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(54) Title: BOAT HULL

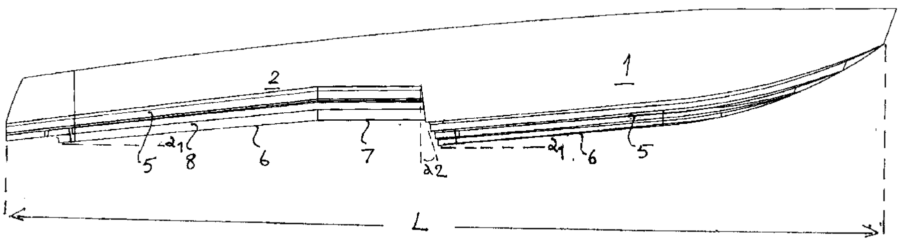

FIG. 1

(57) Abstract: An airless, stepped hydroplaning boat hull has one mid ship step. Two separated wetted planing surfaces are thereby established - a forward surface just forward of the step and an aft surface just forward of an aft edge of the hull. The angles of attack of each planing surface is 2.5 to 4.5 degrees, and are equal. The midship step is located longitudinally 0.55 to 0.65 times the projected water line length of the hull, measured aftward from a aftmost edge of an aft planing surface. The stepped surface has at least three levels of horizontal lifting strakes longitudinally measured from a forwardmost point to aft.

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TITLE OF INVENTION

Boat hull

DESCRIPTION

Adapting this technology to the bottom of non-ventilated stepped hull vessel, which as the vessel is driven forward, will have the effect of lifting it in the water into and in a planing stage. Then the surface tension reduces the draught and therefore in addition the drag.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to hydroplaning non-ventilated stepped hulls for high-speed multipurpose vessels, eg. SROV, Surveying and Rescue Operational Vessels.

2. Description of the Related Art

There has been almost no improvement in planing boat hulls since early 1900. In 1911 the first stepped hull was manufactured in Sweden and before that the multi-hull. In 1920 the V-shaped hull was designed. In 1962 the first 24 degrees V-shaped hull appeared and soon after that the lifting strakes were designed.

Most of the motor powered speed boat designers have increased horsepower instead of improving the hull. Another aspect is that these designers have increased the mass as well, which has resulted in too heavy boats. All together a standard boat of today has no fuel economy at all, as well as the performance and balance have been lost

.

Excluded inertia, three primary forces work against increased speed for boats, namely, the boats mass, the resistance of the water (hydrodynamic drag) on the wetted surface of the hull and the resistance of the air (aerodynamic drag) against the above-water structure of the boat.

Aerodynamic drag affect the performance above 35 knots, but hydrodynamic drag and boat mass affect the performance at all times and can be reduced not only by better streamlining the hull to minimize areas of turbulence and thus wasted energy, but also by reducing the wetted surface area of the hull as well as reducing the weight. Stepped hulls will reduce the drag, as will hydrofoils mounted on the hull, which reduce the drag but only at planing conditions.

Examples of such stepped hulls are disclosed in the following references:
U.S. Pat. No. 1,121,006 (Fauber, Dec. 15, 1914);
U.S. Pat. No. 4,655,157 (Sapp, Apr. 7, 1987);
U.S. Pat. No. 4,231,314 (Peters, Nov. 4, 1980);
U.S. Pat. No. 4,027,613 (Wollard, Jun. 7, 1977);
U.S. Pat. No. 5,191,853 (Adler, Mar. 9, 1993);
U.S Pat. No. 6,666,160 (Örneblad, Dec. 23, 2003);
U.S. Pat. No. 5,456,202 (Schoell, Oct. 10, 1995)
DE 60 2004 009467 T4 (Chantiers Beneteau S.A., Oct. 10, 2007) and
U.S. Pat Appl 2005160960 (Batista et al, publ.date July 28, 2005)

The closest prior art is US 6,666,160, which shows a non-ventilated stepped hull having a front part with a first deadrise of 20 degrees, and a second deadrise of 16 degrees, i.e., a twisted front part, and having a aft part with a first deadrise of 20 degrees and a second deadrise of 16 degrees, i.e., a twisted aft part. This hull does not perform well at planing speed but will twist heavily in the water.

