United States Patent

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[54] **MODULAR HULL VESSEL AND METHOD OF OPERATION**
5 Claims, 2 Drawing Figs.

[52] **U.S. Cl.** **114/77,** 114/16, 114/66.5
[51] **Int. Cl.** **B63b 3/02,** B63b 1/18
[50] **Field of Search** ..... 114/0.5, 0.5 D, 77, 61, 66.5, 16

[56] **References Cited**
UNITED STATES PATENTS

3,279,407	10/1966	Stenger	114/66.5
2,405,115	8/1946	Creed	114/61 X
3,294,051	12/1966	Khelstousky	114/0.5 (D)

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ABSTRACT: A waterborne vessel having a personnel and/or cargo carrier surface hull module, which normally seats on the surface of the water when at rest, is connected by depending struts to a submerged displacement hull module which contains the vessel engines, and its propulsion and steering means, and which provides a substantial portion of the buoyancy for the entire vessel. The struts are designed for extension and retraction so that the displacement hull module may be raised or lowered. The displacement hull module is constituted as a hydrodynamic lift body which, when in lowered position while the vessel is underway, lifts and maintains the entire personnel hull module out of the water to a height at which its bottom is out of contact with the surface of the water and above the crests of any waves thereon. When the vessel is docked or operating in shoal water the displacement hull module is positioned in substantial mating engagement with the bottom of the personnel hull module.

