United States Patent [19]

Lang

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[45] **Oct. 22, 1974**

[54] **SEMISUBMERGED SHIP WITH BOW IMPACT ALLEVIATOR**

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[73] Assignee: **The United States of America as represented by the Secretary of the Navy,** Washington, D.C.

[22] Filed: **July 16, 1973**

[21] Appl. No.: **379,509**

[52] **U.S. Cl.** ..... **114/61,** 114/66.5 H

[51] **Int. Cl.** **B63b 3/00**

[58] **Field of Search** ..... 114/61, 66.5 H

[56] **References Cited**

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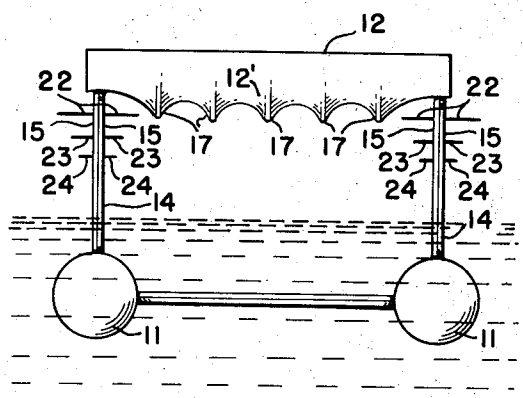
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Primary Examiner—Robert G. Sheridan
Assistant Examiner—Donald W. Underwood
Attorney, Agent, or Firm—Richard S. Sciascia; Ervin F. Johnston; Thomas Glenn Keough

[57] **ABSTRACT**

An improvement is provided for the semisubmerged ship which reduces the impact effect of large waves when they strike the ship's platform. A semisubmerged ship by having at least one submerged elongate hull supporting a platform above the water's surface by at least one water-surface piercing strut is capable of high-speed operation and a large wave directly striking the platform could damage the ship. Including pairs of lifting hydrofoils on the upper reaches of the forwardly disposed water-surface piercing struts raises the platform to reduce the impact force and the possibility of damage to the platform. Similarly configured bow-shaped projections on the underside of the platform generate lifting forces which raise the platform over the waves to reduce the impact force. Designing the bow shaped projections to be cusp-shaped also helps them cleave into the waves to further reduce the impact and the effects of impact on the underside of the platform. The concave surfaces of the cusps translate the impacting force to tensile stresses in their sheet-metal surfaces. These sheet metal surfaces are capable of bearing greater tensile forces without yielding whereas conventional flat surfaces are deformed and end up irregularly shaped.