Another problem with stepped hulls is that they often create a vacuum behind the step. This vacuum increase drag and reduce efficiency. One common way to overcome this problem is to build steps that direct air into the region behind the step. These hulls are referred to as "ventilated" or "aerated" hulls, but then the hull sinks further down in water at planing speed.

U.S. Pat. No. 5,456,202, DE 60 2004 009467 T4, and U.S. Pat Appl 2005160960, all disclose ventilated hulls with different techniques for forcing air in beneath different parts of the respective hull constructions.

Catamaran-hulls will normally reduce the drag; they have better streamlining of the hull and therefore have reduced the wetted surface area.

What is always desired and always required is a boat hull that reduces the wetted surface area when the speed increases over the planing threshold. This will allow for a boat with high stability at low or no speed as well as at high speed both on aft and forward deck. It will also increase speed to a great deal using a similar engine and reduce fuel consumption compared to a standard hull.

This invention provides such a boat hull. In particular the hydrodynamic drag has been considerably reduced and it has turned out that the energy consumption, i.e., the gasoline or diesel consumption has been highly reduced. In comparison with standard hulls, which have almost exponential fuel consumption at higher speeds, the present hull provides for a more flattened energy consumption curve, i.e., the fuel consumption is only minimally increased from low speed to high speed.

SUMMARY OF THE INVENTION

The invention provides an unventilated hydroplaning V24 boat hull that has: a forward portion; an aft portion; one midship step separating the forward and aft portions; a forward planing surface that extends transversely immediately forward of the midship step and has a forward angle α1 of attack being 2.5-4.0 degrees; and an aft planing surface portion that extends transversely and forward of an aft edge of the hull and has an aft angle α1 of attack being 2.5-4.0 degrees. The forward and aft angles α1 of attack is 2.5-4.0 degrees, and when the hull is moving at least at a minimum planing speed, the forward and aft planing surfaces constitute two separated wetted surfaces.

The interval of angles α1 of attack depends of the intended working speed of the boat, the faster the lower angle α1 of attack.

Moreover, each planing surface has a deadrise of 24 degrees. Both the aft and forward portions have the same deadrise angle at the keel line leading edge forward.

The longitudinal location of the midship step also affects performance. In the preferred embodiment of the invention, given a projected length L, the midship step is preferably located longitudinally at 0.55-0.65 times L, measured forward from a forward-most point of the aft/transom. L is the length of the hull excluding any protruding constructions at the stem, or at the aft, such as a bow sprit.

An important aspect is to provide enough planing surface area compared to the mass of the vessel. One square decimeter at an attack angle of 4.0 degrees has a lifting capacity of 40 kg at 40 knots and 2.5 degrees 20 kg at 40 knots. Therefore a manufacture technology that enhances light hull weight vessels combined with supportive internal bottom stringers that lead out all tensions directly into the strongpoints, aft or bow, is used. If the hull has a total of 2.5 square meters of wet planing surface at 40 knots, then the boat must not have a total mass exceeding 1 400 kg in order to reach 50 knots with 150 hps engine.

When minimizing leakage of lifting capacity through longitudinal horizontal surface areas with anti-leakage lifting strakes in at least three levels on each side from bottom and up, then the best results are achieved.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side view of a stepped boat hull according to the invention,

FIG. 2 is a bottom view of the boat hull according to the invention,

FIG. 3 is a perspective bottom view of the boat hull according to the invention,

FIG.4 is a detailed part view of a cross-section of a strake across the longitudinal extension of a boat hull according to the invention,

FIG. 5 shows a cross-section of the boat hull according to the invention at the aft part of thereof showing stringer layout,

FIG. 6 shows a cross-section of the boat hull according to the invention at the forward part of thereof showing stringer layout,

FIG. 7 shows a top view of supportive hull strengthening stringers layout,

FIG. 8 shows a graph over a comparative study related to fuel consumption as a function of speed.

DETAILED DESCRIPTION

The invention is a stepped, V24-bottomed boat hull for use in high-speed motorboats. FIGS. 1 and 2 show a side and bottom view, respectively, of the hull according to the preferred embodiment of the invention; FIG. 3 is a perspective view from a point below and behind the aft, starboard portion of the hull. The hull may preferably be manufactured of vinyl ester and multi-fiberglass mats.

