No. 464,259

COMMONWEALTH OF AUSTRALIA

LETTERS PATENT

Elizabeth the Second, by the Grace of God Queen of Australia and Her other Realms and Territories, Head of the Commonwealth.

To all to whom these presents shall come Greeting:

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Name of Patentee : DAVID ALLEN KEIPER

Address of Patentee : 2101-C Bridgeway, Sausalito, California, United States of America

Name of Actual Inventor : DAVID ALLEN KEIPER

Title of Invention: Hydrofoil sailing craft

Number of Complete Specification: 464,259

Term of Letters Patent: Sixteen years commencing on 6th May, 1970

These Letters Patent have been granted on a Convention application. Particulars of the basic application on which the Convention application is based are as follows:

Name of Convention Country in which basic application filed: United States of America

Date of filing basic application : 7th May, 1969

Application number of basic application : 822,578

IN WITNESS whereof Our Commissioner of Patents has caused these Our Letters Patent to be dated as of the Sixth day of May , One thousand nine hundred and seventy , and to be sealed with the seal of the Patent Office this Thirteenth day of January , One thousand nine hundred and seventy-six .

K. B. PETERSSON,
Commissioner of Patents

PRINTED SPECIFICATION WILL BE SENT WHEN AVAILABLE

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PATENT AND TRADE MARK ATTORNEYS

ESSO HOUSE KENT STREET

SYDNEY, N.S.W.

YOUR REF USSN 822578

OUR REF 14741/70
KEIP/5
EW.

Mr. F.P. Keiper,
P.O. Box 181,
HONEOYE, N.Y. 14471,
U. S. A.

20th January, 1976

Dear Sir/s:

We enclose herewith Letters Patent particularised as hereunder:-

Country: AUSTRALIA No. 464259

Date of Patent: 6th May, 1970
Date of Sealing 13th January, 1976
Term 16 years from 6th May, 1970

Patentee: DAVID ALLEN KEIPER

Invention: "Hydrofoil sailing craft"

7th year's
Taxes fall due to maintain patent in force 6th May, 1976
and annually thereafter

Invention must be worked before 13th January, 1979

Marking of Patented Article Australian Patent No. 464259

Yours faithfully,
SPRUSON & FERGUSON

Encl:

(11) 464259

PATENT SPECIFICATION (21) 14741/70

COPY ISSUED WITH LETTERS PATENT

Class	(52)	91.6; 92.4; 92.6
Int. Cl.	(51)	B63B 1/30 // B63H 9/04, 25/06
Application Number	(21)	14741/70
Lodged	(22)	6th May, 1970
Complete Specification entitled	(54)	HYDROFOIL SAILING CRAFT
Lodged	(23)	6th May, 1970
Accepted	(44)	1st August, 1975
Published	(41)	11th November, 1971
Convention Priority	(30)	7th May, 1969, United States of America, 822,578
Applicant	(71)	DAVID ALLEN KEIPER
Actual Inventor	(72)	DAVID ALLEN KEIPER

Related Art	(56)	429134 (21982/67)	91.6; 92.4; 92.6
		275818 (31827/63)	91.6; 92.2
		53176/64	92.6

The following statement is a full description of this invention, including the best method of performing it known to me :

11746/75-L F. D. Atkinson, Government Printer, Canberra

X733-74-6D-19P.C.

This invention relates to hydrofoil sailing craft.

In unprotected waters, such craft must be able to cope with large and variable heeling forces from its sails, as well as sizable changes in water flow direction and velocity over its hydrofoils during wave encounter. The craft must be able to surmount a drag hump to become fully foilborne, and must do this in moderate wind velocities.

The aim of the present invention is to provide a practical, troublefree hydrofoil configuration, especially suited to a modified multihull sailing craft.

According to this invention, a sailing hydrofoil trimaran having a central hull with two pontoon hulls spaced on opposite sides of the central hull by a deck structure, and wind propulsion means; said trimaran being provided with a bow hydrofoil truss structure having a symmetrically disposed dihedral foil blade with oppositely inclined lifting surfaces, the structure being pivotally attached to the opposite sides of the central hull and to the pontoon hulls above the displacement water line of the hulls on a substantially common pivotal axis, means for securing the structure in a downwardly extending position with lifting surfaces of the blade inclined to provide a positive angle of attack and positive lift, lateral hydrofoil assemblies attached one to each of the pontoon hulls and each having a foil blade inclined outwardly and upwardly, and a stern hydrofoil assembly including lifting foil blades.

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For becoming foilborne in moderate winds, a highly efficient hydrofoil system, efficient said ring, and a light overall weight are required. In fact, the craft preferably should be as light as the lightest of racing multihull yachts. For the craft to operate for extended periods of time, such as offshore, without trouble, moving parts within its foil assemblies themselves should be avoided. The hydrofoil assemblies themselves should be extremely sturdy and well fastened to a rigid hull structure. With fixed foils that must supply widely varying forces for stabilization over a wide speed range, the foils should be of the surface piercing variety. For efficiency, high aspect ratio and deep submergence are highly desirable. On a daysailer or small size cruising yacht, this would involve using a fairly short blade chord length, of the order of 3 to 6 inches, limited on the lower side by necessary fore and aft rigidity of the foil units and by the economics of joining or welding together complex structures. The truss structure provide both strength and light weight, since this form of construction minimizes stresses at the places where blading and struts join together.

For the craft to take off in roughish waters under moderate wind conditions, slender hulls allowing low drag and having excellent initial lateral stability are preferable. Such slender hulls also make for easy water re-entry when the wind drops or when the foils lose stability temporarily. The hull cross section may be such that it is a displacement shape at low speed, becoming more of a planing shape as it lifts. Also, stability, of a lightweight hydrofoil craft under extreme sail side forces is improved by a craft or considerable width. For this reason the trimaran construction is superior. The hulls provide convenient structural fastening points for the hydrofoil assemblies, without having the hydrofoils supported on slender arms as heretofor in mono-hull craft. The considerable overall width of the hulls helps to allow rigging weight to be kept low with reasonable stresses in spite of the extreme sail side forces generated at high speed.