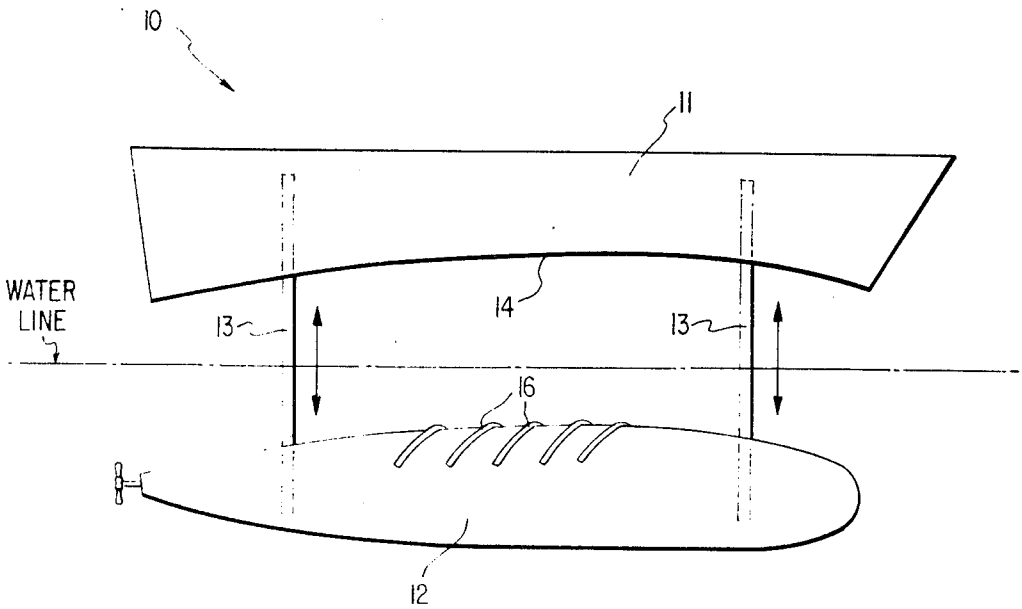


FIG. 1

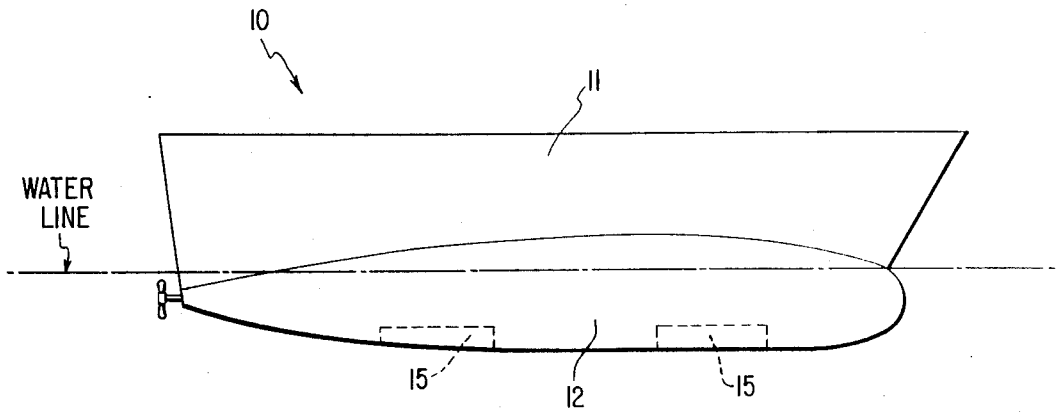
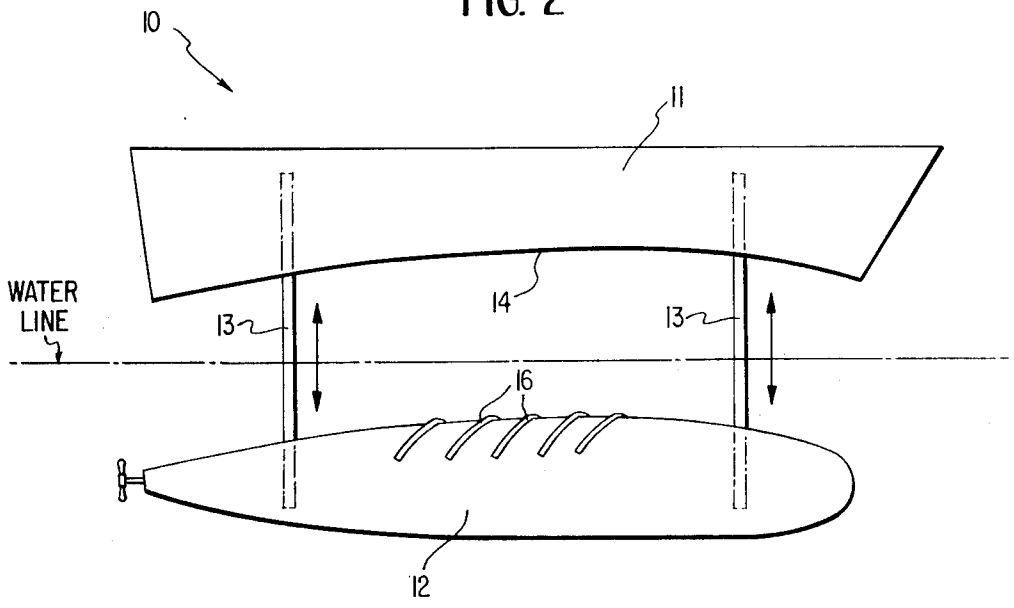


FIG. 2



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MODULAR HULL VESSEL AND METHOD OF OPERATION

BACKGROUND

The present invention relates to the field of surface waterborne vessels which displace a weight of water equal to their own weight. In such vessels the portion of the hull above the waterline is commonly called the surface hull and the portion beneath the waterline is referred to as the displacement hull. The cruising speed of such vessels is adversely affected by the hampering effect of water resistance, surface drag, and particularly the resistance of waves. Wave impact force acts not only against the exposed surface hull but also against a portion of the submerged displacement hull.

Marine architecture has developed surface waterborne vessels equipped with hydrodynamic lift means operative when a vessel is underway to lift and hold the entire hull out of contact with the water surface and at a height sufficient to clear the crests of waves. U.S. Pat. No. 2,906,228 is representative of such vessels; which have come to be known in the art as "-Hydrofoils." This is a generic term applied to any type of waterborne vessel in which struts depending from its hull carry submerged hydrofoil bodies whose angle of incidence may or may not be adjustable. When the vessel is underway, these submerged hydrofoil bodies operate hydrodynamically to lift the entire hull of the vessel out of the water and support it with its bottom out of contact with the water surface and above the crests of waves thereon. This elevated disposition of the hull enables operation of the vessel at speeds much faster than speeds attainable by conventional propulsion means while the vessel is seated on the surface of the water. Ordinarily, the submerged hydrofoil bodies carry propulsion means and steering means for operating the vessel, which means are connected through the struts with engines and controls in the elevated hull. Although the present invention is pertinent to the foregoing general field of marine architecture development, it is founded upon a different and novel application of the basic principles which heretofore have governed the prior art development of waterborne vessels designed so that, when underway, vessel contact with the water through which it is moving is minimized to the greatest possible extent.