Definitions

Deadrise

Deadrise is the angle from horizontal plane to bottom strakes, up to a chine, i.e., the line between actual bottom and the sides of the boat.

In FIGs. 1-2, 1 denotes a forward part having a deadrise of 24°, also nominated as a V24 in the claims, the forward part 1 being separated from the aft part 2 with a midship step 3. The step 3 is somewhat inclined backwards from the lowest point up to the connection with the aft part 2. This inclination $\alpha 2$ is about 4 to 7°. The actual bottom part 4 of the forward part 1 comprises four strake sections 5 running fore and aft on each side of the keel line 6. The midship step 3 is further as a whole somewhat angled forward forming an apex angle of 160-170° indicated with $\alpha 3$ equal to 5-10° at the keel line in order to avoid any air ventilation under the aft part 2 bottom. The strake sections 5 are arranged with an angle $\alpha 1$ of attack of 2.5 to 4.0°.

The aft part 2 comprises a forward portion 7 provided with three strake sections 5, whereby this forward portion 7 has no angle of attack. The length of this forward portion is partly depending on the angle of attack, and is partly depending on the total length of the hull. The aft part 2 further an aft portion 8 provided with three strake sections 5, whereby the strake sections 5 of the forward portion 7 and aft portion 8 are fully aligned in the same way as the three strake sections 5 of the aft part 2 is fully aligned with the three outer strake sections 5 of the forward part 1. It should be understood that the aft part 2 may have four strake sections 5 as well.

The strake sections 5, whereby one such section is shown in detail in FIG.3, comprises one horizontal wall part 9, an inclined wall part 10 being partly bent and a strake border guide or flange 11 pointing downwardly from the horizontal wall part 9 in the region of a next upper strake section 5. The strake border guide or flange 11 being arranged at the outermost border of the respective strake section 5, is besides pointing downwardly as well somewhat inclined outwardly from the horizontal wall part 9. Such a strake border guide or flange 11 extends downwardly with a length of about 10% of the width of the horizontal wall part 9. However the strake border guide 11 must have a minimum height of 5 mm. The strake border guide or flange 11 has an angle $\alpha 4$ of 120 to 135°, to the horizontal wall part 9.

The hull according to the invention is thus provided with horizontal lifting strake surfaces, which are longitudinal members or portions running fore and aft on the outside bottom of the hull in order to create lift and stabilize the V24-hull when at speed. The main strake is located at the keel of the bottom. Then there are at least three levels of corresponding lifting strakes on each side and on the front part 1 and aft part 2. The width of the horizontal walls 9 of the strakes 5 is about 100 mm and the projected width of the strakes 5 is about 200 mm on a boat having a width of 2.1 meter and a weight of about 1400 kg. The formula is w=Lwl x *k1* whereas *k1=0,01*, w=width of strake, Lwl= Length of waterline. It is of most importance to apply a strake border guide at the outside of each lifting strake at a height of h=5-10 mm. I.e., strake border guide extends 10 mm downwardly from the outermost edge of the strake. The formula is h=Lwl x *k2* whereas *k2 =0,001*.

The longitudinal position of the midship step significantly affects the performance of the hull. The outer end of midship step is therefore located longitudinally preferably at 0.55 to 0.65 times the projected water length Lwl, measured from the aftmost part of the stern 12, i.e., the edge of the wet surface at planing.

FIGs. 5-7 shows the placement of stringers inside the hull. The stringers 21 and 22 are placed longitudinally above the next outermost strake section 5 on either side of the of the keel line 6. As FIG. 7 shows the stringers 21 and 22 meet at the front bow 23. Further a cross-stringer 24 is placed above the midship step 3 as well as a stringer 25 is placed cross the hull at the transom stern 12. The stringers 21, 22, 24 have the purpose of automatically leading out all tension from hull to bow or aft. Thus all impacts and other loads are absorbed by the different stringers 21, 22, 24.

High Aspect Ratio

The concept of the "aspect ratio" (AR) of a lifting body is well understood in aero- and hydrodynamics. As a rule of thumb, (AR)=Lws/Sqrt(A), where Lws is the length of wet surface in the direction of flow and A is wetted surface area. The higher the aspect ratio is, the more lift the body will generate for a given value of A and a given flow speed. For greatest efficiency, therefore, a planing surface should have a short length but have wideness, beam, similar as known hydrofoil technique. This high aspect ratio, especially for the aft planing surface, provides much greater lifting force and less drag, than can be achieved in conventional V-bottom or "ventilated" hydroplane hull designs. Drag is the fluid friction, which refers to forces acting opposite to the relative motion of any object moving with respect to a surrounding fluid.