Hydrofoil sailing craft have used a 3-foil system. In a 3-foil symmetrical system, one foil unit is burdened heavily, supplying both lateral stabilizing forces and longitudinal stabilization against sail forward pitching moments and wave encounter. One cannot maximize both longitudinal and lateral stability. In the present invention, the 4-foil system is symmetrical but it acts as a 3-foil asymmetric system when the craft heels a moderate amount from the sail forces because one hydrofoil assembly may leave the water.

When going about no readjustments are needed, since heel in the other direction effectively switches the system over. What is more, the fourth foil, normally airborne on the windward side of the craft, can help to protect the craft from a serious high speed crash dive if the bow foil loses lift through wave action. As the bow foil loses lift and starts dropping, the airborne windward lateral foil comes into action to give necessary support. The lateral foils and stern foil combination stabilizes the craft with a longitudinal trim angle which is only a few degrees lower than normal trim using the bow foil. That is, the stern and lateral foils provide a longitudinal righting couple to prevent the craft from taking a steep dive, giving the bow foil time to recover its own lifting action, without the boat getting into an irreversible dynamically assisted crash in which negative bow lift generates more negative bow lift, with the craft's momentum quickly producing a stern-over-bow somersault, as can occur in a three foil system. If the loaded leeward lateral foil should lose lift through wave action, the craft will heel and spill wind from its sails, thus reducing the heeling force. Slender, buoyant pontoon hulls provide protection from capsize in an extreme case. With bow and stern foil maintaining the craft at the proper fore-and-aft trim angles, the leeward lateral foil can recover lift quickly. Essentially, the foil system is able to fail to safety.

The bow-stern foil combination controls trim of the craft so as to maintain a proper angle of attack on all of the foils as speed changes. At low speed, where foils cannot lift the craft, it is best to have a low angle of attack on all foils, so as to minimize the drag penalty of having the foils at all. As the craft accelerates near the take-off speed, it is optimal to have high angles of attack on the foils. By having an excess area on the bow foil, the craft can be made to lift its bow as much as 5° or so, so as to put high angles of attack on all foils as take-off speed approaches. However, the bow foil is preferably maintained at a higher angle of attack than the stern foil, so as to provide longitudinal stability during the take-off phase. After take-off, as speed increases, foil angles of attack are reduced to get maximum efficiency. This may be accomplished by arranging the foil blades so that the bow foil loses more area than the stern foil as speed increases. This causes the bow of the craft to move gradually down (or rather the stern rises more) to where it is level at the top speed of the craft. The stern foil blade or blades may remain totally submerged through the entire speed range, or else merely come out of the water less than the other foil blades.

As speed increases relative to the true wind speed, more and more of the craft's weight is placed on the leeward lateral foil because of the increased sail side forces. The bow-stern foil combination becomes lightly loaded at high speed with tremendous reserve lifting area if necessary, and thus it acts as a stability sensor to keep roughly correct angle of attack on the heavily loaded leeward lateral foil. If the entire weight of the craft is temporarily imposed upon the leeward lateral foil, the craft does not tend to capsize laterally, for the sail forward pitching moment causes the craft to trim bow down a few degrees. The craft tends to descend and the hulls re-enter the water safely.

By the use of dihedrals on the lateral foils, leeway of the craft can be fairly well eliminated. Zero leeway occurs when the projections on a transverse lateral plane, of the craft weight vector passing through the centre of gravity of the craft, the sail force vector passing through the centre of pressure of the sails, and the lift vector of the leeward lateral foil all intersect at a point. To be strictly correct, sideways windage on the hull and rigging should be combined into the sail force vector. Because the craft of this invention is designed to have a moderate heel, roughly 10 degrees in average conditions, it turns out that the point of intersection of these forces is substantially below the point where the sail centre of pressure passes through the centre plane of the craft. Also, sideways windage on the hulls lifted out of the water, is likely to be considerable, making this point more significantly below. It may be advantageous to place the upper portions of the lateral foil blades at en even higher dihedral, for minimizing leeway when the craft is heeled substantially more than average.

To reduce the possibility of air entertainment on the foils, with consequent loss of lift, most of the foil elements are given a moderate amount (10 to 15 degrees) of sweep. That is, the elements are directed aft as they slope up to emerge through the water's surface.

A problem which may be serious with the hydrofoil sailing yacht is preventing capsize, such as may occur when the craft is moving slowly very close to the wind and a strong gust of wind arrives which is more on the beam. The light weight of the craft, with hydrofoils going deep may contribute to the capsize, since foil drag at low speed may prevent the craft from accelerating as quickly as the typical multihull sailing craft. Very efficient high aspect ratio lateral foils may tend to stall out in the gust situation, and become powerless to prevent capsizing.

Several design factors may be used to prevent capsizing, such as mounting low aspect ratio foils of large area laterally, with dihedral, above or around the pontoon hull water line. Such foils will resist stalling out, even at high angles of attack. In addition the bottoms of the pontoon hulls may be made relatively flat, with moderate dihedral and with hard chines where the bottom joins the sides, thus increasing reaction against heeling moments when a gust strikes. Outward and upward flare of the outer pontoon hull sides will help to keep the righting moments positive when the craft is at a 90 degrees heel if the pontoons are extremely buoyant. The weight of metal hydrofoils underneath the craft will add a significant ballasting effect when the craft is at a 90 degrees heel. A masthead float is helpful to prevent the craft from turning upside down if it should be knocked over by a gust.

The hull requires a special lightweight construction which preserves rigidity by its shape and proportions. Rigidity of the hulls can be obtained by using a "stressed" skin construction, whereby flat plywood sheets are given compound curvature by being fastened to lightweight frames already set up in position. The hull comprises a shell structure with the loads at the hydrofoil fastening points distributed by special framing.

