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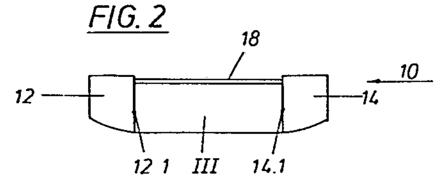
(54) **Catamaran type boat.**

(57) A boat has two hulls (12,14) defining a tunnel between them. The tunnel is defined by substantially straight side walls (12.1, 14.1) of the hulls at least below the water line. Below the water line this tunnel is bridged by at least one hydrofoil section.

FIG. 2



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BACKGROUND OF THE INVENTION

The present invention relates to boats.

More particularly, the invention relates to multihull boats and particularly to catamaran boats with double hulls.

One known type of catamaran boat (which may be an asymmetric planing catamaran boat or displacement or semi-planing catamaran boat) is constructed in such a manner that the tunnel between the two hulls is straight or nearly straight and that the top of the tunnel is relatively free from touch with water. The water passing through the tunnel is restricted minimally, or not at all, and the bottom planing areas of the hulls are horizontal or inclined slightly or strongly sideways outwardly. Thereby, the waterflow of the induced velocities, which create the dynamic lift, are not thrown into the tunnel, which otherwise would let the water rise and create more resistance of the boat hulls and affect its seakeeping quality. The resistance of the boat hulls provides a restriction on the possibility to achieve relatively high speeds with catamaran boats, except if excessive propulsion power and resulting uneconomically high fuel consumption is accepted.

It is an object of the invention to provide an improvement to catamaran hull boats, which will assist in increasing high speed characteristics.

SUMMARY OF THE INVENTION

According to the invention, a catamaran type boat has two hulls, each hull having a side wall facing towards a corresponding side wall of the other hull, the two hulls defining a gap in the form of a tunnel between them. At least one hydrofoil section is provided between the two hulls and extends between them across at least part of said tunnel, the tunnel being defined by substantially straight side walls of the hulls at least below the water line. Attachment means are provided for attaching the hydrofoil section to the hulls in a position below the water line of the hulls. Under the expression "hydrofoil" a wing-like transverse shape is to be understood.

The hydrofoil sections may be in the form of sub-cavitating or super-cavitating sections. The hulls may be in the form of complementary demi-hulls. The hydrofoil section or sections may be continuous and may extend across the full width of the tunnel. The hydrofoil section or sections may be straight, or curved or bent forwardly, or curved or bent rearwardly, or curved or bent upwardly, or curved or bent downwardly. The hydrofoil section or sections may be located near the keel of the hulls or demi-hulls. A number of hydrofoil sections may be provided, and in such a case the hydrofoil sections may be substantially similar, and substantially parallel to each other. The hydrofoil section or sections may be provided near the longitudinal centre of gravity of the two hulls. The hulls may be stepped to reduce skin friction. The steps may be provided on the underside of the hulls extending upwardly. The hydrofoil section or sections may be provided on the bow side of the step.

As the catamaran boat in accordance with the invention moves forward, hydrodynamic forces are produced to give lift. Initially the boat will operate mainly as a normal displacement vessel, but as the speed increases, the lift on the hydrofoil section or sections increases so as to lift the boat thereby decreasing the water resistance.

Further aspects and details of the invention will now be described by way of example with reference to the accompanying schematic drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings there is shown in

Figure 1 a side view of a catamaran boat with two spaced asymmetrical hulls in accordance with the invention;

Figure 2 a front view of the boat seen along arrow II in Fig. 1;

Figure 3a a sectional side view, on a larger scale, of a first embodiment of a hydrofoil section provided on the boat of Figures 1 and 2 and as seen along arrow III-III in Fig. 2;

Figure 3b a sectional side view, corresponding to Fig. 3a but showing a second embodiment of a hydrofoil section;

Figure 4 to 6 on a smaller scale, a plan view showing three different layouts of the hydrofoil section or sections;

Figure 7 to 11 also on a smaller scale, showing a front view of boats with four different forms of the hydrofoil section or sections in accordance with the invention;

Figure 12 on a smaller scale, a plan view of a boat with special hull formations in accordance with the invention;

Figure 13 on a smaller scale, a front view of a catamaran boat shape, which is preferred in one example in accordance with the invention;

Figure 14 a side view of a catamaran boat with a step and seen along arrows XIV-XIV in Fig. 15; and

Figure 15 a view from below of the boat seen along arrow XV in Fig. 14.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring in general to the various drawings it will be noted that the boat hulls are in the form of asymmetrical demi -hulls having a flat longitudinal face facing towards each other and defining a gap or tunnel between them. (A demi-hull could be considered as part of a usual deep-V-planing craft split along the middle length plane and set aside to create the straight tunnel.)

