

[72] Inventor **Kinya Tamura**
Nagasaki-Shi, Japan
[21] Appl. No. **752,564**
[22] Filed **Aug. 14, 1968**
[45] Patented **Dec. 22, 1970**
[73] Assignee **Mitsubishi Jukogyo Kabushiki Kaisha**
Chiyoda-ku, Tokyo, Japan
[32] Priority **Aug. 30, 1967**
[33] **Japan**
[31] **No. 42/55162**

[56] **References Cited**
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Primary Examiner—Andrew H. Farrell
Attorney—Mc Glew and Toren

[54] **SHAPE OF THE STERN FOR A VERY LARGE SHIP**
11 Claims, 24 Drawing Figs.

[52] U.S. Cl..... 114/57
[51] Int. Cl..... B63b 1/08
[50] Field of Search..... 114/57

ABSTRACT: A very large size single screw ship is formed with its bottom at the stern end inclined upwardly. The length of the inclined section amounts to about 10 to 20 percent of the length between the forward and after perpendiculars of the ship. The propeller shaft extends through the hull above the inclined bottom and the path of travel of the propeller blades is above the prolongation of the line of the inclined bottom.

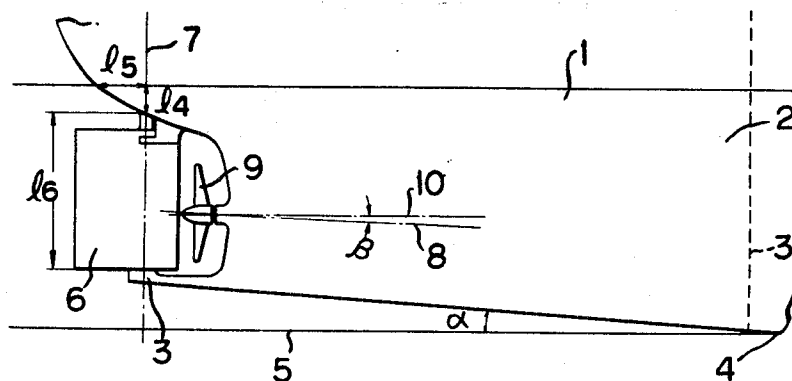


FIG. 1

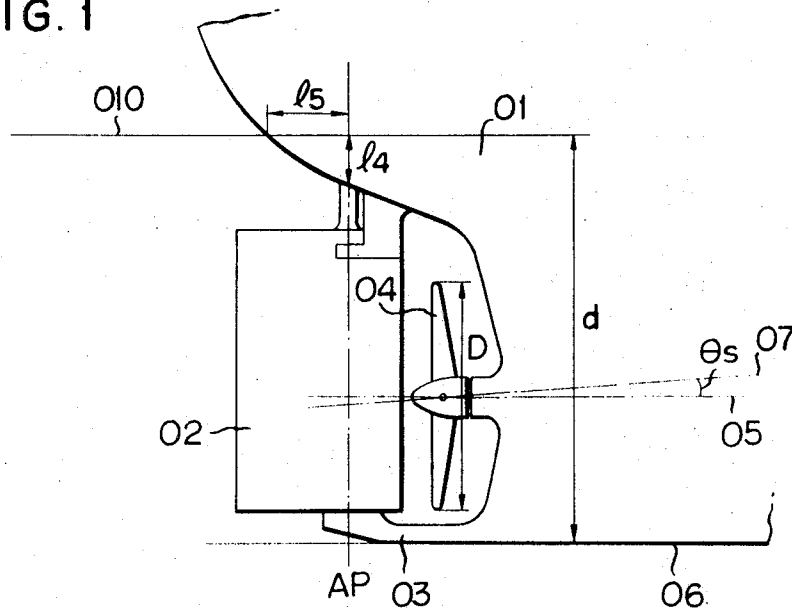


FIG. 2a

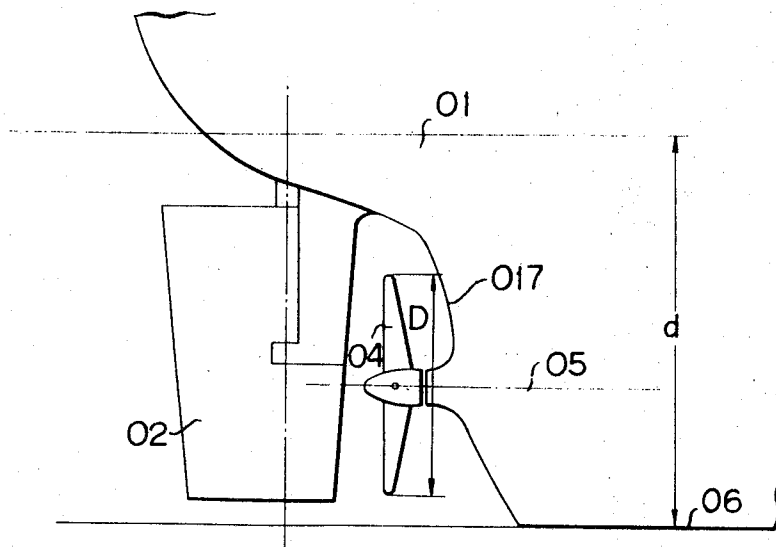


FIG 2b

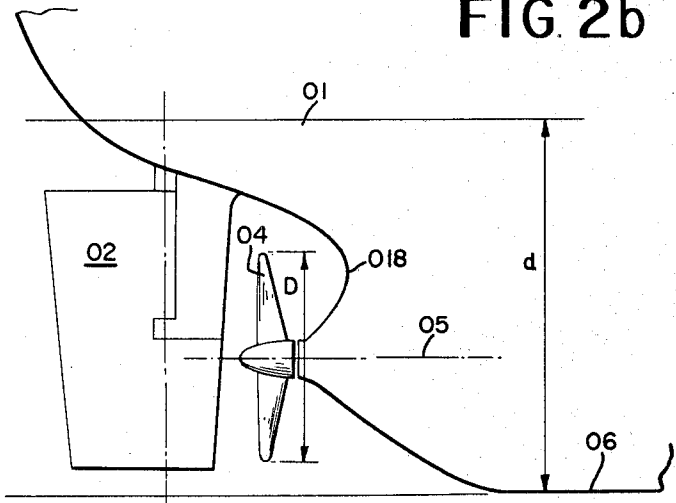
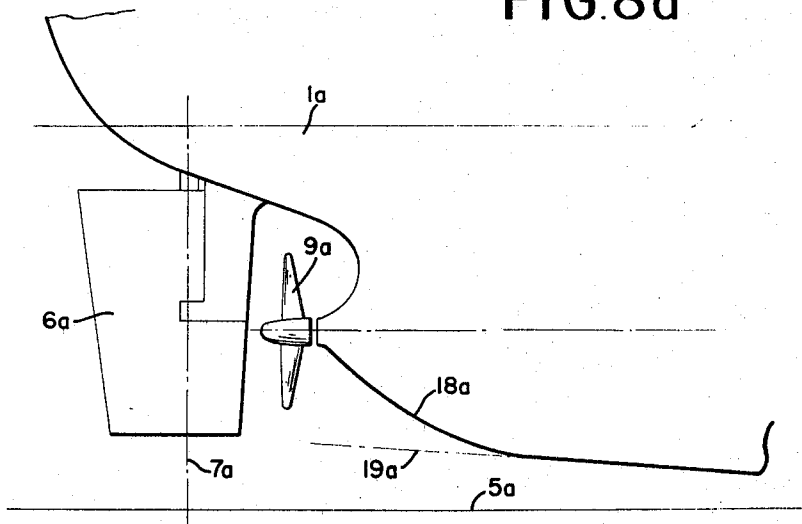