The normal sailing rig must be adapted for the special requirements of the hydrofoil craft. The two main differences are: (1) the craft needs extra thrust forwards to surmount the drag hump which occurs just below the speed at which the craft becomes fully foilborne. Sails need to be highly cambered to get maximum lift during the take off phase when the apparent wind may be some 45 to 90 degrees off the bow. (2) to reach high speed with cloth sails, the sails should be low cambered, to keep the sails from luffing when the apparent wind is coming in some 15 to 30 degrees off the bow. Also, the high apparent wind velocities require lower lift coefficients (lower camber) to prevent excessive heeling moments. To assist in providing this sail shape change automatically as the sheets are hauled in, the sails are preferably loose-footed and their booms pivot aft of the stays to which the sails are attached. For both conditions, but especially for high speed, there must be a streamlined profile where the sail joints the mast. A rotating, profiled mast may be used.

The hydrofoil trimaran offers both high speed and comfort at sea. The craft readily surfs on the fast, moderately sloped, well developed waves, such as are found in the trade winds. Conventional multihulls generally only surf on the slower, much steeper waves, such as the fresh waves generated during storms.

An example of a hydrofoil trimaran constructed in accordance with the invention is illustrated in the accompanying drawings in which:-

Figure 1 is a plan view;

Figure 2 is a bow elevation view;

Figure 3 is a side elevational view;

Figure 4 is a stern elevational view;

Figure 5 is a front elevational view of the port hydrofoil;

Figure 6 is a plan view of the port hydrofoil;

Figure 7 is a fragmentary plan view of the port side of the bow hydrofoil in its retracted position;

Figure 8 is a fragmentary detail of a lower lock for one side of the bow hydrofoil when in its active position;

Figure 9 is a rear view of a stern hydrofoil;

Figure 10 is a side view of the stern hydrofoil with parts cut away; and

Figure 11 is a diagrammatic plan view showing the location of a half of the bow hydrofoil and a side hydrofoil in active position with retracted positions indicated.

The trimaran has a main central hull 20 having a mast 18, and a pair of pontoon hulls 22 and 24 disposed one on each side of and rigidly fixed to the main hull by spars or shell structure as indicated at 21. In multihull craft of this type during normal sailing the pontoons resist the heeling due to sail forces so that heavy keels are rendered unnecessary. In order to provide hydrofoils for such a craft, that may be effective to support the hulls clear of the sea and yet provide sufficient lateral stability, as well as fore and aft control, a bow hydrofoil assembly 26, port and starboard lateral hydrofoil assemblies 28 and 30 are supported by each of the pontoons, and a stern hydrofoil 32 which in this example also serves as a rudder, are provided.

The bow hydrofoil assembly 26 is symmetrical with respect to the longitudinal and vertical axis of the craft and is secured to the main hull on opposite sides thereof at pivot points 34, 36, and similar pivot points 38 and 40 in alignment therewith, located on the inside walls of the pontoons 22 and 24 adjacent the bow ends thereof. The assembly comprises a "V" like lifting element 45 supported by vertical struts 42 and 44 on opposite sides of the main hull 20 and inclined struts 46 and 48, 50 and 52, extending laterally from the respective struts 42 and 44 to support the lifting element in the form of a hydrofoil blade 45 of NACA 16-510 section, or other suitable blade section, which for convenience may extend from one pivot point 38 to the other pivot point 40 in a wide V sufficient to extend well below the bottom of the main hull 20, when in the position as indicated in Figure 2.

The central sections 49 and 51 of the blade bears an angle to the horizontal of about 30 degrees, and the upper sections 53 and 55 extend upwards to the pivots 38 and 40 at an angle of about 50 degrees. The struts 46 and 50 extend to the joints between the sections 49 and 51, 53 and 55, and adequate bracing 60 and 62 is provided to complete a truss structure. The struts and bracing are of thin elongated streamlined section to provide maximum strength and minimum resistance to water flow. The apex 64 of the dihedral formed by the blade sections 49 and 51 is so located with respect to the common axis of the pivots 40, 36,34 and 38, as to readily clear the bow of the main hull so that the bow hydrofoil may be retracted to a horizontal position wholly above the water line and clear of the prow as indicated in Figure 3 at 26'.

In order to hold the bow hydrofoil assembly in active position with the struts 42 and 44 extending downwardly and somewhat forwardly as indicated in Figure 3, there is provided a transverse brace 66, fixed to the bottom 68 of the centre hull 20, the brace having at its ends a fitting adapted to engage and be fixed to the struts 42 and 44 to securely hold the struts in the active position. This fitting may comprise an inter-engaging tongue 67 and groove 69 as shown in Figure 8 to resist lateral forces, and a shear pin 61 or other form of lock to resist fore and aft movement. A shear pin on either side is provided to protect the craft against damage should a heavy floating obstruction be encountered by the bow hydrofoil assembly. The shear pins may be manually set in place upon lowering the bow assembly to its effective position, or if desired, such shear pins may be actuated by suitable control rods or cables (not shown) extending to a convenient point near deck level and above the water line.

It will be seen from Figure 3 that the bow hydrofoil blade sweeps forwardly and downwardly by about 10 degrees. When the structure is in the active position shown, the blade will have an angle of attack of about 5 degrees.

As shown best in Figures 9 and 10, the stern hydrofoil assembly comprises a rigid swivel frame 71 having an upper channel member 70 and a lower transverse member 72 pivoted centrally in upper and lower gudgeons 74 and 76 fixed centrally at 78 to asplit transom of the main hull 20. The members 70 and 72 are diagonally braced by channels 80 and struts 82. Each member 70 and 72 is provided with upstanding ears 84 and 86 on its ends. Pivotally secured to the ears 86 of the lower member 72 by bolts 87 are streamlined sectioned frame members 88 and 90 which also serve as rudder blades. These blades have enlarged portions 89 and 91 extending upwardly past the ears 84 of the member 70 to which they are secured by shear bolts 85, passing through suitable apertures provided therefor. A plurality of apertures may be provided in each of the ears 84 and disposed on an arc centred on the bolts 87, to permit alteration of the angle of attack of the stern foil lifting blades. The lower ends of the rudder blades 88 and 90 are provided with transverse hydrofoil or lifting blades 92, 94 and 96 of aerofoil section such as NACA 16-510.