In the "hydrofoil" type of vessel illustrated in the aforesaid U.S. Pat. No. 2,906,228 such contact is minimized by lifting the normal displacement hull of the vessel entirely out of the water after the vessel is underway. In another prior art type of vessel designed to minimize such contact, represented by German Pat. No. 590,270, a submerged displacement hull portion of the vessel is connected by upstanding struts to a personnel carrier hull which is held above and out of contact with the water surface solely by buoyancy imparted through displacement action of the submerged hull portion, which portion is streamlined to offer the least possible resistance to its passage through the water.

At the present stage of marine architecture development, the hydrofoil principle introduced by Alexander Graham Bell is the basis of prior art methods and means employed to lift the hull of a vessel entirely out of the water and hold it clear above the surface while the vessel is underway. In all such methods and means known to me prior to the advent of my present invention, hydrofoil bodies are separately and/or independently attached to some portion of the vessel's hull, and generally are subject to independent control to vary their angles of incidence whereby to regulate their hydrodynamic lift action while the vessel is underway.

At this point attention is directed to the fact that a mere "-streamlined" body moving in the direction of its longitudinal axis in a horizontal plane through a body of water is, while so moving, per se hydrodynamically incapable of exerting a vertical lifting force.

Although modern adaptations of the hydrofoil to normally surface waterborne vessels have accomplished the objective of lifting a vessel out of the water and supporting it with its bottom out of contact with the water surface and clear above the tops of waves while the vessel is underway, the advantages thus gained are greatly offset in practice by the complexity of the problem of balancing a large mass on a support which is only a small fraction of the weight of the mass; thereby creating an essentially unstable dynamic system. In such vessels the hull, normally designed for water displacement use, is lifted out of the water and actually flown through the air while supported by foils normally designed for air use but which move through water instead. Furthermore, the lift requirements are such that the horsepower present used in these vessels could practically drive a conventional planing hull vessel through the water at approximately the same speed.

SUMMARY

The present invention provides a novel method and means for controlling the in transit attitude of a surface waterborne vessel whereby to minimize water resistance, and particularly the resistance imparted by the action of waves. In marine architecture, wave resistance in relation to the speed of a vessel is expressed in Froude numbers, which increase with increase in speed. It is known that at Froude numbers of 0.3 and greater, wave resistance increases at a very fast rate; so much so that the speed of full bodied conventional surface vessels (vessels with Archimedes principle displacement hulls) is limited to a Froude number of about 0.5.

The present invention provides also a normally surface waterborne vessel that supports its weight by means of a submerged displacement hull, in which the displacement hull itself is distinct from the surface hull portion of the vessel and is constituted as a hydradynamic lift body, operative when the vessel is underway, to lift the entire surface portion of the vessel from the water and support it at a selected height above its surface while the entire displacement hull remains submerged.

The present invention additionally provides a surface waterborne vessel having a surface hull and a separate submerged displacement hull connected thereto and which displaces a weight of water equal to a substantial portion of the entire weight of the vessel, in which the displacement hull is vertically movable bodily below the surface hull, and in which the displacement hull is constituted as a hydrodynamic lift body operative, while the vessel is underway, to lift the entire surface hull to a selected height above the surface of the water and support it at that height while the displacement hull remains submerged.

The present invention makes it possible to utilize nuclear power for the operation of large merchant vessels, passenger liners, naval craft and the like, in a more economical and practical manner than with current installations using atomic reactors which require massive shielding.