FIG.8d



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KINYA TAMURA

FIG. 3

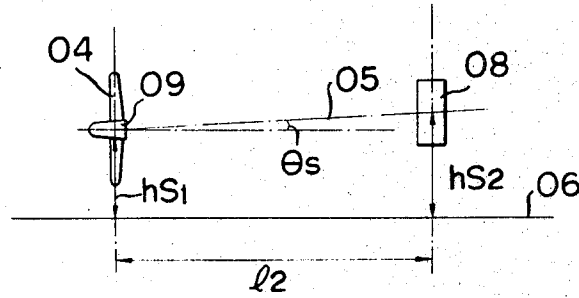


FIG. 4

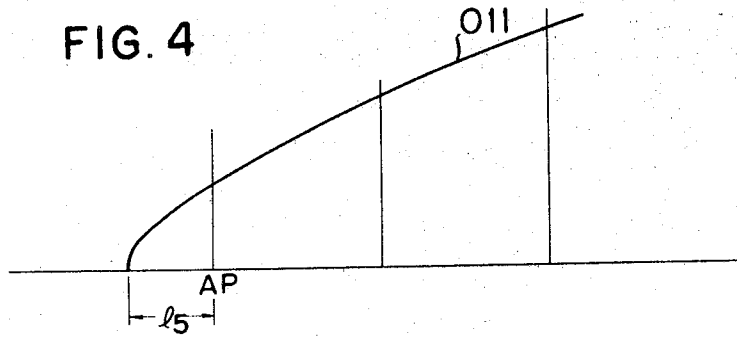
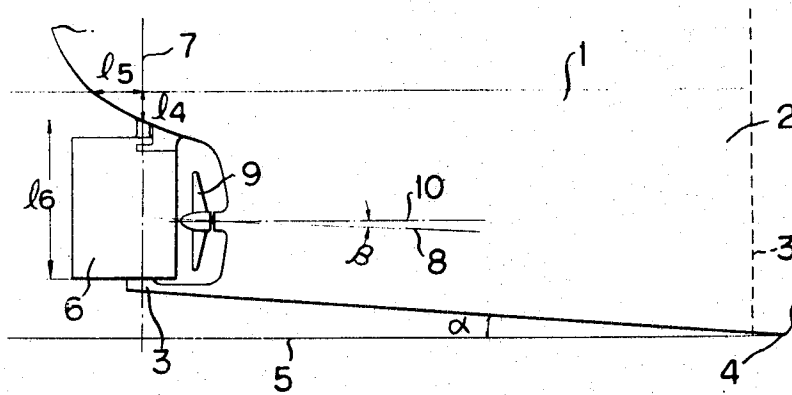


FIG. 7a



INVENTOR
KINYA TAMURA
BY
McGraw and Toren
ATTORNEYS

FIG. 5

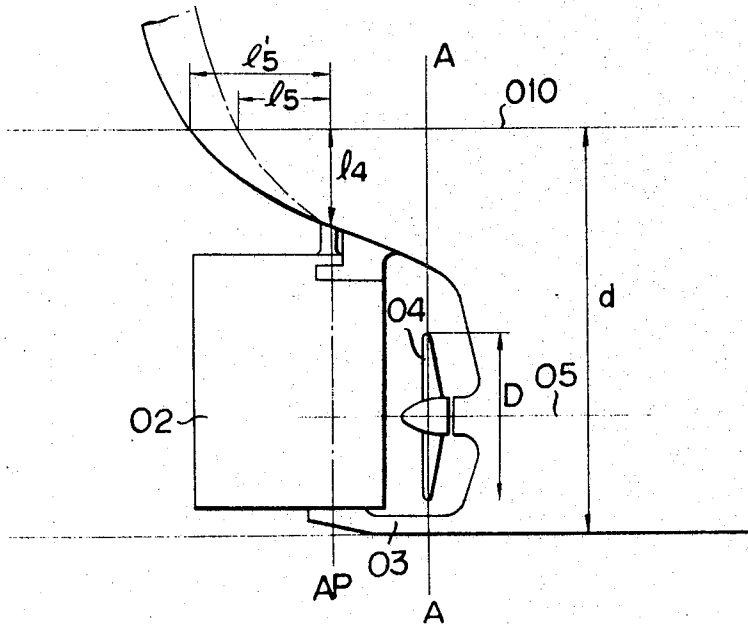
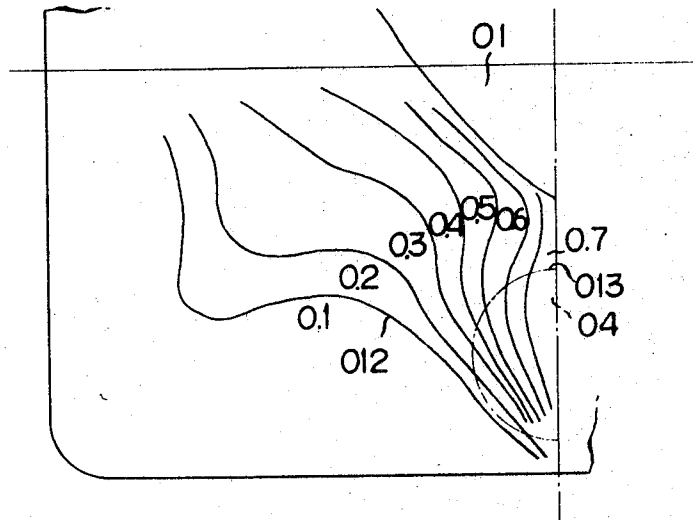