These blades are braced by diagonal struts 98 and 97, and stiffeners 100 and 102, all of steamline section, to provide a rigid stern hydrofoil structure together with the swivel frame 71, when the hydrofoil blades are disposed in operative position as shown in Figure 3. When in this operative position, the rudder blades 88 and 90, are preferably forwardly swept as indicated, and the hydrofoil blades 92, 94 and 96 may have a substantially zero angle of attack, which may be varied by employing different apertures in placing the shear bolts 85.

The upper channel 70 is provided with upstanding ears 101 to receive a tiller 103, or other suitable gear for steering the swivel frame 71 may be provided. The spacing between the upper portions 89 and 91 of the blades 88 and 90 are such that, upon removal of the shear bolts 85, the lower portion of the stern hydrofoil assembly may be swung rearwardly and upwardly to a vertical position out of the water, with the upper portions 89 and 91 of the blades 88 and 90 swinging clear of the hull sidewalls in being swung forwardly and downwardly to a depending position where such portions may act as rudders during displacement sailing. The channel braces 80 and member 70 are notched at 81 and 73 respectively to receive the diagonal struts 97 and 98, and apertures 104 in the side blades are provided to align with the apertures in the ears 84 so as to receive the shear bolts 85, and thus hold the hydrofoil structure in an upstanding retracted position, while the free ends 89 and 91 of the blades 88 and 90 extend well below the water line to act as rudders as is indicated at 91' in Figure 3. Since the portions 89 and 91 of the blades 88 and 90 are of shorter length, these portions are preferably made wider as indicated to render them more effective as rudders. The blades 89 and 91 preferably do not extend into the water a distance greater than the draft of the main hull 20. To facilitate the positioning of the stern hydrofoil assembly in the inactive position, and nested in the frame 71, the pivotal centre of bolts 87 may be disposed rearwardly of the ears 86 of the frame 71 as indicated in Figure 10, and the bracing 97 and 98 may be offset forwardly as also indicated in Figure 10 so that the notches 81 and 73 may be shallow and avoid weakening the structure.

The lateral hydrofoil assemblies 28 and 30, being left and right handed, or mirror images of each other, a description of one will suffice herein. The port lateral hydrofoil 28 comprises divergent struts 122 and 124 of streamline section to which are fixed hydrofoil blades 126, 128, 130 and 132 of suitable section, against such as NACA (National Advisory Committee on Aeronautics, now known as National Aeronautics and Space Administration NASA) 16-510. The blades 128 and 130 extend inwardly of the strut 122, and their ends are braced by a tie member 134. Suitable bracings 136, 137, 138 and 140 and 142 further brace the structure. The upper end of the struts 122 and 124 terminate in a plate 141 that is pivoted on a heavy pivot stud 143, extending through a knuckle block 144. The knuckle block 144 is pivoted in a deck fitting 148 with the pivot axis disposed above and outboard of the gunwhale of the pontoon hull 22. The pivot axis extends at an angle inclined to the fore and aft axis of the craft.

The upper blade 126, at its inner end is braced at 127 and provided with spaced jaws 131 adapted to inter-engage with and receive a tongue-like fitting 129 rigidly secured to the pontoon hull at a point near the water line at 152 and be secured by a removable bolt 153, to form a rigid connection therebetween. A diagonal brace 154 is pivotally secured at its forward end to a fitting 156, fixed to the pontoon hull deck. The pivotal axis in the fitting 156 is aligned with the axis of the fitting 148. The brace extends to the strut 124 at a point above but adjacent to the blade 126 and is pivoted at 125 to the strut on the axis coincident with the pivot axis of the stud 143. The mounting of the foil assembly on the pivot axes in the fittings 148 and 154, and 144 and 125 is such as to permit the assembly to be retracted from the water and swung over the deck, after which the assembly pivots around the axis of the stud 143 and brace pivot 125 to a retracted position lying on the deck, in the approximate position indicated at 28' in Figure 11, all without interference with shrouds necessary to sailing craft.

As in the case of the bow and stern foil assemblies, the lateral hydrofoil assemblies preferably have forward and downward sweep as indicated. In addition, as with the bow assembly, the lateral hydrofoil sections of the blading are provided with an angle of attack of about 5 degrees.

The hydrofoils above described are preferably formed from stream-lined aluminium alloy or other lightweight metal sections or extrusions or hollow stainless steel sections all suitably welded, into a rigid truss-like structure. While there are disclosed specific truss structures found to be effective, it should be understood that the blading and support structures may take many forms.

The claims defining the invention are as follows:

1. A sailing hydrofoil trimaran having a central hull with two pontoon hulls spaced on opposite sides of the central hull by a deck structure, and wind propulsion means; said trimaran being provided with a bow hydrofoil truss structure having a symmetrically disposed dihedral foil blade with oppositely inclined lifting surfaces, the structure being pivotally attached to the opposite sides of the central hull and to the pontoon hulls above the displacement water line of the hulls on a substantially common pivotal axis, means for securing the structure in a downwardly extending position with lifting surfaces of the blade inclined to provide a positive angle of attack and positive lift, lateral hydrofoil assemblies attached one to each of the pontoon hulls and each having a foil blade inclined outwardly and upwardly, and a stern hydrofoil assembly including lifting foil blades.

2. A trimaran according to Claim 1, wherein the stern hydrofoil assembly also includes steering elements.

3. A trimaran according to Claim 1 or Claim 2, wherein each of the lateral hydrofoil assemblies is secured to its pontoon hull at three points.