5 Claims, 9 Drawing Figures



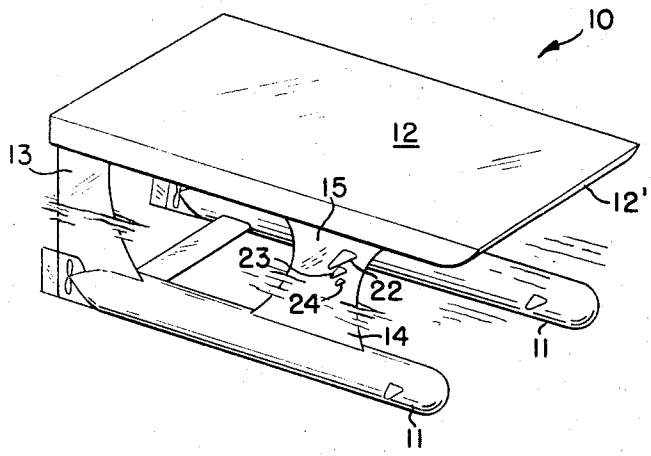


FIG.1

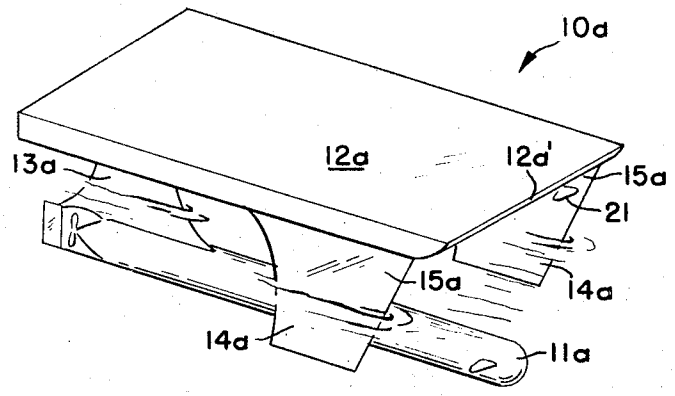


FIG.2

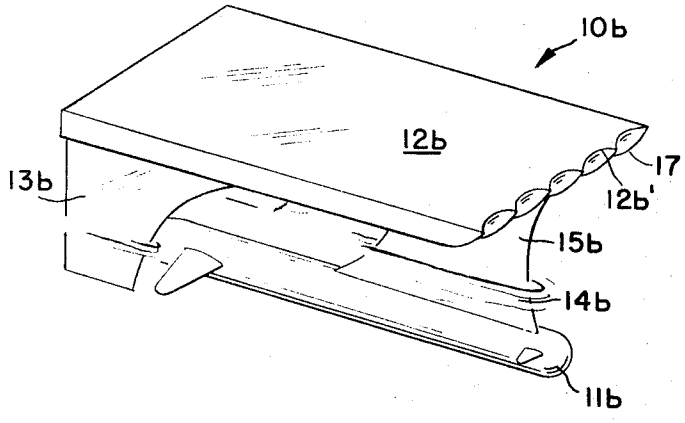


FIG.3

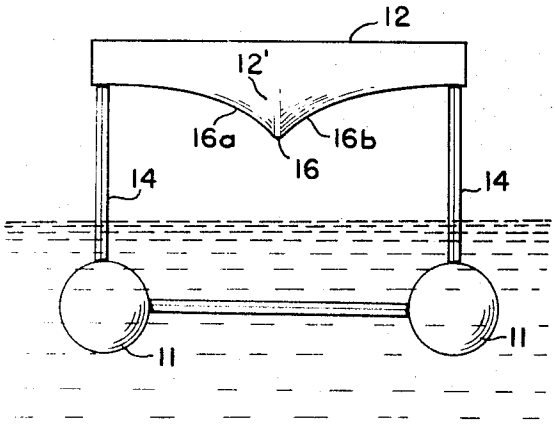


FIG.4

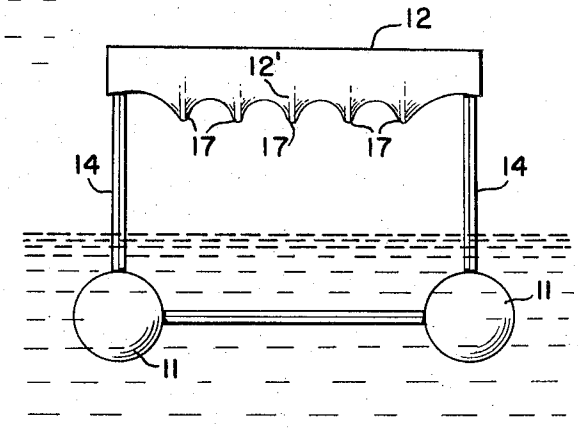


FIG.5

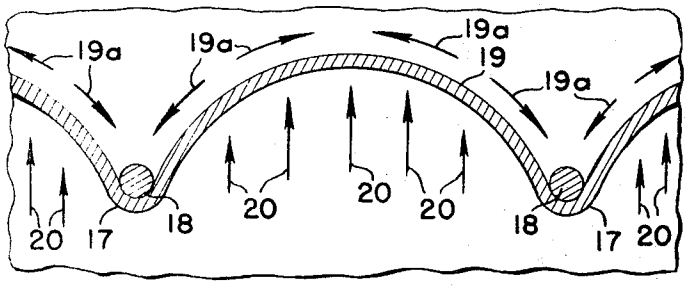


FIG.5a

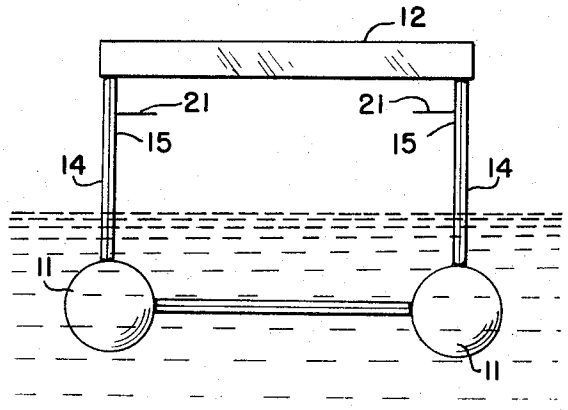


FIG.7

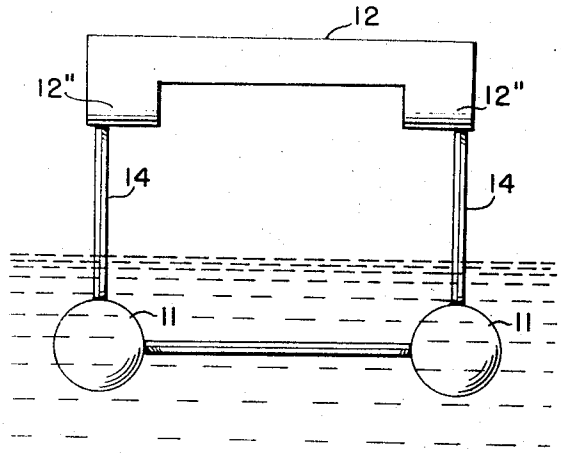


FIG.6

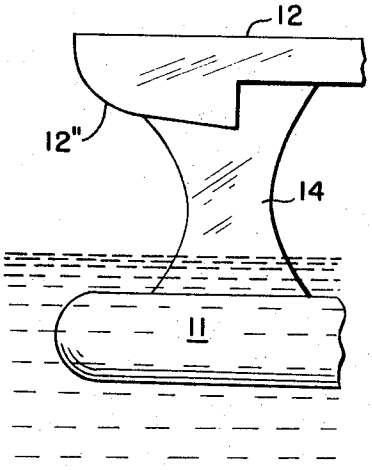


FIG.6a

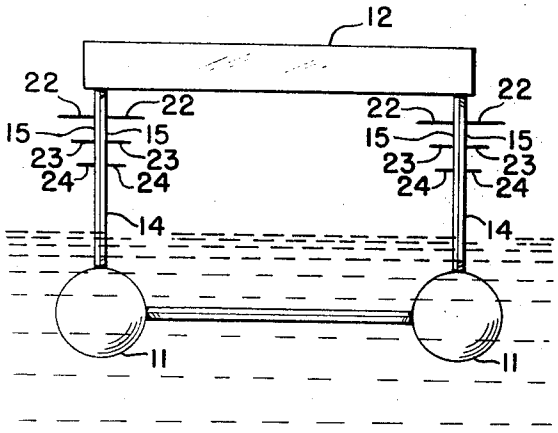


FIG.8

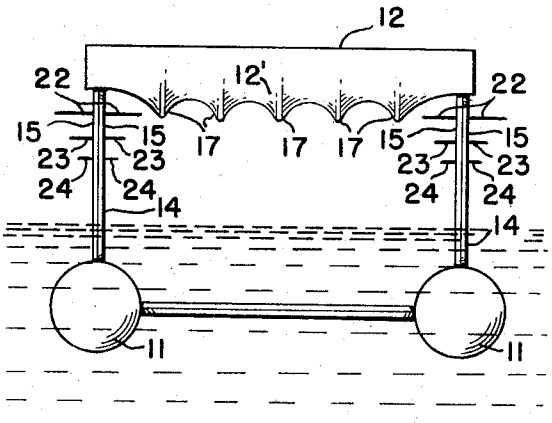


FIG.9

SEMISUBMERGED SHIP WITH BOW IMPACT ALLEVIATOR

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

Most conventional surface ships and catamaran-type vessels create excessive spray and wave drag, even though some have had their bows modified to break cleanly through the water; however, when unusually high sea states were encountered, these bows tended to plow through the waves and water would break over the bow and deck. One attempt to reduce the problems associated with excessive plowing and wave drag is shown in U.S. Pat. No. 3,530,815. This catamaran-type ship employs an anti-pitching hydrofoil section disposed below the water's surface. The hydrofoil is articulated to lift the vessel and to lessen the ship's pitching tendencies. Hydrofoils also are used on a full-time basis to control attitude on an air-cushion vehicle of the type shown in U.S. Pat. No. 3,661,110. The hydrofoils in this vehicle are disposed below the water's surface to provide hydrodynamic lift in much the same manner as practiced by conventional hydrofoil boats. Thus, it is evident that particularly-shaped bows and hydrofoils routinely have been employed on a full-time basis to hydrodynamically provide lift and high-speed stability. Yet the state of the art fails to recognize the use of such structures carried above the water's surface to guard against the damage caused by unusually large waves. Where high-speed stability is inherent, such as in the case of the semisubmerged ship thoroughly disclosed and claimed in U.S. Pat. No. 3,623,444, only the possibility of damage by unusually high sea states poses any hazard. A typical embodiment of the semisubmerged ship has 30-foot long supporting struts. As a result, in sea states having waves less than 30 feet from crest to trough, safe-high-speed operation is maintained by appropriately controlling the ship's fully-submerged control surfaces. But in higher sea states which could bring waves in-contact with the broad expanse of its platform, permanent damage could occur. In fact, there is every reason in expect that there will be a deformation to the bottom-side of the platform. Some means should be provided for reducing the effects of impact on the platform other than creating excessively heavy structure which penalizes the payload. A continuing need exists for such a means as the semisubmerged ship travels at high speed.

