in a fluid.

17. A floating assembly dock for constructing a ship by modules which comprises a plurality of ballast tanks for buoyantly supporting said dock, a construction floor, a cradle in a first area of said floor defining a modular assembly area, means for rotating said cradle substantially ninety degrees, a plurality of assembly rests in a second area of said floor for supporting completed portions of said ship, the lengths of said assembly rests being conformal with the shape of the hull of said ship, and means for maintaining a watertight seal between said assembly dock and the hull of said ship under construction.

No references cited.

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