4. A trimaran according to any one of the preceding claims, wherein the bow hydrofoil is retractable to a position above the displacement water line.

5. A trimaran according to Claim 3 or Claim 4 when dependent on Claim 3, wherein the lateral hydrofoil assemblies are attached to the pontoon hulls so that they can pivot about an axis extending generally fore and aft through two of the points, and each assembly is retractable by movement about this axis upon disconnecting the assembly from its third point of securement.

6. A trimaran according to any one of the preceding

claims, wherein the foil blades are of a NACA 16-510 section.

7. A trimaran according to Claim 2, or any one of Claims 3 to 6 when dependent on Claim 2, in which the stern hydrofoil assembly comprises a rectangular frame having transverse members pivoted centrally on a substantially vertical axis in gudgeons on the stern of the central hull, and having spaced side members extending substantially vertically, a pair of rudder blades, each having a relatively horizontal pivotal connection to the frame side members at each side of the frame, and each blade having a first rudder blade portion for displacement sailing extending on one side of the horizontal pivotal connection a sufficient distance to act as rudder blades when extending downwardly from the horizontal pivotal connection and into the water, and a second rudder blade portion extending from the other side of the horizontal pivotal connection a greater distance than the first rudder blade portions, a transverse hydrofoil blade connecting the second rudder blade portions, and means for locking the blades to the frame with the first rudder blade portions or the second rudder blade portions and the hydrofoil blade, extending into the water.

8. A trimaran according to Claim 1, substantially as described with reference to the accompany drawings.

9. A trimaran as set forth in claim 1 wherein the lateral hydrofoil units and the foils thereof are provided with sweep in the order of 10 to 15 degrees directed aft as the foils come up to emerge through the water's surface.

10. A trimaran as set forth in claim 1 wherein the lifting surfaces of the bow hydrofoil truss structure have sweep in the order of 10 to 15 degrees directed aft as the lifting surfaces come up to emerge through the water's surface.

11. A trimaran as set forth in claim 1 wherein the lateral hydrofoil units and the foils thereof, and the lifting surfaces of the bow hydrofoil truss structure have sweep in the order of 10 to 15 degrees directed aft as the foils and lifting surfaces come up to emerge through the water's surface.

DATED this SECOND day of JULY, 1975

DAVID ALLEN KEIPER

Patent Attorneys for the Applicant
SPRUSON & FERGUSON

464259

FIG.1.

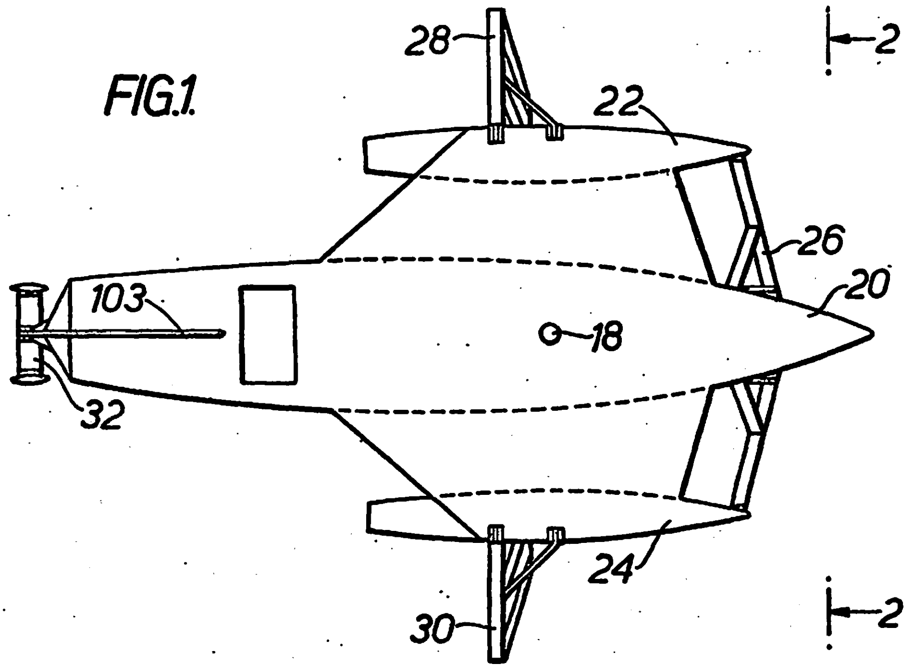
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FIG.2.