FIG. 6



INVENTOR.
KINYA TAMURA

BY *McGraw and Trew*
ATTORNEYS

FIG. 7b

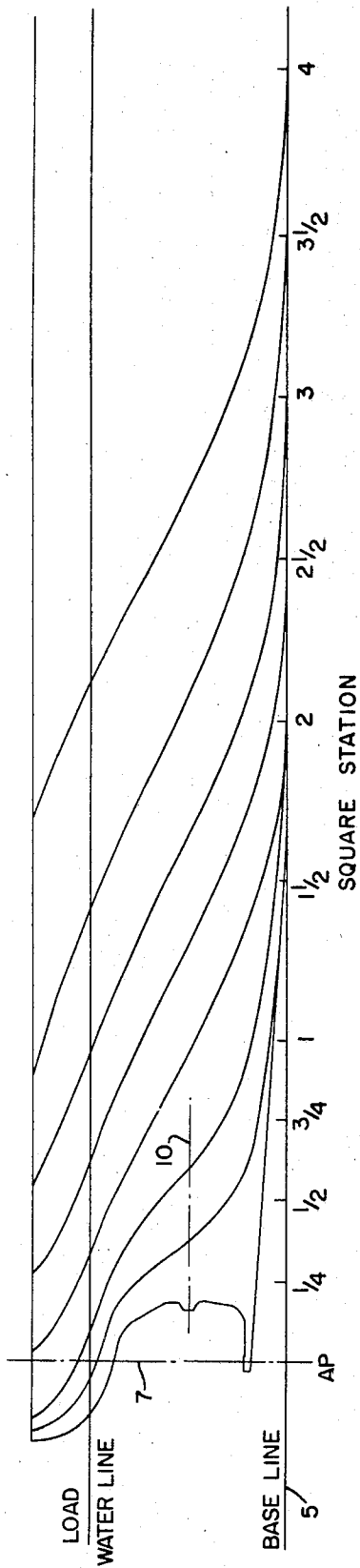
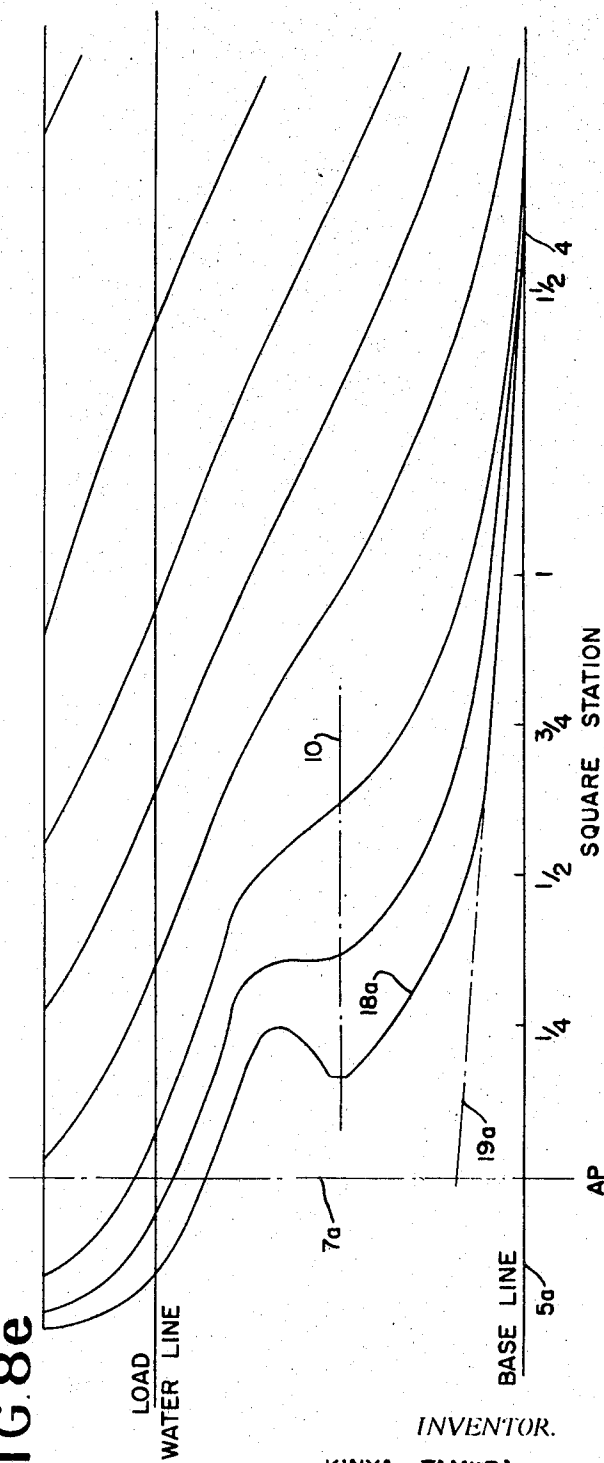


FIG. 8e



INVENTOR.

KINYA TAMURA

FIG. 8a

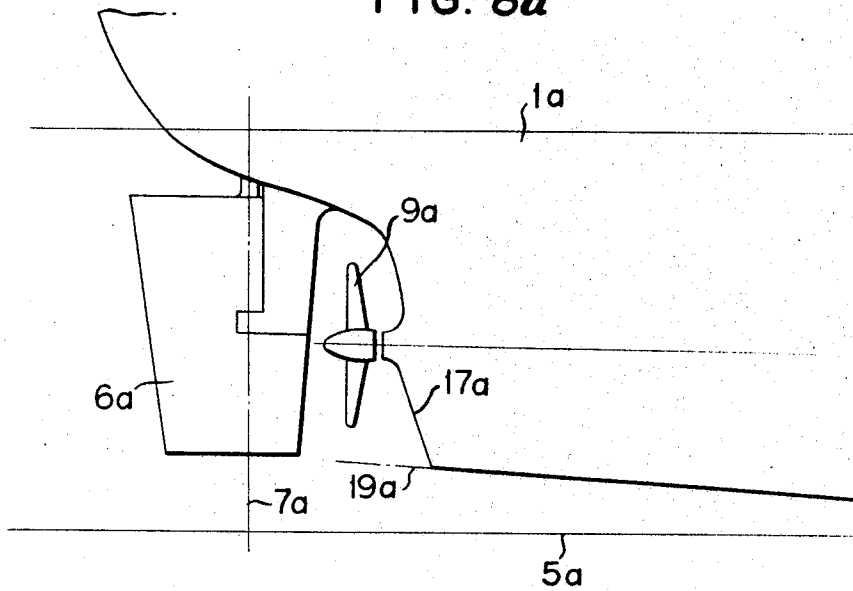
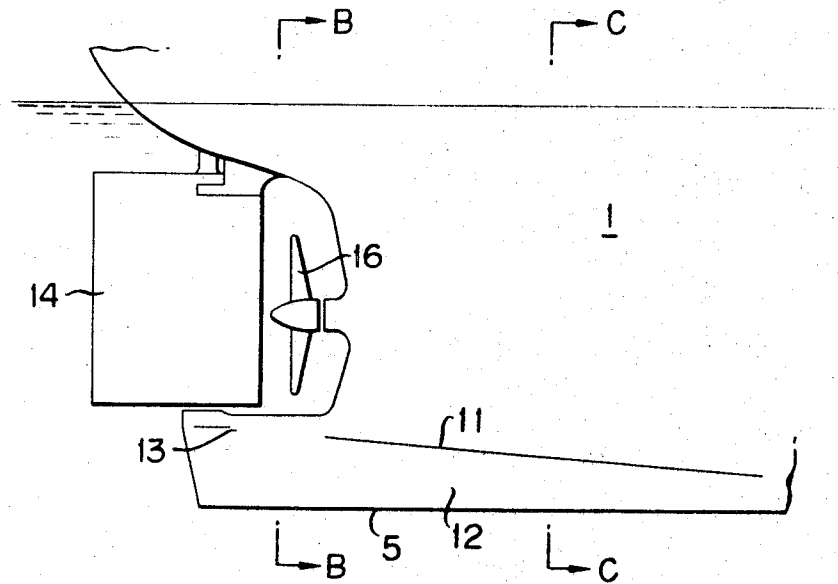