In its broad aspects, as here shown, the surface waterborne vessel of the present invention comprises a surface hull module and a separate, submerged, displacement hull module. Both are watertight. When assembled in mating relation, as seen in FIG. 1, they constitute in their entirety a complete surface waterborne vessel in which the surface hull module is designed as the general utility and personnel carrier portion, and in which the displacement hull module carries the power plant, the propulsion means, fuel, and other mechanism necessary to operate the vessel. The displacement hull module constitutes in its entirety a hydrodynamic lift body and, in addition, provides a substantial portion of the buoyancy for the entire vessel.

The two modules are connected by the struts arranged to permit relative vertical movement between the modules such that the displacement hull module may be raised and lowered in relation to the surface hull module. The displacement hull module is provided with buoyancy regulating means and also with hydrodynamic lift action regulating means, both controlled from the surface hull module.

When the vessel is docked, or operating in shoal water, the hull modules are maintained in substantially mated engage-

ment and with the surface hull module seated on the water surface in the conventional manner of waterborne vessels. When the vessel is in deep water, and it is desired to cruise with the bottom of the surface hull module elevated above and out of contact with the water surface and wave crests, the submerged displacement hull module is lowered to its limit depth. At this stage the surface hull module remains seated on the water surface and provides a minor portion of the vessel's buoyancy. When the vessel is put in motion with the displacement hull module in lowered position, the resulting hydrodynamic action of the displacement hull module resulting from its forward motion through the water applies a vertical lift force which, in conjunction with the buoyancy lift force of the module, operates to lift the surface hull module entirely out of the water and to hold it supported in raised position with the bottom of the surface module out of contact with the water surface and spaced above the crests of waves while the vessel is underway.

Buoyancy of the displacement hull module and also its generated additional hydrodynamic lift action are regulated by controls in the surface hull module operating through the struts that connect the modules. Furthermore, the displacement hull module may be equipped with conventional hydroplanes (not shown) similar to those employed on submarines for directional inclination of the hull as it moves through the water, and which are operated by controls in the surface hull module.

IN THE DRAWINGS

FIG. 1 is a schematic representation in side elevation of a modular hull vessel incorporating the present invention, prior to deployment of its displacement hull module.

FIG. 2 is a schematic representation of the vessel shown in FIG. 1, but with its displacement hull module in fully deployed position, with the vessel underway.

DETAILED DESCRIPTION

The foregoing drawings are schematically illustrative of the best method and means I have thus far devised for reducing my invention to practice.

As shown, a surface waterborne vessel, indicated in its entirety by reference character 10, has a surface hull module 11, and a submerged Archimedes principle displacement hull module 12 which displaces a weight of water equal to a substantial portion of the entire weight of the complete vessel. The surface module is the normal personnel carrier portion of the vessel, having the usual accomodations for crew, cargo, and passengers if any. The displacement hull module contains the engines, and the propulsion and steering mechanism for operating the vessel and may include cargo holds. It contains also the fuel supply and other mechanism for operating the vessel. Struts 13, operative for vertical extension and retraction, permanently connect the modules so that the displacement hull module may be raised and lowered relative to the surface module. The struts 13 may provide communication between the modules and may be designed to permit the free passage of personnel from one to the other and to contain means for conveying engine exhaust products of combustion from the displacement hull as well as for ventilating it.

The bottom 14 of the surface hull module is watertight and preferably is designed for substantial mating engagement with the top of the displacement hull module when the latter is in fully raised position. The displacement hull module is itself watertight; so that the modules are capable of movement through the water as independent waterborne vessels connected as a unit by the struts 13 and any other means that may be desired. As indicated in phantom, the displacement hull module is equipped with conventional ballast tanks 15 for regulating its buoyancy in the conventional manner of such devices.

The paramount feature of the present invention is the use of the displacement hull module itself to impart a hydrodynamic lift force sufficient, when the vessel is underway, to lift the entire surface hull module from the water and support it in elevated position as shown in FIG. 2. For this purpose the displacement hull 12 is constituted as a hydrodynamic lift body which acts in accordance with the laws of hydrodynamics to lift the entire vessel as it moves through the water. At the same time, it provides a substantial portion of the buoyancy for the entire vessel.

The lift action of the displacement hull module is under selective control by regulator means 16, here shown as conventional spoilers on its top surface, operative to vary selectively the hydrodynamic effect of the hull.