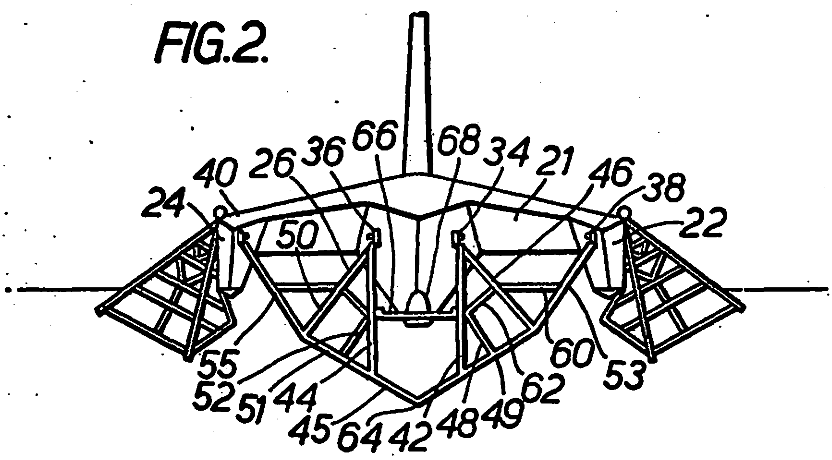
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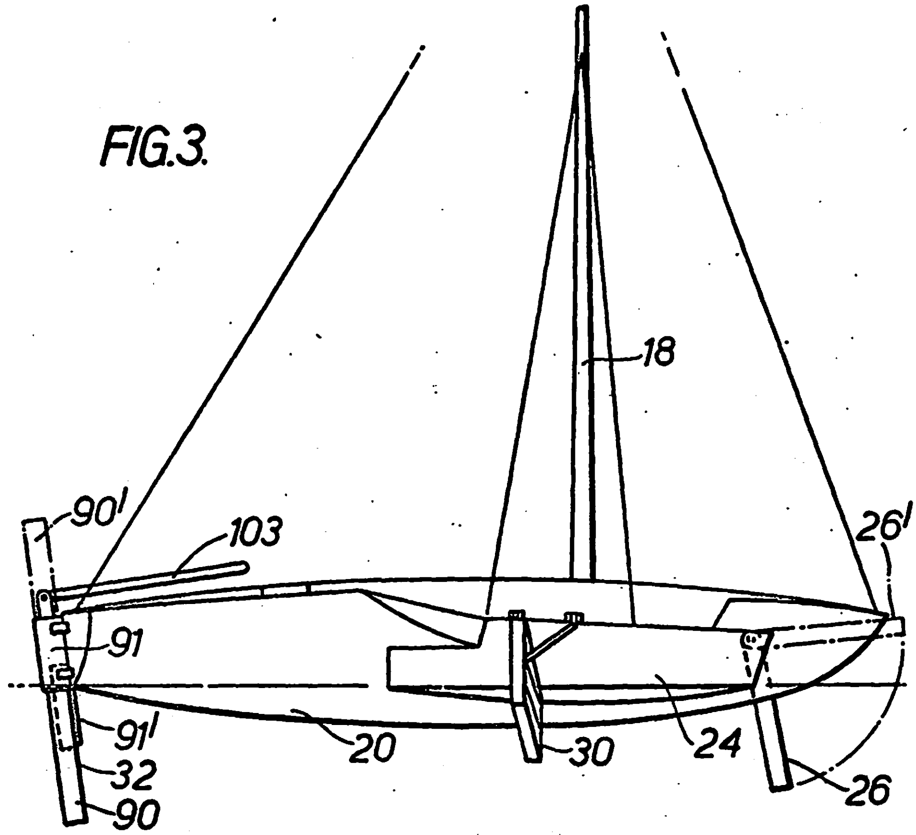
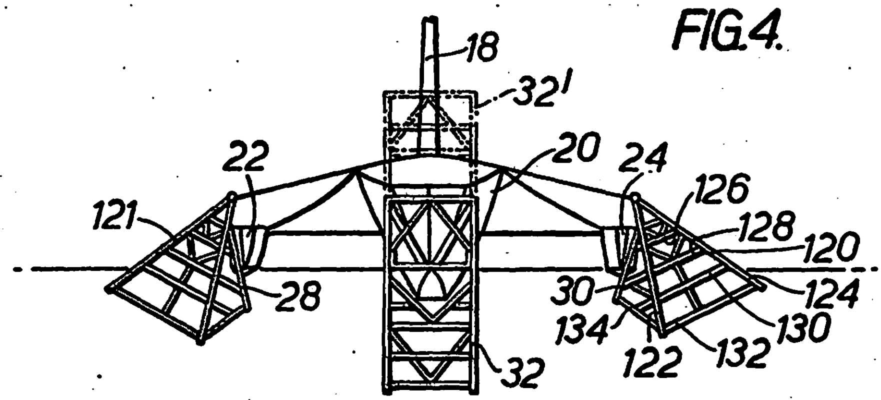
FIG.3.



90'
103
18
26'
91
91'
32
90
20
30
24
26

FIG.4.



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126
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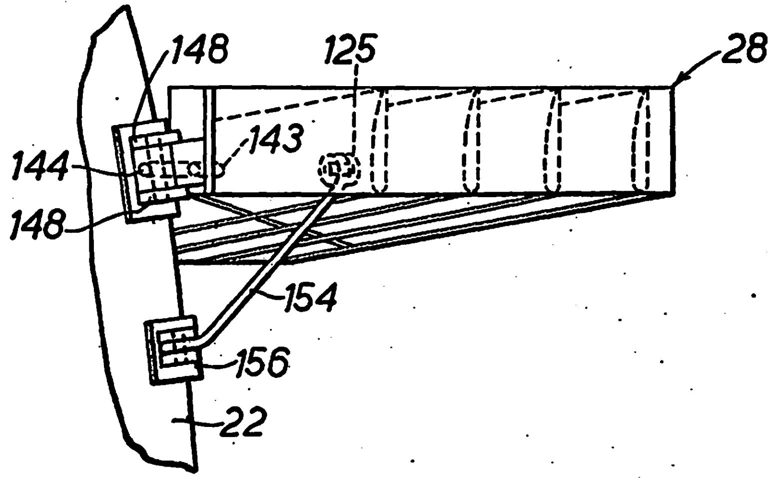
148
125
28
143
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148
154
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22

FIG.6.

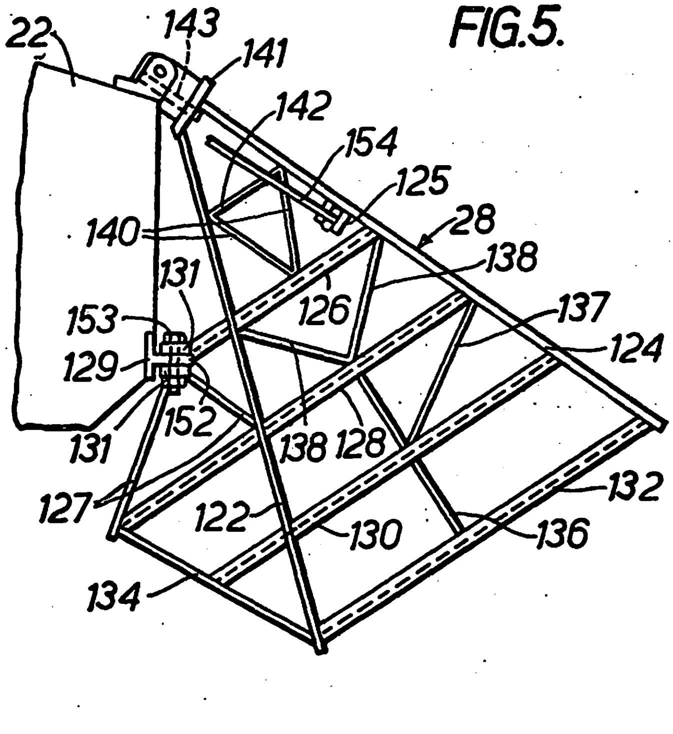
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FIG.5.