Referring in particular to Figs. 1 and 2, the catamaran boat 10 includes two boat hulls 12 and 14 separated by means of a tunnel 16. The hulls 12 and 14 are joined together by means of joining members or struts 18 in the normal manner. The hulls 12, 14 have straight faces 12.1 and 14.1 facing towards each other.

Between the hulls 12 and 14 a hydrofoil section 20 is provided. Two types of hydrofoil cross-sections are shown on a larger scale respectively in Figs. 3a and 3b.

Figure 3a shows a sub-cavitating section 20.1 and Figure 3b a super-cavitating section 20.2.

For high speed boats, say over 36 knots (especially for 60 knots and more), the hydrofoil has the profile section 20.2 of a supercavitating foil or a superventilated foil with sharp leading edge 20.3 and blunt trailing edge 20.4 - as used on propeller constructions (see Fig. 3a). At such high speeds the usual subcavitating foil (20.1 of Fig. 3a) cannot operate efficiently and cavitation would occur resulting in efficiency loss and cavitation damage to the foil and near-hull regions. Super cavitating foils and superventilated foils, because of the proximity to the water surface, can also achieve good lift-drag ratios and do not suffer cavitation damage or efficiency drops. If a superventilated foil is applied, the entry of air to the low pressure region must be ensured. This is possible, e. g. by introducing a vertical step in the hulls near the foil attachments (see Figs. 14 and 15), or, by a swept foil with dihedral, which approaches the water level near the fixing points, or by other known ways of easing ventilation of the foil and/or eventually by forced ventilation by pumping air or gases (exhaust) to the foil low pressure field regions.

In Figs. 4 to 6 different layouts of the hydrofoil sections on boats are given.

In the case of Fig. 4 the boat 10.1 is provided with a horizontally extending V-shaped hydrofoil section 20.5 pointing forwardly. In the case Fig. 5 the boat 10.2 has a correspondingly formed hydrofoil section 20.6 pointing rearwardly.

In Fig. 6 the boat 10.3 has a number of hydrofoil sections 20.7, 20.8 and 20.9 which are parallel to each other.

In Figs. 7 to 11 different shapes of the hydrofoil sections as seen horizontally are illustrated.

In Fig. 7 the boat 10.4 has a hydrofoil section 20.10 which is straight, and in Fig. 8 the boat 10.5 has a hydrofoil section 20.11 which is curved downwardly, whereas in Fig. 9 the boat 10.6 has a hydrofoil section 20.12 curved upwardly.

In Fig. 10 the boat 10.7 has a hydrofoil section 20.13 which is V-shaped with the apex pointing upwardly, and in Fig. 11 the boat 10.8 has a V-shaped section 20.14 with the apex pointing downwardly.

The boat 10.9 of Fig. 12 has two hulls 12.2, 14.2 provided with a hydrofoil section 20.15 inbetween. The hulls 12.2, 14.2 are respectively provided with steps 22, 24 seen in plan view and being behind the hydrofoil section 20.15.

The boat 10.10 of Fig. 13 has two boat hulls 12.3, 14.3 which are shaped to form a U-shaped form. The lower surfaces 26, 28 are inclined slightly to the horizontal. The hydrofoil 20.16 is provided at the bottom ends of the hulls 12.3, 14.3 as indicated.