The modular hull arrangement of the present invention is particularly useful in its adaptation to the employment of atomic power for the operation of surface waterborne vessels. A nuclear reactor carried in the displacement hull module is effectively shielded from the surface hull module is effectively shielded from the surface hull by the in situ layer of water above the top of the displacement hull when it is in lowered position. The insulating effect of water on radioactive emissions is well known, but so far as I am aware the prior art has not made use of sea water in situ for shielding a nuclear reactor that is the power source for operation of a surface waterborne vessel. In this respect my invention is unique.

From the foregoing, it is apparent that the present invention is fundamentally a normally surface waterborne vessel that supports its weight by means of a submerged hydrofoil which actually is also a water displacement hull of the vessel and which provides a substantial portion of its buoyancy. The displacement hull operates hydrodynamically while the vessel is underway to exert a vertical force tending to lift the submerged hull to the surface of the water.

As used in the foregoing specification and in the following claims the term "displacement hull" means a hull which utilizes the Archimedes principle; and the term "hydrodynamic lift body" means a submerged body which, when moving through water, acts in the manner of an airfoil moving through air.

METHOD OF OPERATION

For docking and for relatively shoal water cruising the modules 11 and 12 are connected substantially in mating engagement as shown in FIG. 1. At this stage the attitude of the complete vessel is such that the modules together constitute an overall Archimedes principle hull assembly which in its entirety displaces a weight of water equal to the weight of the vessel. The displacement module provides a substantial portion of the vessel's buoyancy and the remainder is supplied by the surface module.

When the depth of water is sufficient for cruising with the submerged displacement hull lowered, appropriate mechanism controlled from the surface hull is operated to lower the displacement hull module to its limit depth, and the ballast tanks are manipulated to decrease its buoyancy by lowering the center of gravity, thereby maintaining the vessel as a stable dynamic system. As the vessel proceeds, the hydrodynamic action of the fully submerged displacement hull module resulting from its forward motion through the water automatically generates and applies a vertically acting force tending to lift the module to the surface of the water. This added hydrodynamic lift, coupled with the constant lift exerted by the buoyancy of the submerged module, is sufficient to lift the entire vessel. Accordingly, when the submerged module 12 rises toward the surface it correspondingly lifts the entire surface module 11 out of the water to the same extent.

So long as the vessel is in forward motion the generated hydrodynamic lift of the submerged module 12 is exerted continuously, and if not controlled it would automatically carry the module to the surface, thereby altering the attitude of the vessel. The entire surface module would then be held in elevated position at a height above the surface of the water equal to the length of the fully extended struts 13, thus

establishing an essentially unstable dynamic system which could cause the vessel to capsize.

Dynamic stability of the system is maintained in the present invention by operation of the lift regulating means **16** to govern the extent of generated hydrodynamic lift applied by the submerged module; so that the module is not allowed to rise to a level of instability.

It will be apparent to persons skilled in the art of surface waterborne vessel design that, in an Archimedes principle hull, initial buoyancy of displacement alone cannot supply the force required to lift a separate but necessary component of the vessel to an abnormal height above the level of its loaded waterline while the vessel is underway. Additional lift force is necessary to accomplish that purpose, and it must be applied in such manner that it does not render the dynamic system of the vessel unstable. In the present invention that additional lift force is supplied by the generated hydrodynamic action of a submerged hull that carries all the engines, fuel, propulsion means, steering means, and other mechanism required to operate the vessel, and which is constituted as a hydrodynamic lift body.

It is within the purview of my invention, and intended, that the surface hull module may be designed to provide either optimum aerodynamic characteristics for passage through air or a combination of aerodynamic and other designs so as to maximize its efficiency and utility as a carrier, whereby to maximize aerodynamic and hydrodynamic factors in each of both media.

The portion of total buoyancy of the vessel that is provided by the subsurface hull module is selectively variable for adaptation to local cruising conditions. Preferably it should be from about 40 percent to about 95 percent.