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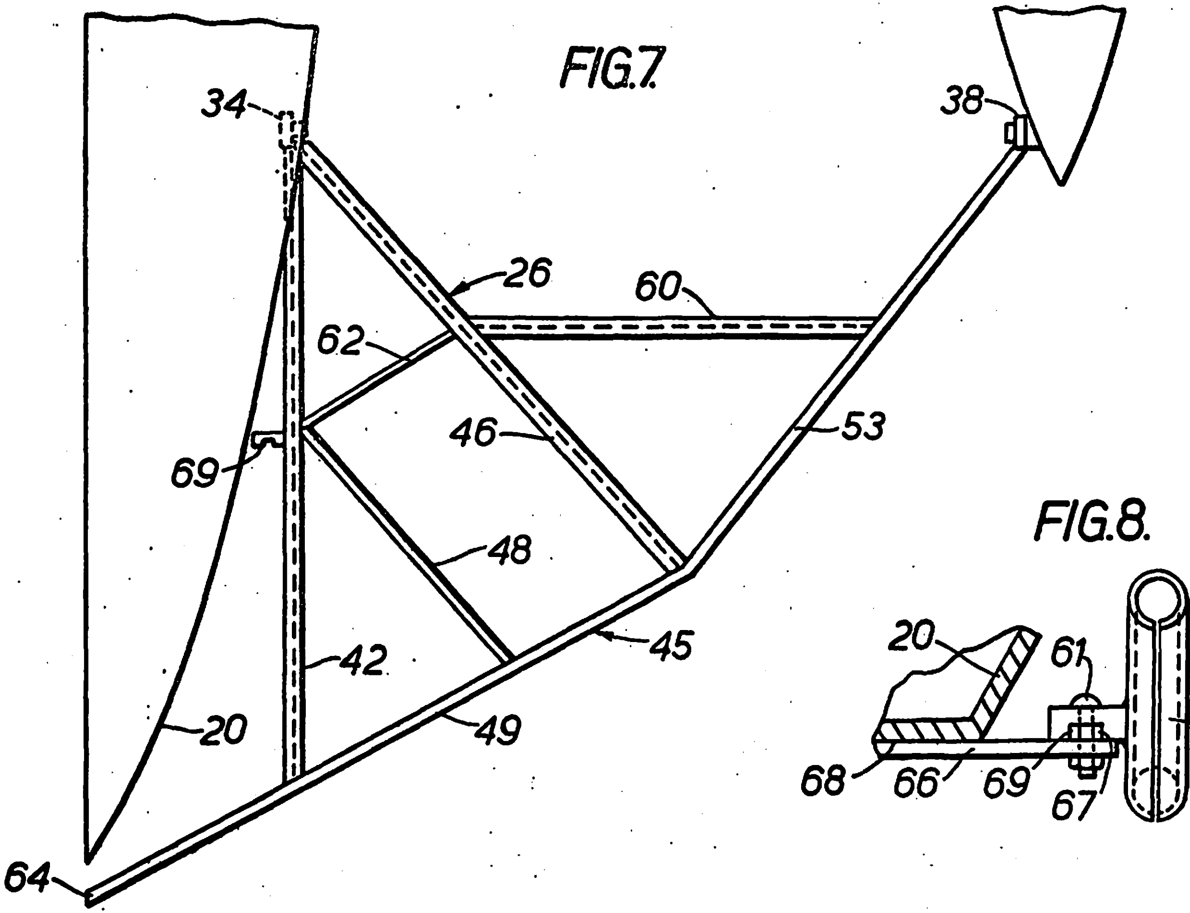
FIG.7.

FIG.8.



14.7.41 70

FIG.9.