FIG. 9a



INVENTOR
KINYA TAMURA

BY *McGlew and Loren*
ATTORNEYS

FIG.8b

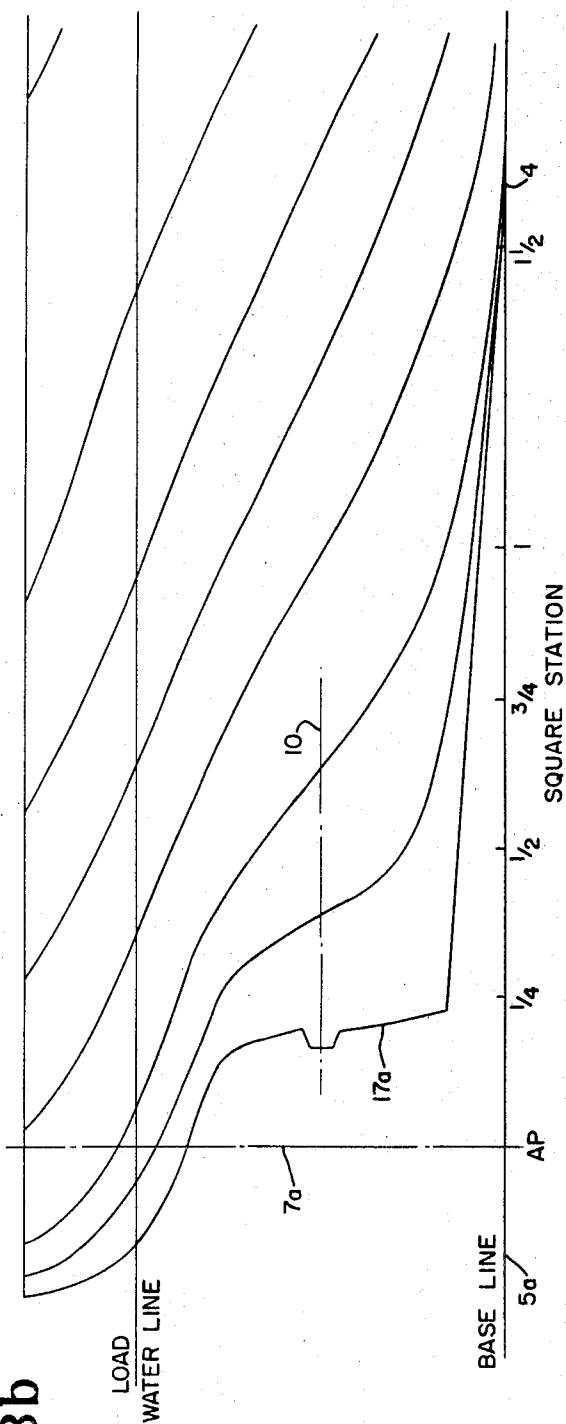


FIG.8c

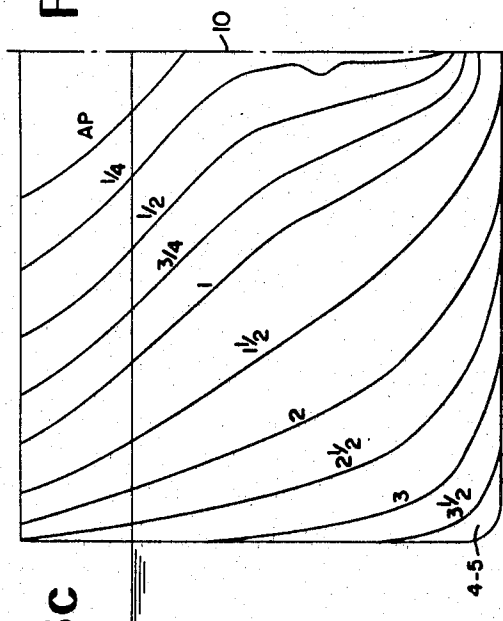
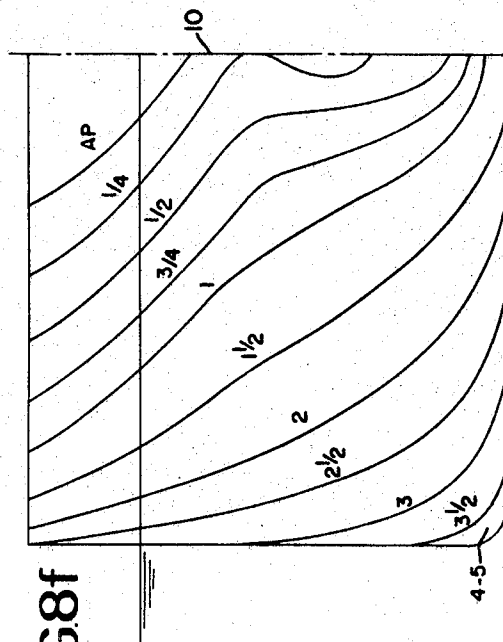
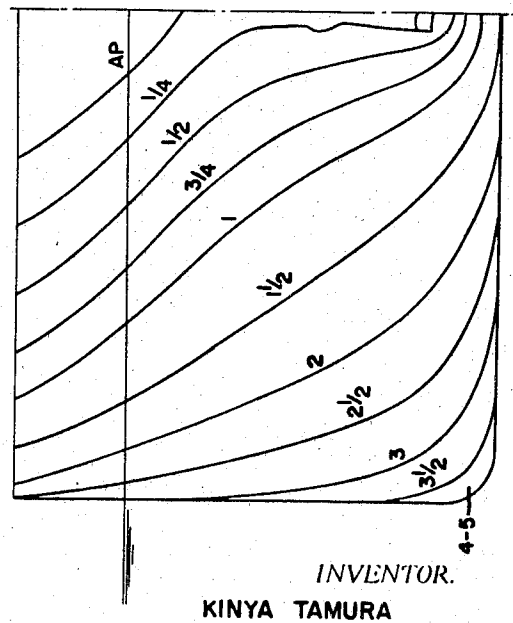
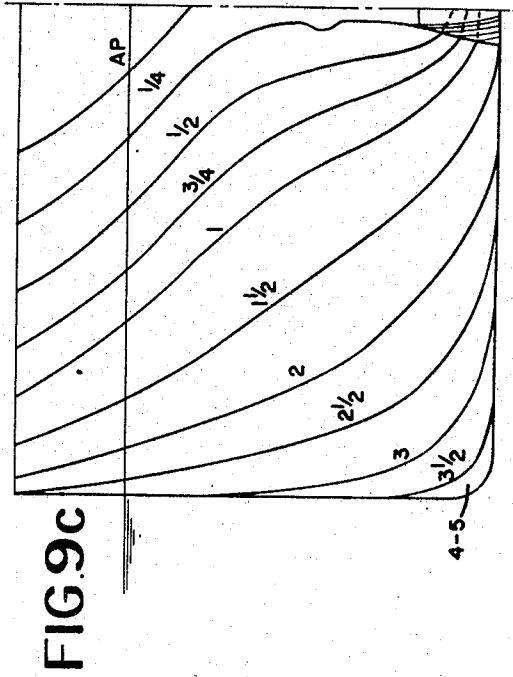
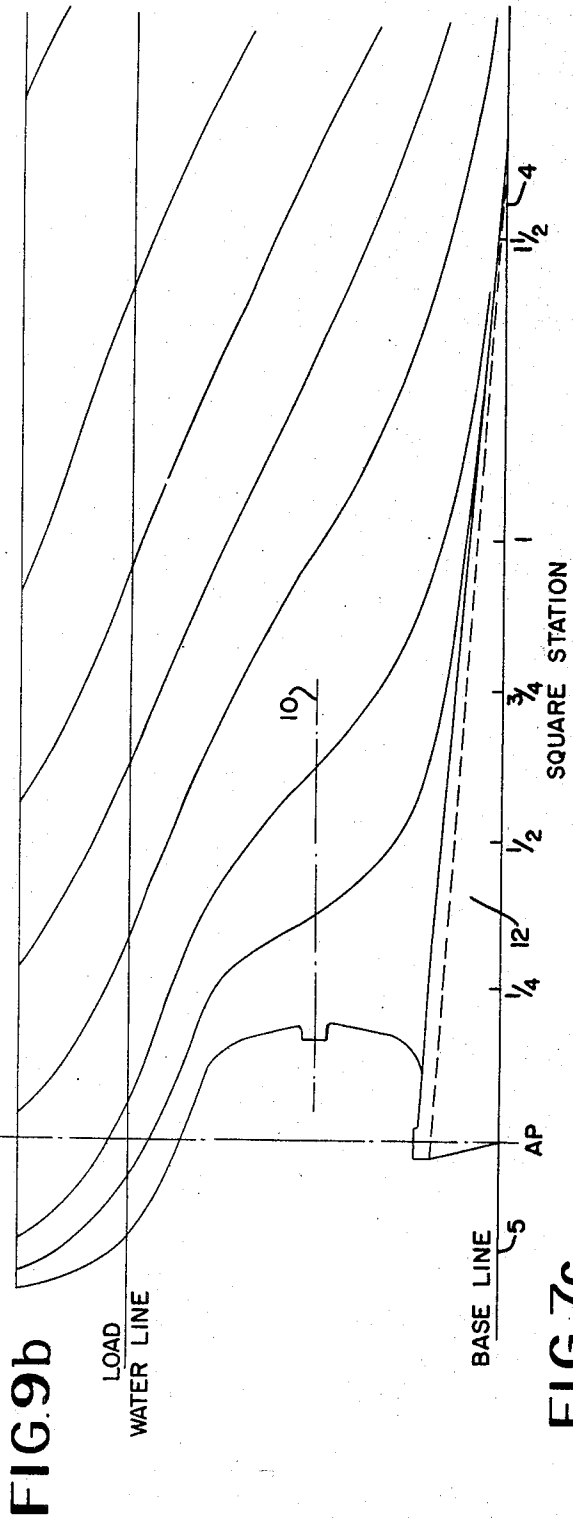