The hydrofoil section in accordance with the invention provides an induced velocity on the water streaming through the tunnel and creates a lift force which "unloads" the rest of the boat. As the lift creating efficiency of a hydrofoil is considerably higher than that of a planing hull (or a catamaran planing hull) the allover resistance of a boat fitted with a hydrofoil section in accordance with the invention can be reduced considerably. The effect is improved when more lift is created by the hydrofoil. However, the hydrofoil does not contribute as such to the longitudinal or transverse stability, as this is done by the remaining load on the boat hulls. This means that only part of the load can be taken up by the hydrofoil, and the extent of which depends on stability parameters of the catamaran boat and the desired seakeeping and manoeuvrability of the boat.

In theoretical terms, when 50% of the load is carried by the hydrofoil, the resistance coefficient $\varepsilon = R_t/\Delta$, with R_t = total resistance, Δ = displacement mass, becomes

$$\varepsilon_{total} = \frac{\varepsilon_{boat} + \varepsilon_{hydrofoil}}{2}$$

which would have values for the example of a 10m, 40 knots boat of about

$$\varepsilon_{total} = \frac{0,3 + 0,08}{2}$$

$$= 0,19$$

(as compared to 0,30 without hydrofoil)

This means that the resistance coefficient of the boat is reduced from 0,3 to 0,19 because of the action of the hydrofoil. The effect is higher when the load on the hydrofoil is increased. From a practical point of view the optimum weight distribution has to be determined in each individual case.

Surprisingly, tank tests have shown that the boats total resistance within the interesting region of higher Froudenumbers is at least equal to the total resistance of a standard hydrofoil craft and contrary to hydrofoil crafts remains practically constant over a broad range of velocities. Thus, the advantages of hydrofoil crafts are retained without retaining their disadvantages.

The hydrofoil should be positioned longitudinally at a position where its resistant force does not create an undesirable trim moment and such that there is no undesired interference between the hydrofoil and the boat hulls. The resultant lift forces must attach somewhere near the centre of gravity of the boat and here again it depends on the boat's trim characteristic if the centre of pressure of the hydrofoil is slightly in front or behind the centre of gravity of the boat. If the boat is designed principally on a deep V-hull characteristic and is intended to run at relatively high speeds, it may be better to put the centre of pressure slightly in front of the centre of gravity of the boat so as to reach the desired higher trim angles at high speed. If, however, the trim angle will become too high, the danger of porpoising exists.

If the demihulls of the catamaran are built corresponding to deep-V-planing boat characteristics then a good foil arrangement with further advantage can be achieved if the resultant lift force of the foil (or foils) is slightly behind the longitudinal centre of gravity LCG (say 2% to 5% but depending on the trim characteristics of the special hulls used) in order to achieve a nose-down trim moment of the foil against the hulls. This offers the advantage that the boat with foil does not take up the excessive high trim angles when running at speeds near the so-called "hump-resistance" which is considerably reduced by the trim action of the foil. This allows much more economical cruising speeds (reduced speeds) and an extended range of the boat. At high speeds this foil arrangement prevents excessive high trim angles which would lead to porpoising. If the foil is shifted too far to the stern, so that the resultant lift attacks too far behind the longitudinal centre of gravity, the boat takes up excessive nose-down trim at speed which again increases the resistance. There exists an optimal position for the resultant lift force towards the LCG which depends on hull and foil trim-interaction and is best found in model tests.

The best efficiency should be achieved by means of only one hydrofoil, but if the tunnel is too narrow to allow an optimum foil to be fitted, a multiple of foils may be used (see Fig. 6). However, it must be borne in mind that the seakeeping behaviour of the hulls will be influenced by the hydrofoils.

The proposed catamaran boat with hydrofoil support will be sensitive to deviations from the proper trim at speed and with a single foil arrangement the longitudinal centre of gravity always has to be near to its best position, which is often not easy to achieve under varying service and load conditions. Therefore it is advantageous if a trim steering device is available. This could be done by a much smaller pilot foil, acting like a horizontal rudder and being installed near the stern of the demi-hull (or demi-hulls), preferably on the inside of the vertical tunnel. It can be a foil spanning the whole tunnel width or one or two sub-foils only, attached to the demi-hulls. If more than one main foil is used, one foil can have an adjustable angle of attack, preferable the one furthest away from the longitudinal centre of gravity LCG.

A further possibility of trim adjustment is by using propulsion systems with so-called "power-trim" wherein the propeller can be steered to act partly upwardly or downwardly and thus creating desired trim forces.