SUMMARY OF THE INVENTION

This invention is directed to providing an improvement for the semisubmerged ship which has at least one hull completely disposed beneath the water's surface, a platform carried above the water's surface, and at least one water-surface piercing strut member interconnecting the hull and platform. The improvement is a means carried on the forward portion of the semisubmerged ship above the water's surface being appropriately shaped for reducing the effects of impact when high waves strike the platform.

It is a prime object of this invention to provide an improvement for the semisubmerged ship.

A further object is to provide for means reducing the impact on the bottom-side of the platform of the semisubmerged ship when unusually high sea states are encountered.

Another object is to provide ski-like or bow-like projections for reducing the effects of impact.

Yet another object is to provide an arrangement of dependent cusp-shaped members carried on the forward portion of the platform for reducing the effect of the impacting force of large waves.

Still another object is to provide lifting hydrofoils carried above the normal water line for reducing the impacting force of large waves.

Yet another object is to provide a combination of cusp-shaped members and lifting hydrofoils normally carried above the water's surface to reduce the impact of large waves.

Yet another object is to provide cusp-shaped members fabricated to ensure the generation of nondestructive tensile forces when the members contact large waves.

These and other objects of the invention will become more readily apparent from the ensuing specification when taken with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1, 2,** and **3** are three typical embodiments of the semisubmerged ship each mounting a variation of the impact reducing means.

FIG. **4** is a front view of a single dependent cusp-shaped member functioning as the impact reducing means.

FIG. **5** shows several dependent cusp-shaped members arranged in a side-by-side relationship and functioning as the impact reducing means.

FIG. **5***a* shows a cross-sectional detail of a dependent cusp-shaped member.

FIG. **6** is a variation of a dependent member.

FIG. **6***a* is a partial side view of FIG. **6.**

FIG. **7** shows a front view of a single lifting hydrofoil functioning as the impact reducing means.

FIG. **8** is a front view showing a plurality of pairs of lifting hydrofoils functioning as the impact reducing means.

FIG. **9** shows a combination of dependent cusps and hydrofoils functioning as the impact reducing means.

DESCRIPTION OF THE PREFERRED EMBODIMENT

This improvement is specifically intended for modification of the semisubmerged ships of U.S. Pat. Nos. 3,623,444 and 3,730,123 issued Nov. 30, 1971 and May 1, 1973 to Thomas G. Lang. In these drawings, three representative types of the semisubmerged ship, **10, 10***a* and **10***b*, are shown in FIGS. **1, 2,** and **3,** respectively. The semisubmerged ship of FIG. **1** has two elongate hulls **11** each supporting a platform **12** by an aft water-surface piercing strut **13** and a forward water-surface piercing strut **14** (only one aft and forward strut are shown). The type of FIG. **2** has a single elongate hull **11***a* supporting a platform **12***a* via a single aft water-surface piercing strut **13***a* while a pair of water piercing forward struts **14***a* depends from opposite lateral extremes of the front portion of the platform. Lastly, the third representative semisubmerged ship of FIG. **3** has a single elongate hull **11***b* supporting a platform **12***b* by a single forward water-surface piercing

strut **14***b* while a pair (only one being shown) of aft water-surface piercing strut members **13***b* depend of opposite lateral extremes from the aft portion. In all of the disclosed embodiments the hulls preferably contain the propulsive machinery for driving an interconnected screw or equivalent propulser and fuel crew's quarters are optionally located in the hulls. The platform is supported a considerable distance above the surface of the water and, by being so placed, provides a stable platform for hauling supplies, passengers, or for serving as a stable weapons platform. The forward and aft struts are shaped for a minimal hydrodynamic reaction to surface spray and wave action and canard fins and horizontally oriented stabilizers or cantilevered vanes are mounted on the submerged hulls to responsively control the vessel's attitude. The configuration, design considerations, and details of the semisubmerged ship are thoroughly discussed in the above referred to U.S. Pat. Nos. 3,623,444 and 3,730,123. A ship fabricated in accordance with the teachings of these patents is capable of sustained high-speed operation in relatively high sea states due, in part, to the placing of the elongate hulls and control surfaces beneath the area of surface wave action. Hydrodynamically designed struts reaching this area of surface wave action do not create excessive drag and they support a large platform above and beyond the turbulance associated with wind and waves to permit smooth, rapid, up to and in excess of, 40 knot speeds.