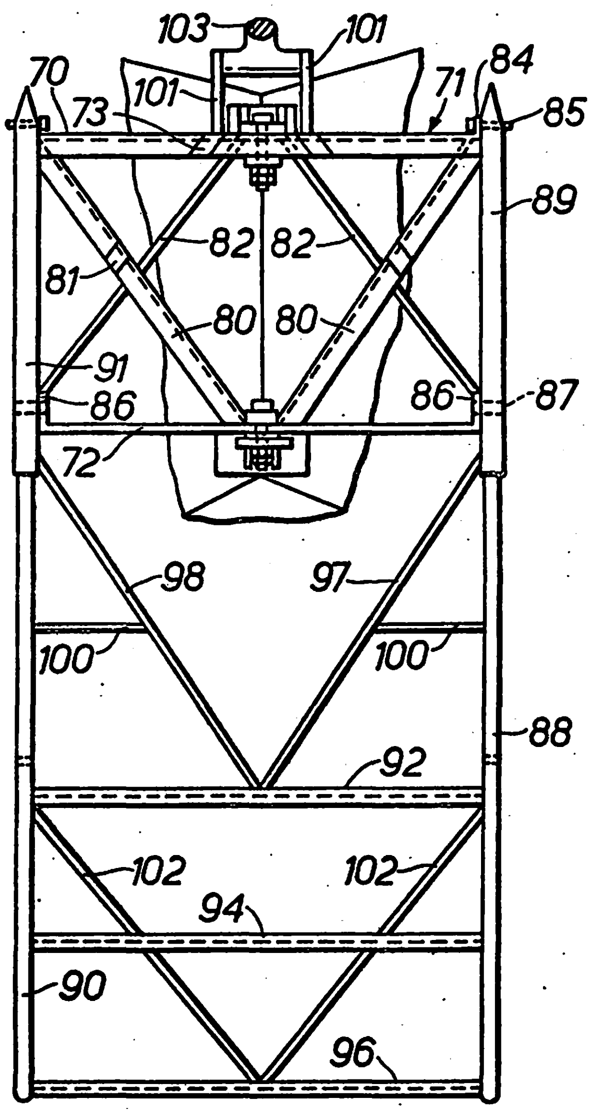
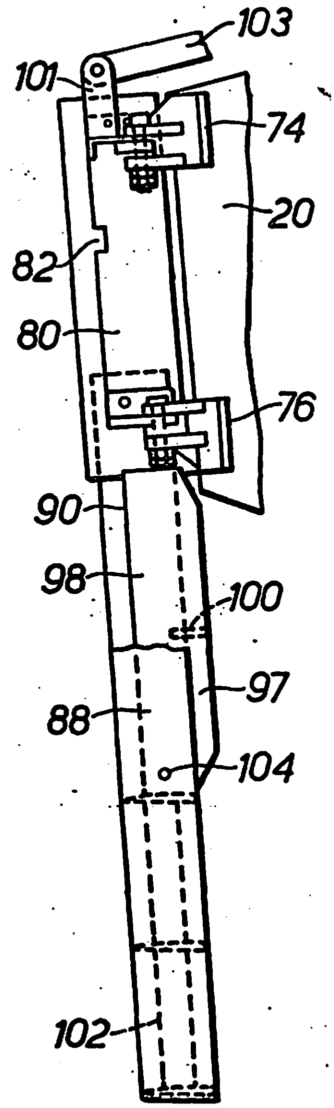


FIG.10.



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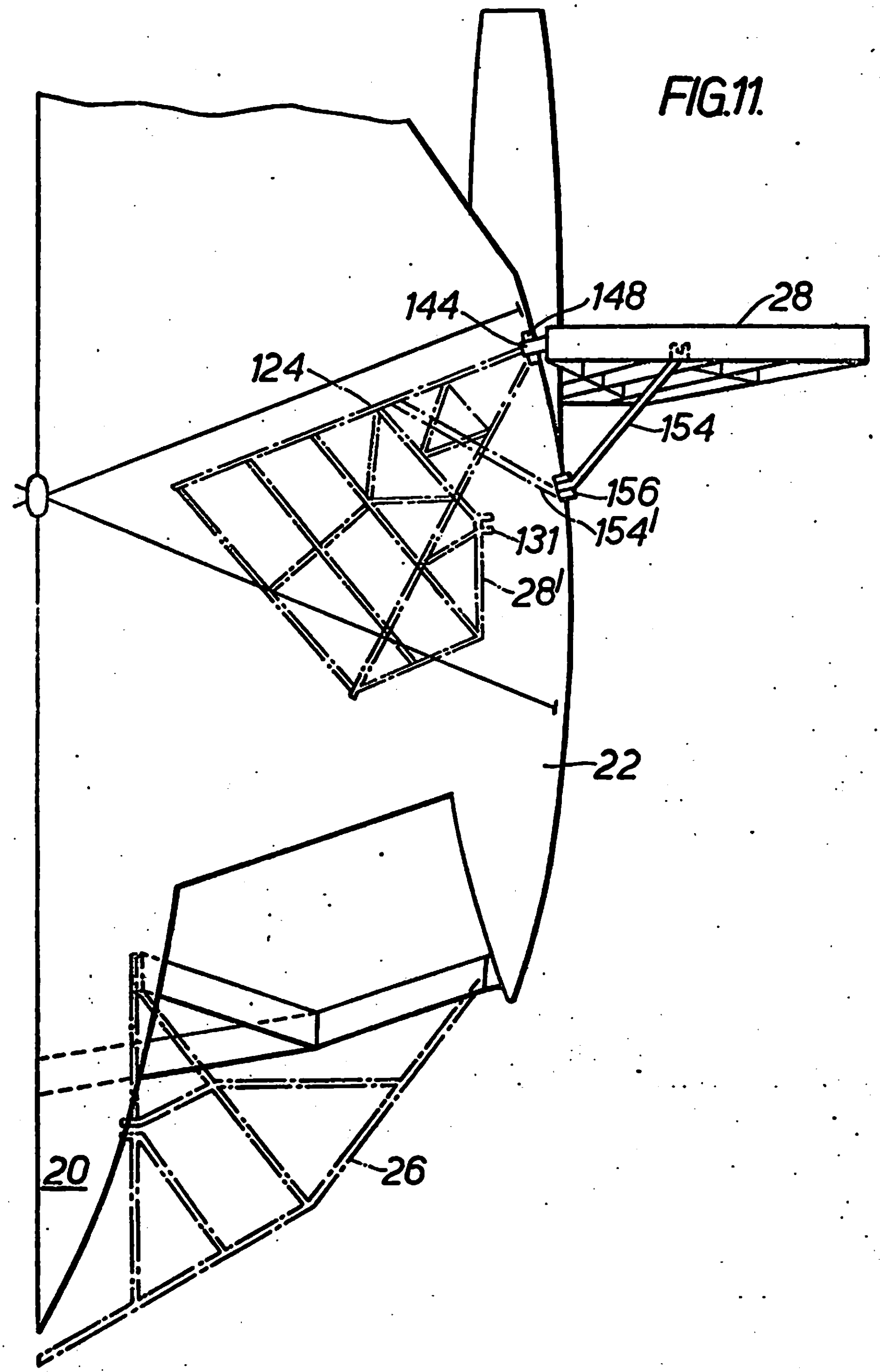

FIG.11.

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