FIG.8f



INVENTOR.
KINYA TAMURA



INVENTOR.
KINYA TAMURA

FIG. 10

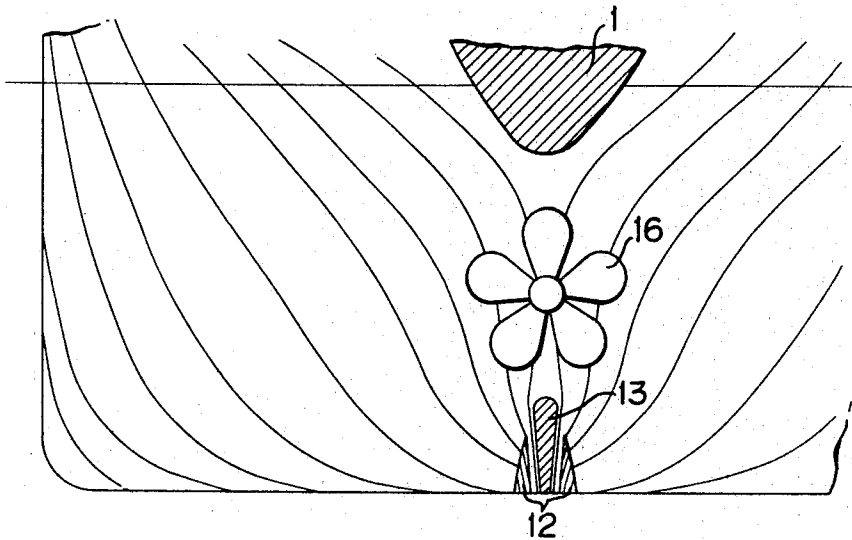
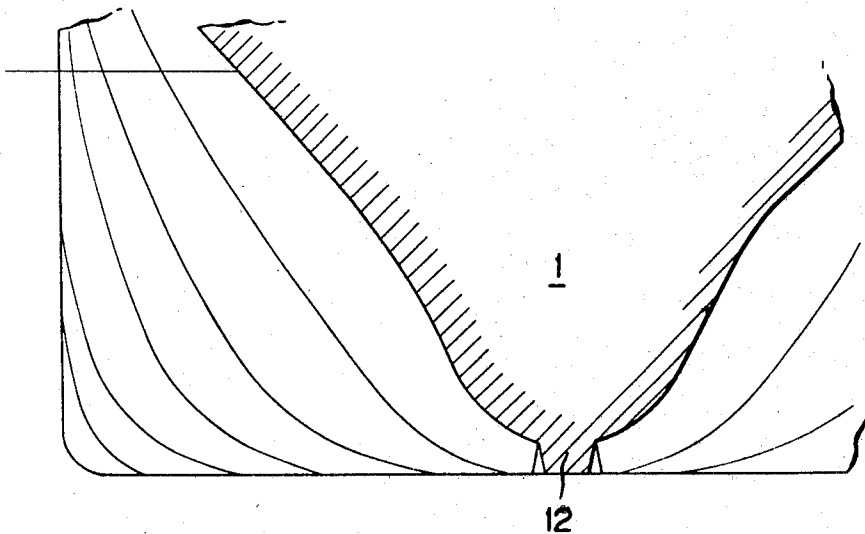


FIG. 11



INVENTOR
KINYA TAMURA
BY *McGraw and Town*
ATTORNEYS

FIG. 12

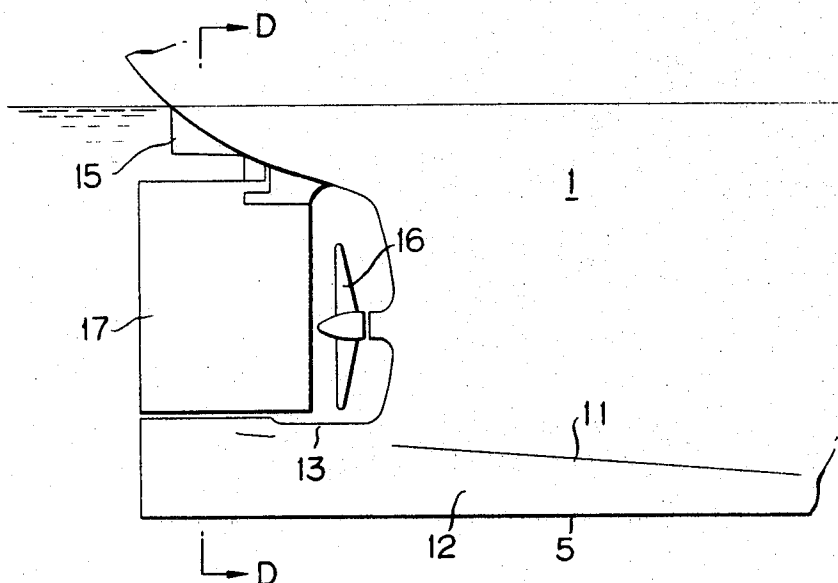
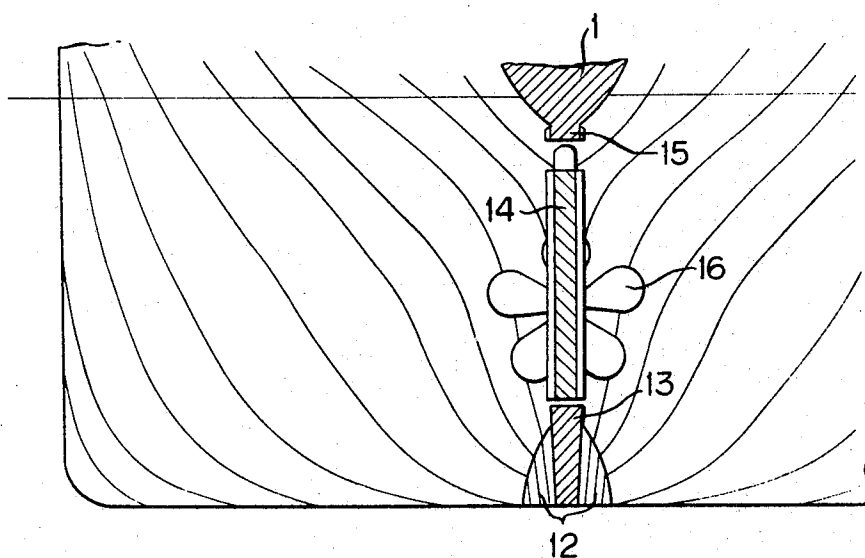