However, in severe sea states, waves reach heights in excess of the distance the struts hold the platform above the water's surface. When this occurs, there is a strong likelihood of deformation or rupture of the bottom-side of the platform as it plows into the large wave. Furthermore, any cargo not securely locked in place or any crewmen caught on the exposed upper deck of the platform are certain to be swept overboard as water rushes over the top of the platform. Thus, modifications of the patented semisubmerged ships were needed which would diminish the high wave's damaging impact on the platform and lessen the chance of water being taken over the bow.

The modifications to the semisubmerged ship, i.e., the embodiments of this invention, which reduce the possibility of damage to the platform are either located at the underside of bow portion **12'**, **12***a'*, and **12***b'*, or on the upper areas **15**, **15***a* and **15***b* of the forward struts **14**, **14***a*, and **14***b*, or, a combination of both locations. However, with respect to setting forth these several embodiments, FIGS. **4** through **9** and the ensuing description will be concerned with the twin-hulled semisubmerged ship of FIG. **1**. Similar modifications of the semisubmerged ships shown in FIGS. **2** and **3** will be obvious in view of the following description.

The embodiment of FIG. **4** shows a single cusp-shaped member **16** dependent from bow portion **12'** and longitudinally rearward along the length of platform **12**. As the semisubmerged ship travels through the water and the crest of the large wave slams against the bow portion the apex of member **16** first contacts the wave and splits it gradually. The bottom surface of the platform gradually slides into and over the wave and a single full impact of the full force of the wave on the otherwise flat underside of the platform is avoided. By designing arcuate contours **16***a* and **16***b* of member **16**, there is a translation of force as it effects the surface of the skin-like plate forming the bottom-side of platform **12**.

In FIG. **5** the second embodiment of this invention shows the twin-hulled semisubmerged ship mounting a plurality of smaller cusp-shaped members **17** from bow portion **12'** backward along the length of platform **12**. These cusp-shaped members have the cross-sectional configuration of a ceratoid cusp for hydrodynamically interacting with impinging large waves to prevent damage to the platform. Here again, the full impact of the crest and body of an unusually large wave is prevented from striking the bottom of platform **12** at one time since the wave is broken-up by the contours of the several smaller cusp-shaped members. The platform rides up and over the wave's crest on the cusp-shaped members and the full impact of the wave is deflected from the otherwise planar surface of the platform's underside. To further reduce the full impact the apex of each cusp-shaped member **17** has a rounded convex curvature; this further avoids presenting a planar surface to the wave's surface. For purposes of demonstration, note that FIG. **3** shows cusp-shaped members **17** on the single hull semisubmerged ship. These cusp-shaped members also are included in the embodiments depicted in FIGS. **4** and **5**. Details of all the embodiments are set out in FIG. **5***a* which shows an internal framework **18** in the form of an elongate steel rod. The rod longitudinally extends substantially the length of platform **12** from forward to aft and curves upward at bow portion **12'**. A skin-like plate covering **19** having an arcuate cross-sectional configuration in the shape of adjacent ceratoid cusps extends over adjacent internal frameworks **18**. Such an arrangement results in plate covering being held in tension, see arrows **19***a*, when an upward pressure represented by arrows **20**, is exerted by the crest of a large wave slamming against the platform. Because of the manner of construction of cusp-shaped members **17**, a translation of force is made. The punishing impact the lower skin-like plate covering **19** is subjected to (which would deform a flat conventionally mounted plate), is translated into internal tensile stresses which the cusp-shaped configuration is particularly adept at bearing.

A variation using dependent structure is shown in FIGS. **6** and **6***a*. Here, ski or bow-shaped members **12''** continue downward from bow portion **12'** in a rounded contour. Upon striking a large wave, member **12''** lifts the bottom of platform **12** from the wave's path. Member **12''** optionally extends the length of the platform.