A straight foil, seen from the front (Fig. 2, Fig. 7), should provide the best efficiency. The dynamic forces created if entering a wave or breaking through the surface in a wave and re-entering the water again, in which cases often very high incidence angles are created on the foil, can become excessively high and lead to destruction of the hydrofoil and the boat. Furthermore, the angle of attack in rough seas varies continuously around the designed value and can lead to early onset of cavitation, or in turn to compensate for this a large foil area and small optimum incidence angles have to be provided in the design, which will reduce the efficiency of the hydrofoil. Accordingly, to solve this problem, a hydrofoil with a sweep back angle (Figs. 4, 6) is provided. This prevents abrupt impact forces in extremely rough seas and reduces the danger of any early onset of cavitation due to the fluctuating incidence angles of the hydrofoils in rough seas. It further allows floating objects to be hit at lower impact forces and to bring them to the boat centre, out of the reach of the propellers behind the hulls. If floating objects are frequently encountered, the hydrofoil could be split in the longitudinal centre of the boat to allow passage but this would reduce the hydrofoil efficiency. Thus, a number of hydrofoils can be provided spaced along the hulls, and these can be adjustable and retractable as required.

The sweep back foil has the further advantage to increase dynamical trim stability of the boat and to reduce the vehement trim motions of the boat in heavy seas and provide a more steady run and to reduce the dipping in of the boat in the trough of a following sea wave due to orbital motions in the wave. Thus the foil can provide a dampening of vertical and trim accelerations.

The angle of attack of the hydrofoil at running conditions should be near the optimum value of the chosen hydrofoil, but it is influenced by the boat's trim angle. In other words, both have to be adapted to each other to achieve a good result. A wrongly fitted hydrofoil can increase the resistance and eventually reduce resistance in smooth water runs but increase it in rough water runs.

The hydrofoil attachment construction may be adjustable and steerable so as to vary the indidence angle or its positioning in the longitudinal direction relative to the boat hulls in order to trim the boat to best conditions and lowest resistance for various service conditions.

A further suggestion for reducing the resistance is to reduce the area in the tunnel by a stepwise cut back in the hulls in places near to the stern (Fig. 12). There could be a multiple of steps 22, 24 in this manner. These steps are provided for inducing air behind the steps so as to reduce friction.

The hydrofoil should be fitted as deep as possible to allow sufficient water flow over it. However, when the hydrofoil is used partly for transverse stabilization, it could be deeper in the longitudinal centre of the boat and rise near to the water level at the tunnel sides (see Fig. 11). If the boat would incline transversely air would break in and reduce the lift creation on the higher side and a stabilization moment would be created which tends to return the boat to the horizontal position. This effect could be made stronger if the hydrofoil is fitted to the catamaran hulls just underneath of one of the cut-backs to reduce the area, which is in touch with water, as the air would break in easier into the low pressure field over the hydrofoil.

To reduce the danger of broaching, the catamaran hull should not have very high dead rise angles in the fore-ship but it should be built rather similarly to a modern deep V-delta hull or even have a bottom plate on the inner side near the tunnel with reduced dead rise angle as a strip over the whole length of the tapered foreward at the stern (see Fig. 13).

For boats operating mostly at relatively high speeds the planing bottom of the demi-hulls can additionally also be stepped, as is known from "stepped monohulls", in order to reduce skin friction resistance. Entry of air at speed to the steps has to be assured by known methods including eventual forced ventilation.

Figures 14 and 15 show a boat having hulls 30, 32 having a foil 34 between them and, just behind, where it joins the hulls, steps 36, 38 in the boat hulls 30, 32 respectively. The ventilated bottom areas are indicated by reference numerals 40, 42. Water contact areas 44, 46 and 48, 58 are as indicated. The boat hulls 30, 32 are joined by means of cross supports.

The stern step areas 46, 50 in touch with water at speed determines mainly the trim of the boat and is vertical positioning and angle towards the inflow are of importance. In different speed ranges and different wave conditions different vertical positionings and angles are optimal and it is of advantage to install the stern step areas 46, 50 so that their position vertically and their angle to the inflow can be altered or steered to reach any desired trim as it is known for monohulls already. This arrangement can be used as a trim steering device to allow the operator to bring the boat into the optimal trim position at any possible service condition.