FIG. 13

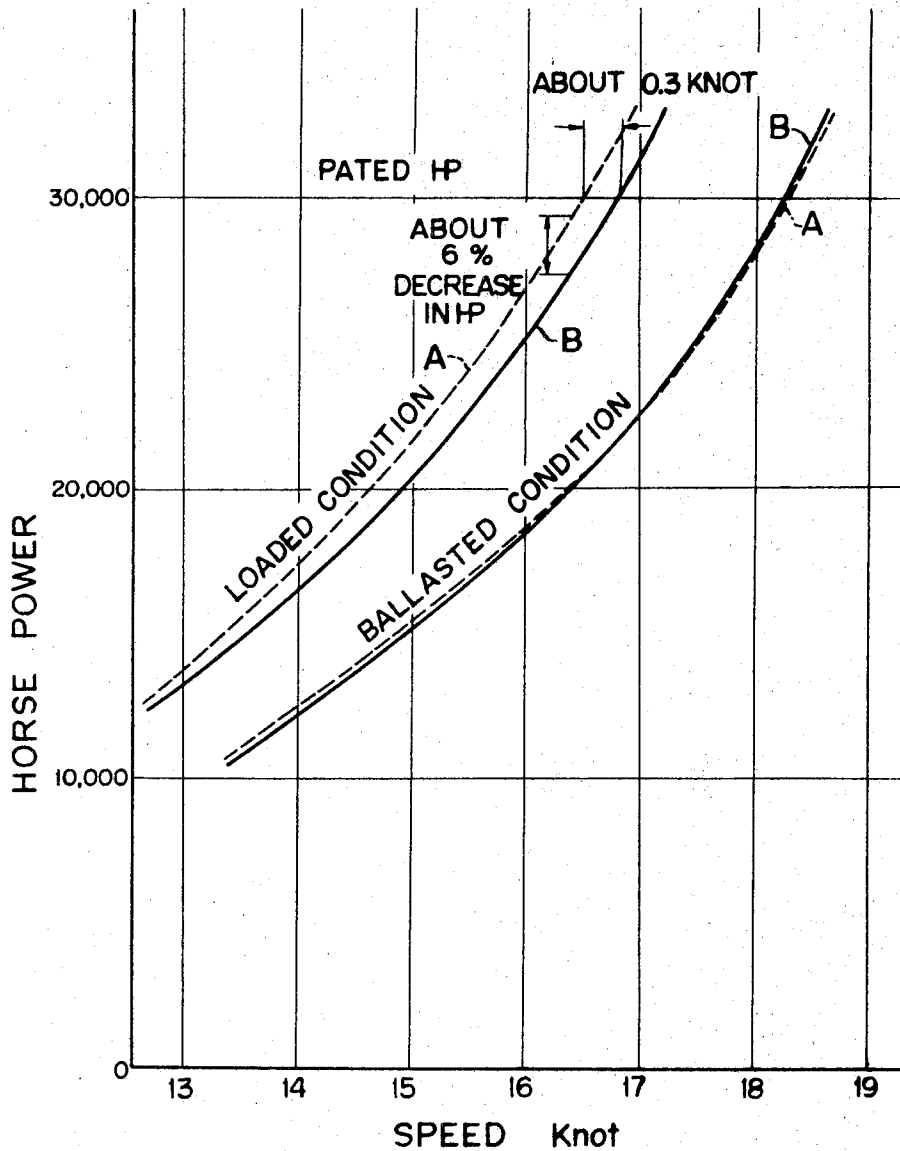


INVENTOR,

KINYA TAMURA

BY *McGlew and Toren*
ATTORNEYS

FIG. 14



INVENTOR.
KINYA TAMURA

BY *McGraw and Toren*
ATTORNEYS

SHAPE OF THE STERN FOR A VERY LARGE SHIP

SUMMARY OF THE INVENTION

The present invention is directed to the shape of the stern of a very large ship in the range of 200,000—500,000 d.w.t. and, more particularly, it is directed to the configuration of the bottom of the ship at the stern.

In the case of normal-sized ships, as a rule, the propeller is located as far below the surface of the water as possible in order to avoid the propeller intersecting the surface of water in the ballasted condition. However, when a main engine of large capacity is used in the ship, it is necessary to increase the rake angle of the propeller shaft, particularly, where an aft engine is employed. Further, for ships in the range of 200,000—500,000 d.w.t., which will appear in the future, it is preferable to increase the draft of the vessel as much as possible from the standpoint of economics. If the propeller of such a large ship is designed, its propulsive efficiency, which consists of a hull efficiency and a propeller efficiency, will be reduced because the ship speed is almost the same as that of the normal-sized ship and because the propeller loading becomes larger than that of the normal-sized ship. When the draft of the ship is increased its eddy resistance becomes greater and the reference length of the hull must then be increased to reduce the eddy resistance, however, such a step should be avoided from the standpoint of economics. Accordingly, there are many problems to be faced in the design of a very large ship in the range indicated above, and such problems will be explained in greater detail hereinafter.

Therefore, the primary object of the present invention is to provide a large ship in the 200,000—500,000 d.w.t. range with a shaped bottom at its stern end which will increase the hull efficiency while decreasing its construction cost.

Another object of the invention is to provide the ship with an upwardly inclined bottom at its stern end. The inclined portion of the bottom is arranged to extend from a point in the vicinity of the forward end of the engine room to the stern. Moreover, the propeller shaft is arranged to pass through the hull of the ship at a point above its inclined bottom with the blades of the propeller traveling in a path located above the prolongation of the line of the upwardly inclined bottom of the ship.

Still another object of the invention is to locate the propeller relative to the bottom of the ship so that it is sufficiently high enough to be disposed in the zone of the following wake. In this way the following wake can be utilized to increase the propulsion performance of the ship even though the propeller is too small for the hull. Moreover, by raising the line of the propeller shaft the engine room is reduced in length which decreases the required volume and results in lowered construction costs. In addition, the sagging moment of the ship in its loaded condition is reduced due to the decrease in the volume in the engine room and, further, the submerged depth of the hull is diminished which shortens the water line length of the ship and thereby effects a reduction in both its eddy resistance and its reference length.

Moreover, another object of the invention is to incline the propeller shaft upwardly relative to the base line of the ship. In this way the height of the double bottom required for the support of the engine is reduced and the construction costs of the ship are cut down.

Still, a further object of the invention is to employ a direction stabilizing plate along the upwardly inclined bottom of the ship to increase its stability and to reduce the area of the rudder which also contributes to a more economical construction for the ship.

Therefore, the present invention is directed to a large-sized single screw ship in the 200,000—500,000 d.w.t. range, in which the bottom of its hull at the stern end is inclined upwardly from a position spaced a considerable distance forwardly of the stern. Preferably, the point at which the bottom of the ship commences to be inclined upwardly is located near the forward end of the engine room and extends for a length of

approximately 10 percent to 20 percent of the length between the forward and after perpendiculars of the ship. In this arrangement the propeller shaft extends through the hull of the ship above its inclined bottom and the radially outer edges of the propeller blades are located in a path of travel positioned above the prolongation of the upwardly inclined line of the bottom of the ship.

In one embodiment a direction stabilizing plate is provided along the upwardly inclined bottom to the stern of the ship.

Further, a shoe piece for the ship's rudder can be secured to the direction stabilizing plate. Moreover, an auxiliary section of the direction stabilizing plate can be fixed to the hull rearwardly of the propeller and above the rudder.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which there are illustrated and described preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

In the Drawings

FIG. 1 is a schematic side view of the stern of a conventional size ship provided with a single screw propeller;

FIG. 2a is a view similar to that in FIG. 1 but illustrating a ship of the "Mariner-type";

FIG. 2b is a view similar to FIG. 2a exhibiting another ship of the "Mariner-type";

FIG. 3 is a schematic view exhibiting a conventional propeller shaft system;

FIG. 4 is a schematic view of the profile of the load line of the hull in a conventional ship;

FIG. 5 is a schematic side view of a stern of a very large ship in the 200,000—500,000 d.w.t. range;

FIG. 6 is a view taken along line A-A in FIG. 5 showing the contour curves of the following wake of the ship;

FIG. 7a is a schematic side view of the stern of a conventional type ship having a bottom in accordance with the present invention;

FIG. 7b is a view of the buttock line of the ship shown in FIG. 7a;

FIG. 7c is a body plan of the rear half of the ship shown in FIG. 7a;