Less Induced Drag

As is also well known, a drag-inducing vortex is created at the outboard edges of each planing surface of a hydroplane hull. This induced drag is usually the greatest drag force on a planing hull. As is mentioned above, conventional planing hulls have a single, large, planing surface that widens as it goes aft. This large area has a correspondingly large turbulent edge. Certainly, a traditional, non-stepped planing hull will have a turbulent increased drag area about four times as large as of the hull of the invention. Ventilated hulls have two to three times more disturbed increased drag area due to their increased tip vortex. Even sharp edges, having a radius of 5 mm or less on the edges of the midship and aft surface step that extends transverse to the longitudinal axis of the hull, give less induced drag.

Lower Drag

At a high planing speed, which, for boats having a length of 8.1, at the water line, means a speed in the range of 22-50 knots, the hull has 60% less total wetted area than that of a conventional V-bottom , and up to 50% less total wetted area than that of a so-called air-ventilated stepped hull. This is in part thanks to the fact that the region between the wetted areas (the planing surfaces) is above the water at speed, and in contrasts to conservative straight, V-bottom hulls, in which the wetted area is a single, large, roughly triangular region extending from the stern to midship. Moreover, the hull according to the invention is self-adjusting, so that no motor trim is needed; this in turn keeps the propeller force horizontal, thus maximizing the driving force.

Lateral Plan and Pounding

When the hull according to the invention is planing, it is "riding" on the two planing, wetted surfaces. As speed increases, the surface area of the wetted surfaces will decrease. The lateral surface, will remain to a large extent constant. The hull according to the invention therefore has two dynamic centers, separated by the step, which each remains in the same position relative to the center of gravity of the hull at any given planing speed. The boat is almost free of "galloping," or pounding, which is an occurrence known to increase drag by around 5% due to the increased wetted area when the nose "dips;" furthermore the up-down "pounding" motion itself creates an energy loss.

More Dynamic Lift

It is known that the center of lifting force of a planing area is roughly one third of the chord length of the surface, measured from the leading edge - the closer to the trailing edge of a lifting surface one measures, the closer it gets to zero. In the hull according to the invention, there are two separate leading edges (one per planing surface), which therefore provide more dynamic lift than a single surface of the same area.

Hydrodynamic Transverse Stability

At the transom area as mentioned above, the portion of the trailing edge of the aft planing surface is located forward, by approximately 9-14% of the length from the stern to the step, relative to the edge portions outboard on either side. The effect of this is that, at the far aft of the hull (especially aft of the edge), the planing surface acts as a "catamaran" in that greater dynamic lift is built up on the outboard portions of the planing surface than near the keel line. This helps prevent chine walking ("swinging"). In order to soften the behavior at speed it is possible to arrange horizontal trimming plans on each side of the engine at the water surface, or at the surface on each side of the propeller in case of inboard motor.

Unventilated

Many different advantages of the hull according to the invention are described above. One should note that the invention is able to achieve all of these with a hull that is unventilated. It would be possible to ventilate the hull according to the invention, but it has been found that the other unique features of the invention do not depend on this and that ventilation provides no advantage except for the case there should be airfoil wings with lifting capacity, i.e., aeroplane wing design.

Main Structural

The hull has an outboard engine or stern drive engine and a propeller mounted on a transom on the hull. Any propulsion system that can get the hull to a planing speed will benefit from the invention. Nonetheless, by method of illustration; a prototype, of the invention used a Evinrude E-TEC 150 horsepowers (hps) (2-stroke), gasoline-fueled, outboard engine driving a 14×26-inch (diameter × pitch) stainless propeller and raised 50 mm. The prototype boat was 8.1 x 2.1 (waterline length) meter, and tests were conducted with two adults, 2 x 80 kg and 40 liters of gasoline. The total weight of boat, engine, fuel, equipment and persons was 1480 kg.

Without departing from the main features of the invention, these results will depend on such factors as increased load, chosen engine, weather conditions, a.o.