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BREMEN

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DR RER NAT HORST ZINNGREBE
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0051073

UNS. ZEICHEN: A 400

ANMELDER/INH: Abeking & Rasmussen

AKTENZEICHEN: New Patent Application

DATUM: October 22, 1980

Abeking & Rasmussen, Schiffs- und Yachtwerft (GmbH & Co.), An der Fähre 2, D-2874 Lemwerder

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Catamaran Type Boat

C l a i m s

1. A catamaran type boat having two hulls, each hull having a side wall facing towards a corresponding side wall of the other hull, the two hulls defining a gap in the form of a tunnel between them, characterized in that at least one hydrofoil section (20) is provided between the two hulls (12, 14) and extends between them across at least part of said tunnel, the tunnel being defined by substantially straight side walls of the hulls at least below the water line, and further characterized in the provision of attachment means for attaching the hydrofoil section to the hulls in a position below the water line of the hulls.

2. A boat as claimed in claim 1, characterized in that said hulls have an asymmetrical form and a common plane of symmetry between them.

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3. A boat as claimed in claim 1 or 2, characterized in that the ceiling of the tunnel is partly or fully submerged when floating at rest and is free of water contact at speed.

4. A boat with two hulls as claimed in claims 1 - 3, in which the hulls are in the form of complementary demi-hulls.

5. A boat as claimed in claims 1 - 4, in which the hydrofoil section is located near the keel of the hulls.

6. A boat as claimed in claims 1 - 5, in which the hydrofoil section is continous and extends across the full width of the tunnel.

7. A boat as claimed in claims 1 - 6, in which the hydrofoil section is curved forwardly.

8. A boat as claimed in claims 1 - 7, in which the hydrofoil section is curved rearwardly.

9. A boat as claimed in claims 1 - 8, in which a number of hydrofoil sections are provided.

10. A boat as claimed in claim 9, in which the hydrofoil sections are substantially parallel to each other.

11. A boat as claimed in claims 1 - 10, in which the hulls are stepped to reduce skin friction.

12. A boat as claimed in claims 1 - 11, in which the hydrofoil section is a subcavitating profile section.

13. A boat as claimed in claims 1 - 11, in which the hydrofoil section is a supercavitating profile section.

14. A boat as claimed in claim 9 or 10, characterized in that the hydrofoil sections are arranged above each other.

15. A boat as claimed in claims 9 or 10, characterized in that the hydrofoil sections are stacked along the length of the tunnel.

16. A boat as claimed in any of claims 1 - 15, characterized by means for adjusting the angle of attack of at least part of at least one hydrofoil section.

17. A boat as claimed in any of claims 1 - 16, characterized in that the hydrofoil section or sections are provided near the longitudinal center of gravity of the hulls.

18. A boat as claimed in claim 11, characterized in that said steps are provided on the under side of the hulls extending upwardly.

19. A boat as claimed in claim 11 or 18, characterized in that the hydrofoil section or sections are provided on the bow side of the steps.