FIG. 8d, 8e and 8f are views similar to FIG. 8a, 8b and 8c exhibiting another ship of the "Mariner-type";

FIG. 9a is a schematic side view of the stern of a ship similar to that shown in FIG. 5, however, disclosing another embodiment of the present invention;

FIG. 9b and 9c are views similar to 7b and 7c;

FIG. 10 is a sectional view taken along line B-B in FIG. 9;

FIG. 11 is a sectional view taken along the line C-C in FIG. 9;

FIG. 12 is a schematic side view of still another embodiment of the present invention;

FIG. 13 is a sectional view taken along line D-D in FIG. 12; and

FIG. 14 is a graphical illustration of the comparison of tank tests made on two models, one embodying the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1 the stern of a conventional ship is illustrated comprised of a main hull 01, a rudder 02, a shoe piece 03 extending rearwardly from the bottom of the hull for supporting the rudder, and a single screw propeller 04. By comparison, the "Mariner-type" stern, shown in FIG. 2, does not have a shoe piece and the rudder is secured to the main hull 01 at its upper end. In FIG. 2b a so-called bulbous stern, which is also a "Mariner-type" stern, is shown, in this arrangement the space

between the stern frame 018 and the adjacent propeller 04 is much greater than that illustrated in FIG. 2a. The upper half of the full line 017 has a configuration generally similar to that shown for the stern of the ship in FIG. 1, however, the lower portion of the full line, that is, extending below the propeller shaft 05 diverges away from the propeller 04 providing a wider space than that indicated in FIG. 1. The dash line 018 discloses a so-called bulbous stern, with the space between the stern and the adjacent propeller being much greater than that shown by the full line 017.

In conventional ships having sterns of this type, it is usual that the diameter D of the propeller is in the range of 50—70 percent of the full draft d of the ship. If, while under propulsion, the propeller 04 intercepts the surface of the water the propulsion efficiency of the ship is reduced. When such a condition exists the intake of air into the propeller causes it to idle. Further, solid objects floating on the surface of the water may damage the propeller. Accordingly, it is usually desirable to locate the propeller as far below the surface of the water as is possible in order to avoid the occurrence of such defects even in the ballasted condition. The propeller is connected through a propeller shaft 05 to the main engine and, if the main engine of such a relatively large capacity it may not be possible to install it normally within the hull. In such a case the propeller shaft is inclined rearwardly and downwardly at an angle θ_s with respect to the horizontal line 05, as shown in FIG. 1, which permits the installation of the main engine, though usually the propeller shaft 07 is positioned in parallel relationship with the base line 06 of the ship. In most cases, the rake angle θ_s of the propeller shaft 05 is about 2° (35/1000 in grade) and is especially large in the cases of aft engine ships, such as tankers and ore carriers.

Another possibility of the installation of large-sized main engines within the hull is achieved by increasing the distance or l_2 between the propeller 04 and the engine (especially for a condenser 08 as in a turbine ship), as shown in FIG. 3. However, as a result of this step the length of the engine room is naturally increased, and this solution to the problem is not considered advisable.

Normally the rear edge of a stern intersects the load line 010 at a position spaced a distance l_5 behind the after perpendicular AP, see FIG. 1, of the hull. If the distance l_5 is small then the section 011 of the main hull 01 taken along the load line 010 has the shape of a circular segment, see FIG. 4, and it is necessary to decrease the height of the chord to reduce its eddy resistance. Accordingly, the distance l_5 has to be increased according to the submerged depth l_4 of the hull 01 at the line AP. The value of l_5 is usually about 2 percent of the distance L_{pp} , that is, the distance between the forward and after perpendiculars. In a tanker and an ore carrier, the water line length L_{wl} equals L_{pp} plus l_5 , it is adopted as the reference length of the hull construction and has to be reduced as much as possible in order to reduce the construction costs. In most instances l_5 is fixed at a value below 2 percent.

In very large ships in the 200,000—500,000 d.w.t. range, which will be built in the future, it is considered economical to increase the draft d as much as possible. The ratio of D/d , that is, the diameter D of the propeller to the draft d of the ship is reduced to about 40 percent or less by increasing the draft. Further, in such a ship if the height of the main engine is small relative to the size of the hull, then owing to the large draft of the vessel an unoccupied space is left above the engine. As a result, in its loaded condition the holds of the ship become far heavier than that of the engine room, and the sagging moment of the hull is increased.

Usually, the propeller 04 and its shaft 05 are located as far below the load draft line as possible, see FIG. 5 in order to make the height of the engine bed from the base line as low as possible from the view point of the reduction of construction cost.

In FIG. 6, the contour curves 012 show the equiwake lines and the numerals described on the curves show the values of wake, which are measured on the plane perpendicular to the

center line of the hull at the propeller position. Here, wake is defined by

$$1 - (V_x/V_s)$$

where V_s is ship speed, and V_x is longitudinal component of local water speed relative to the ship.

As shown in FIG. 6, owing to the large draft of the vessel, the relatively small diameter and the lower location of the propeller axis 05, the high wake zone is shifted upward from the propeller disc 013, and the wake is not fully utilized in assisting the propulsion of the ship. Therefore, it can be concluded that the reduction in the diameter D of the propeller results in a reduction of the hull efficiency. Therefore, it can be concluded that the reduction in the diameter D of the propeller results in a reduction of the hull efficiency. In FIG. 6, dash lines 014 indicate the direction of a streamline in a plane perpendicular to the center line of the hull.

From FIG. 5 it will be evident that the submerged depth l_4 is increased in accordance with the draft d of the ship. Therefore, to reduce the eddy resistance behind the stern, it is necessary to avoid the shape of the section 011 of the main hull, indicated in FIG. 4, by increasing the distance l_5 as indicated by l'_5 . On the other hand since the water line length, L_{wl} , is adopted as the reference length of the hull construction, it is desirable, from the view point of reduced materials costs to make the water line length shorter.

Embodiments of the present invention are illustrated in FIGS. 7a to 13. In FIG. 7a a conventional type stern of a single screw ship utilizing an aft engine is shown. The bottom of its main hull is inclined upwardly from a point 4 near the forward end 3 of the engine room 2. The forward end 3 of the engine room is positioned forwardly of the after perpendicular AP by approximately 10—20 percent of L_{pp} . The angle α of the upgrade of the bottom of the ship is in the range of 2° — 10° . The sloping portion of the bottom of the ship between the point 4 and the line AP, corresponding to the axis 7 of the rudder 6, is shown as a straight line or it may be a slightly curved line. In the vicinity of point 4 the bottom of the ship is smoothly rounded. A propeller shaft 8 can be provided along the horizontal line 10, which is parallel with the base line 5 of the ship, and extends through the center of the propeller, or it may be inclined rearwardly and upwardly with respect to the horizontal line 10. The tangent of the angle β of the upgrade is in the range of 10/1000—60/1000.

In the arrangement shown in FIG. 7a, since the bottom of the ship at the stern is disposed above the base line 5, the height l_6 of the rudder is reduced. By reducing the height l_6 the weight and cost as well as the resistance stemming from the rudder are decreased, and moreover, a similar decrease is attained in the weight, cost and resistance stemming from the shoe piece 3. Further, a smoother flow can be obtained along the stern of the ship and the resistance due to the shape of the stern is diminished.