From an alternate point of view, the present invention is a normally surface waterborne vessel **11** complete in all respects except for its engines, fuel tanks, propulsion and steering means, and auxiliary mechanisms, all of which are contained within a hydrodynamic lift body **12** that is also a buoyance component which supports the vessel when it is at rest on the surface of the water. When the vessel is underway, the component **12** may be lowered beneath the vessel; whereupon it functions hydrodynamically to generate and apply a vertical lift force which acts in addition to the vertical lift force of the component's buoyancy to raise the component from its lowered depth toward the water surface and correspondingly lift the vessel **11** completely out of the water by means of the supports **13**. The buoyance of the submerged component and also its generated hydrodynamic lift effect are regulated selectively from controls in the vessel to maintain it in elevated position at a height such that the bottom of the vessel is out of contact with the water and above the tops of any waves thereon. This necessitates a reduction in buoyancy appropriate to maintain the dynamic system of the vessel in a condition of stability, but the loss is compensated by the added hydrodynamic lift supplied by the component **12**.

I claim:

1. The method of minimizing water and wave resistance against a surface waterborne vessel having a hull assembly including a personnel carrier surface module and an engine carrier subsurface module which together have a combined buoyancy initially supporting the entire mass of the vessel, which method comprises: decreasing the initial buoyancy of the subsurface module and lowering it below its initial depth; causing the lowered module to generate and exert a hydrodynamic lift force which, added to the remaining buoyancy lift of the lowered module, causes the module to rise toward the surface of the water and correspondingly elevate the surface module thereabove; and controlling the magnitude of the lift forces to maintain the subsurface module at a desired depth while the vessel is underway.

2. The method of minimizing water and wave resistance against a surface waterborne vessel having an Archimedes principle hull assembly including a subsurface displacement module and a surface module supported thereon, which comprises: decreasing buoyancy of the subsurface module and lowering it below the surface module to an initial lower limit depth substantially greater in extent than its original depth; placing the vessel in forward motion; applying to the lowered subsurface module a motion generated hydrodynamic lift force sufficient when combined with the instant buoyancy lift force of the module to lift the module to the surface of the water while the vessel is in forward motion at cruising speed; and controlling magnitude of the combined hydrodynamic and buoyancy lift force of the subsurface module so that it lifts and maintains its supported surface module at a height above the water surface substantially equal to the distance the subsurface module is raised from its initial limit depth level.

3. The method of lifting and holding the hull of a normally surface waterborne vessel above and out of contact with the surface of the water while underway, which comprises: lowering beneath the bottom of the hull an attached buoyancy component of the vessel containing the engines, fuel, steering and propulsion means, and other mechanisms for operating the vessel; decreasing buoyancy of the lowered component to maintain the dynamic system of the vessel in stable condition; manipulating the lowered component to create by motion of the vessel a hydrodynamic lift force acting in addition to the remaining buoyancy lift force of the lowered component to raise the component and the attached hull to an extent such that the hull is held above and out of contact with the surface of the water; and selectively adjusting the height at which the hull is held above the water surface by regulating the magnitude of the hydrodynamic and buoyancy lift forces of the lowered component.

4. In a surface waterborne vessel having an Archimedes principle hull constituted by a subsurface module and a separate surface module mounted thereon, in which the subsurface module is a buoyant hydrodynamic lift body providing a substantial portion of the buoyancy for the entire vessel; means for lowering the subsurface module to a limit depth below the surface module, said lowering means including means for supporting the surface module of the subsurface module in vertically spaced relation thereabove; means for selectively controlling the buoyancy of the subsurface module; and means for selectively controlling hydrodynamic lift action of the subsurface module whereby to apply to that module a vessel-motion generated lift force which, added to the lift force of the buoyancy of the module, acts to raise the entire vessel to a level at which the means supporting the surface module holds the entire surface module out of contact with the water surface and above the top of any waves thereon.

5. In a waterborne vessel having an above surface hull module and a submerged buoyant displacement hull module: means operative while the vessel is underway to raise and lower the displacement hull module to selective positions of adjustment relative to the surface hull module; the body alone of said displacement hull module constituting means operative solely in response to forward motion of the vessel to generate and apply to the displacement hull module a vertical lift force in addition to its inherent buoyancy lift force.