FIG. 1

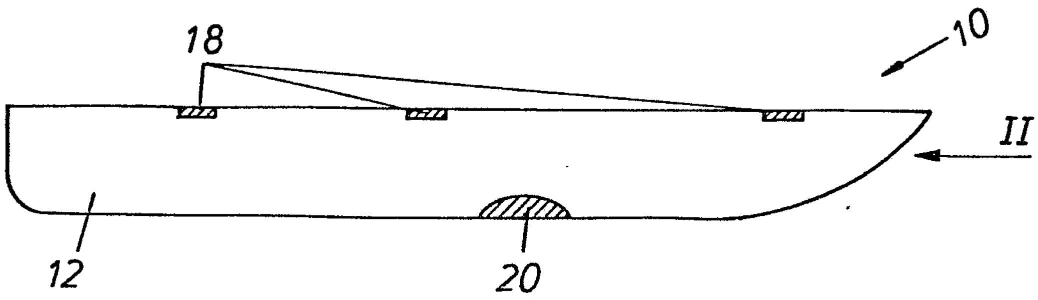


FIG. 2

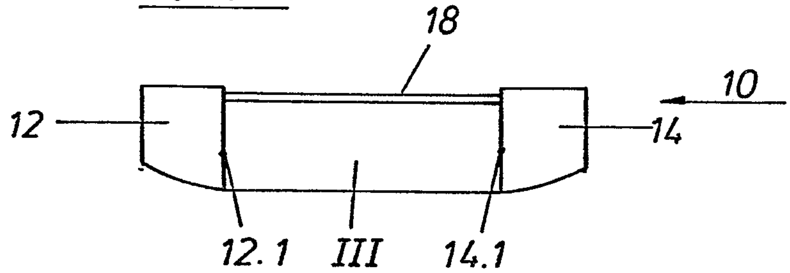


FIG. 3a

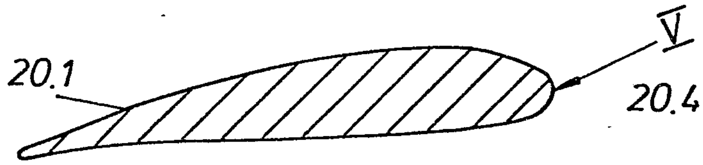


FIG. 3b

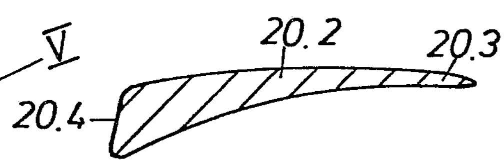


FIG. 4

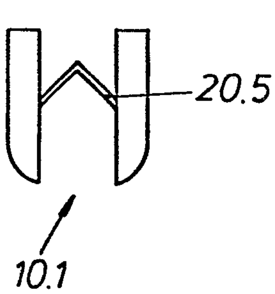


FIG. 5

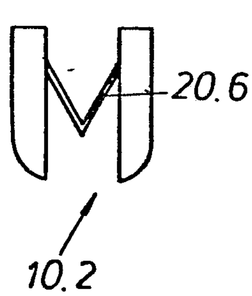


FIG. 6

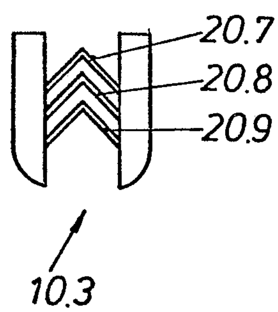


FIG. 7

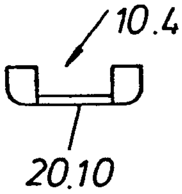


FIG. 8

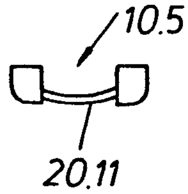


FIG. 9

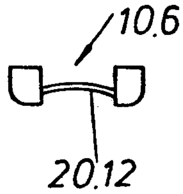


FIG. 10

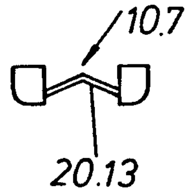


FIG. 11

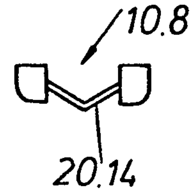


FIG. 12

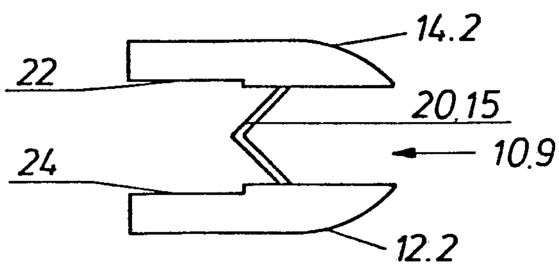


FIG. 13

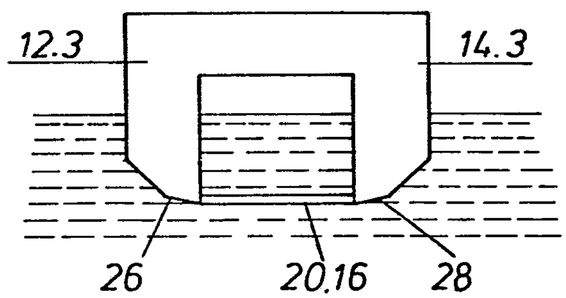


FIG. 14

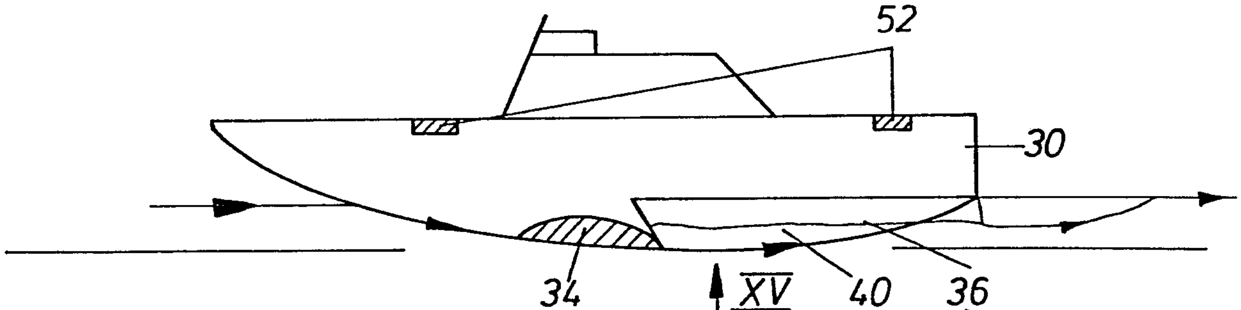
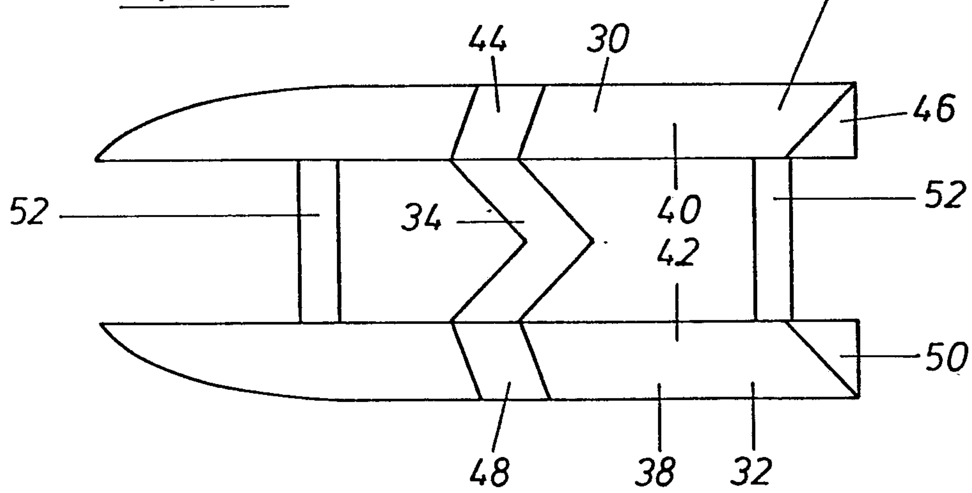


FIG. 15



European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 80 10 6535

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
X	US - A - 3 179 077 (WAI PO LOO) * Column 2, figures 1-9 * --	1,2,4, 6,9,10
X	GB - A - 1 524 938 (CANTIERE NAVAL-TECNICA S.P.A.) * Page 2, lines 31-55, 114-124; figures 1,2,4 * --	1,2,4, 6,9,10, 16,17
X	CH - A - 605 244 (SUPRAMAR) * Column 4, lines 8-68; column 5, lines 1-14; figures 1-5 * --	1,2,3, 5,6,11, 16,18, 19
	DE - A - 1 531 592 (H. NAUDITT) * Pages 4-8; figures 1-4 * --	5,6,7, 9
	US - A - 3 044 432 (G.J. WENNAGEL et al.) * Column 2, figures 1-6 * --	12,13
	US - A - 3 995 575 (A. JONES JR.) * Column 8, line 63-68; column 9, column 10, lines 1-4; figures 17 and 18 * ----	14,15

CLASSIFICATION OF THE APPLICATION (Int Cl.³)

B 63 B 1/24
1/12

TECHNICAL FIELDS SEARCHED (Int Cl.³)

B 63 B

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	29-06-1981	PRUSSEN