Because of the inclined bottom of the ship the propeller 9 is raised relative to the water level and is moved into a region in which the value of the following wake is greater, and, as a result, the propulsive performance of the ship is improved. Further, with the upward displacement of the propeller its shaft is also raised and, therefore, the engine can be shifted closer to the stern since a sufficient space is afforded between the engine and the walls of the engine room. Accordingly, the engine room can be decreased in length and the height of its double bottom reduced due to the upward inclination of the bottom. These changes in the construction of the ship effectively reduce its cost. Since the position of the engine within the ship is elevated the space above it is reduced and the sagging moment of the ship in its loaded condition is decreased. It can be appreciated that with the bottom of the ship inclined upwardly, its submerged depth l_4 , which coincides with the after perpendicular AP, is also reduced. With the reduction in l_4 the corresponding distance l_5 is also reduced and the water line length of the ship is shortened without a resultant increase in eddy resistance. As a con-

sequence, the construction cost of the the ship is considerably minimized.

In FIG. 8a, a ship having a "Mariner-type" stern is illustrated, and the stern portion of its bottom is shaped in accordance with the present invention. The bottom of hull 1a is inclined upwardly from the forward end of the engine room, not shown, and is disposed in diverging relationship with the base line 5a toward the stern of the ship. At the stern the line 7a corresponds to the after perpendicular AP, and also operates as the axis of the rudder 6a. A propeller 9a extends rearwardly from the hull and is located above the prolongation of the upwardly sloping bottom of the ship indicated by the line 19a. Similar to the showing in FIGS. 2a and 2b, the sterns of the ships in FIGS. 8a and 8d have different configurations, one is shown by full lines 17a in FIG. 8a, in which the lower portion is more widely spaced from the propeller than its upper portion, and the other is shown in full lines 18a, in FIG. 8d disclosing the so-called bulbous stern.

FIGS. 8b and 8c and 8e and 8f show further illustrations of the aft portions of the ships illustrated in FIG. 8a and 8d, respectively indicating the buttock line and body plan of the rear half of the hull. The bottom of the stern portion of the ship disclosed in FIG. 8c is shaped in accordance with the present invention.

In another embodiment of the invention, illustrated in FIGS. 9a to 11, a direction or course stabilizing plate 12 is positioned along the upwardly inclined bottom of the ship 11. The inclination of the bottom of the ship 11 is similar to that previously described. In FIG. 9a the direction stabilizing plate 12 is shown extending to the rear end of the shoe piece 13 for the rudder 14, while the embodiment shown in FIG. 12 has the direction stabilizing plate 12 extending rearwardly of the shoe piece to the after end of the rudder 17. Further, in FIG. 12, an auxiliary stabilizing plate 15 is provided on the hull above the rudder. In both of the arrangements, FIGS. 9a and 12, a propeller 16 is disposed between the hull and the rudder.

By means of the direction stabilizing plate 12 the stability of a large-sized ship is maintained and a decrease in the size of the rudder is achieved. By employing the direction stabilizing plate as reinforcement for the shoe piece 13 the shoe piece itself becomes stronger and more simple in construction. Another advantageous feature of the direction stabilizing plate 12 is its use in placing the hull in a ship building berth or as a supporting member for the hull in a dry dock.

In FIGS. 10 and 11, the arrangement of the direction stabilizing plate 12 is shown along the bottom of the hull and with relationship to the shoe piece 13 below the rudder 14.

In FIG. 14 the results of tank tests are shown which were performed to prove the advantages of the present invention. Using two model ships of a 200,000 d.w.t. supertanker, one was provided with a conventional stern construction, as shown in FIG. 5 while the other was given the stern and bottom configuration of the present invention as illustrated in FIG. 7a. In the model shaped according to the present invention the bottom of the ship has an inclined upgrade of 3.5° with the point of inclination commencing forwardly of the after perpendicular by a distance of about 15 percent of the total length between the after and forward perpendiculars. The tests were conducted to compare the model ships in propulsive performance with the models tested in the fully loaded condition and in the ballasted condition (half of the hull load) respectively. The ship speeds and required shaft horsepowers are converted into those of the super tanker. In FIG. 14 the curve A shown by the dotted line, indicates the propulsion performance of the conventional model, while the curve B, shown in full line, discloses the performance of the model embodying the present invention. As will be noted from the curves, in the ballasted condition there is less difference between the two models than there is in the fully loaded condition. In the loaded condition it indicates that for a reduction in horsepower of about 6 percent the same speed is obtained in the model designed according to the present invention as compared to the conventional arrangement, or to put it another

way, an increase of 0.3 knots is obtained in the model according to the invention by employing the same horsepower.

As mentioned previously, due to the arrangement of the upwardly inclined bottom of the ship, an aft engine is disposed upwardly toward the stern so that the propeller shaft passes through the hull above the inclined portion of the bottom. With the position of the propeller elevated it is located in a region in which the following wake has a greater value and is more effective in promoting the propulsive efficiency of the ship. In this way, difficult problems of degradation of the propulsive performance of a very large ship in the range as mentioned previously, can be effectively handled though the propeller is too small for the hull. When the position of the propeller is elevated its propeller shaft is lifted and space is provided between the engine and the walls of the engine room. By repositioning the engine in this manner the length of the engine room is reduced and the space between the engine room and the bottom of the ship also is made smaller. With this rearrangement in the construction of the ship the cost of the double bottom of the engine room is decreased. Moreover, by cutting down the volume of the engine room the sagging moment of the ship in its loaded condition is reduced even though this is considered to be difficult to attain in such a large ship. Another advantage gained by this construction is the decrease in the submerged hull depth l_4 at the after perpendicular AP which results in a reduction in the water line length of the ship since the value of l_5 is also reduced. Because of these changes the vortex resistance is cut down, and by decreasing the reference length of the ship a corresponding reduction in the cost of the ship is effected.

Moreover, another advantageous feature of the invention is the employment of the direction stabilizing plate which permits very large ships in the 200,000—500,000 d.w.t. range, to be maintained on course, and in a stable condition with relative ease while reducing the rudder costs. As mentioned previously the direction stabilizing plate is also useful in supporting the ship during construction or when it is located in dry dock.

I claim:

1. A large-sized single screw ship comprising a hull having a stern end, the bottom of said hull being inclined upwardly to its stern end from a location spaced forwardly from the stern end, a propeller shaft extending through said hull at its stern end, and a propeller mounted on said shaft with the radially outer edges of the blades of said propeller located in a path of travel disposed wholly above the rearward prolongation of the upwardly inclined bottom of said hull.
2. A ship, as set forth in claim 1, wherein said propeller shaft is inclined upwardly in the rearward direction from its point of connection to an engine within the ship to said propeller.
3. A ship as set forth in claim 1, wherein said hull of the ship is in the 200,000—500,000 d.w.t. range.
4. A ship according to claim 1, wherein the bottom of said hull is inclined upwardly from a point forward of the after perpendicular for a distance ranging between 10 percent to 20 percent of the length between its perpendiculars.
5. A ship as set forth in claim 4, wherein the upwardly inclined portion of the bottom of said hull forms an angle in the range of 2° to 10° with the prolongation of the bottom of the hull forwardly of the point at which the bottom commences to incline upwardly.
6. A ship as set forth in claim 1, wherein a rudder is mounted on said hull rearwardly of said propeller, and the lower end of said rudder is located in a horizontal plane located above a horizontal plane passing through the stern end of the bottom of said hull.
7. A ship as set forth in claim 6, wherein a shoe piece being attached to and extending rearwardly from the upwardly inclined bottom of said hull is secured to the lower end of said rudder.
8. A ship as set forth in claim 6, wherein a course stabilizing plate extends downwardly from and along the upwardly inclined bottom of said hull and extends rearwardly below the propeller.

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9. A ship as set forth in claim 8, wherein said course stabilizing plate is aligned below the rearward end of said rudder.

10. A ship as set forth in claim 8, wherein an auxiliary course stabilizing plate is affixed to said hull rearwardly of said propeller and above said rudder.

11. A ship as set forth in claim 8, wherein the rear end of said course stabilizing plate is below and forward of the rearward end of said rudder.

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