Looking to the embodiment of FIG. **7**, a single lifting hydrofoil **21** is mounted on each of the forward struts **14** in an area **14a** located well above the surface of the water. Only when an unusually large wave is encountered does this hydrofoil become wetted, and only then does it hydrodynamically cooperate with the mass of water to lift the platform over the crest of the wave to avoid impact-damage. In the alternative, the lifting hydrofoil has a cross-sectional configuration to ensure the creation of such lift, or it is a hydrofoil canted with respect to the direction of forward motion to ensure the generation of the lifting force.

Improved lifting is provided by the cascaded hydrofoil arrangement shown in FIG. **8**. Here, pairs of oppositely extending lifting hydrofoils **22**, **23**, and **24**, are mounted on a separate forward strut **14** in the area **14***a* located well above surface wave action. Note that the

smallest pair of lifting hydrofoils is located nearest to the water's surface and that the intermediate pair of lifting hydrofoils and the largest upper pair of lifting hydrofoils are disposed at positions further up on the strut. As an unusually high wave strikes the semisubmerged ship while it travels through the water, lowest pair **24** of lifting hydrofoils contacts the large wave and begins to exert a relatively small lifting force. If the lift created by pair **24** is insufficient, and as the semisubmerged ship continues to plow into the wave, pair **23** of lifting hydrofoils begins to slice into the the crest of the large wave to generate a greater lifting force is generated.

If the additive lifting force created by pair **24** and pair **23** is insufficient to raise the platform and the semisubmerged ship continues to plow into the wave, pair **22** becomes wetted and the platform is lifted from the wave's path.

The two types of impact reducing means depicted in FIGS. **5** and **8** are combined in the embodiment of FIG. **9.** A plurality of smaller cusp-shaped members **17** depending from platform **12** and the aforedescribed pairs of oppositely extending lifting hydrofoils **22, 23,** and **24** are mounted on the struts of the twin hulled semisubmerged ship. The hydrodynamic reactions of both the cusp-shaped members and the lifting hydrofoils are substantially identical to that described above, and the additive lifting force produced assures high-speed safe passage in high sea states. It naturally follows that there is little chance of water coming over the bow and men and materials are protected.

This improvement gives the semisubmerged ship concept a high-speed; capability that is not overly influenced by the surrounding sea states. The aforedescribed impact reducing means are not normally wetted and, therefore, function only when high sea states must be dealt with. The semisubmerged ship's superior capabilities are not compromised but are improved by inclusion of the present invention.

Obviously, many modifications and variations of the present invention are possible in the light of the above teachings, and it is therefore understood that within the scope of the disclosed inventive concept, the invention may be practiced otherwise than specifically described.

What is claimed is:

1. In a semisubmerged ship having at least one elongate hull completely disposed beneath the water's surface, and a platform joined to the elongate hull and carried above water's surface by at least one water-surface piercing strut dependent from the platform, an improvement therefor is provided comprising:

means carried on the semisubmerged ship above the water's surface for reducing the effects of impact when waves higher than the length of at least one water-surface piercing strut approach the platform, the impact reducing means includes a plurality of dependent cusp-shaped members forming the underside of said platform in a juxtaposed relationship and the impact reducing means further includes a plurality of pairs of oppositely extending members mounted in a vertically spaced relationship on each forwardly disposed strut.

2. An improvement according to claim **1** in which the plurality of dependent members are cusp-shaped and forming the underside of the bow of said platform and each of the pairs of oppositely extending members are hydrofoil shaped to produce a lifting force.

3. An improvement according to claim **2** in which each of the plurality of cusp-shaped members includes an elongate rigid element curving upward toward and being secured to the forward portion of said platform at its front end and on an aft portion of said platform at its second end and a skin-like element extending over and reaching between adjacent elongate rigid elements and the pairs of oppositely extending hydrofoils are configured with increasing dimensions with respect to one another.

4. An improvement according to claim **3** in which the apex of each cusp-shaped member has a convex curvature at the bow and each of the pairs of oppositely extending hydrofoils are oriented to produce a lifting force.

5. An improvement according to claim **4** in which said skin-like element of the plurality of cusp-shaped members is an integral plate shaped like a series of ceratoid cusps for translating impact forces to tensile forces in the skin-like plate when large waves strike and there are disposed pairs of oppositely extending hydrofoils arranged to present surface areas of increasing dimensions in proportion to their proximity to the platform.

* * * * *