Comparative Results

The invention compared the performance of the hull, here called FFWD, according to the preferred embodiment of the invention with several other conventional hulls under essentially identical sea states and with the same two-person load. The specifications of the embodiment of the invention used in the test are stated above with reference to the working prototype. The results are summarized in Table 1 below. In Table 1 it is shown, for each tested hull, the make and model, length × width in meters (m), the mass (kg), the motor effect (in horsepower), the maximum achieved speed Vmax (knots).

As Table 1 shows, no other hull exceeded the 51 knot top speed of the invention. Only the C-Rib made it, but required motor effect 360% greater than the 150 hp engine used by the invention to do so.

Table 1

Make Mod	LxW (m)	Mass	Engine	Vmax
FFWD	8.7x2.1	1480 kg	150hp	50kn
Arctic Blue	8.4x2	1500 kg	300hp	45kn
Rupert 26	8.1x2	1500 kg	225hp	40kn
C-Rib30	9x2.8	2500 kg	550hp	50kn

Test Study

A comparative study concerning the fuel economy has been made wherein data concerning different boats and motors have been compared with a fuel economy related to the present hull. Data have been obtained from the Swedish Boat Magazine - VI BÅTÄGARE - when it comes to other boats than the present one,1) herein called FFWD provided with a 150 hps outboard Evinrude engine. The other hulls teste were 2) Anytec 750 hps having a 300 hps engine, 3) Buster Super Magnum having a 300 hps Yamaha engine, 4) Yamarin Cros 75BR having a 300 hps engine and 5) an XO 24ORS Open having a 250 hps engine. The hulls tested are conventional aluminium hulls. All gasoline fed.

As evident from the data the fuel consumption is about 1.8 litres per nautic mile at a speed of about 43 knots per hour for the boats 2) to 5) compared to 1.8 litres per nautic mile at a speed of 61 knots per hour for the present boat 1). Or, 0.9 litre per nautic mile at a speed of 45 knots per hour for the boat 1). It means that the present hull only needs less than 50% of fuel compared to that of a conventional hull.

CLAIMS

1. A hydroplaning unventilated stepped V24 bottom boat-hull comprising:

a forward part (1);

an aft part (2);

a single keel line (6) extending fore and aft and lying in a single vertical plane of symmetry;

a midship step (3) separating the forward and aft parts;

characterized in

a single forward planing surface extending transversely immediately forward of the midship step (3) and having a first nominal forward angle α1 of attack of 2.5-4 degrees an aft planing surface portion extending transversely and forward of an aft edge of the hull and having a nominal aft forward angle α1 of attack of 2.5-4 degrees,

said first nominal forward and a second aft angles of attack being measured in the plane of symmetry between the hull and a water line that extends fore and aft and passes through lowest points of the forward and aft portions, respectively; whereby said first and second angels are identical,

whereby both the aft and forward parts (1, 2) have at least three continuously running strake sections (5), each with same deadrise angle at a keel line (6) from a respective leading edge forward;

[the nominal forward angle α1 of attack lies in the range 2.5-4.0 degrees;]

and whereby the stepped midship is angled with a forward apex [forwardly to form an angle to] at the keel line of 160 to 170 degrees,

and

whereby the hull with its forward and aft planing surfaces, at moving at least at a minimum planing speed, is arranged to constitute two separated wetted surfaces.

2. A boat hull according to claim 1, wherein the strake sections (5) each comprise one horizontal wall part (9), an inclined wall part (10) and a strake border guide or flange (11) pointing downwardly from the horizontal wall part (9) in the region of a following upper strake section (5).

3. A boat hull according to claim 2, wherein the strake border guide (11) shows an angle $\alpha4$ of 120 to 135° to the horizontal wall part (9).

4. A boat hull according to claim 1, wherein the midship step (3) is somewhat inclined backwards from the lowest point up to the connection with the aft part (2), this inclination being about $\alpha2$, 4 to 7°.

5. A boat hull as defined in claim 1, in which the forward angle of attack is 4.0 degrees.

6. A boat hull as defined in claim 1, wherein the hull has a projected water line length L; and the midship step (3) is located longitudinally at 0.55 to 0.65 times Lwl, measured forward from an aftmost edge of an aft planing surface at the transom stern.

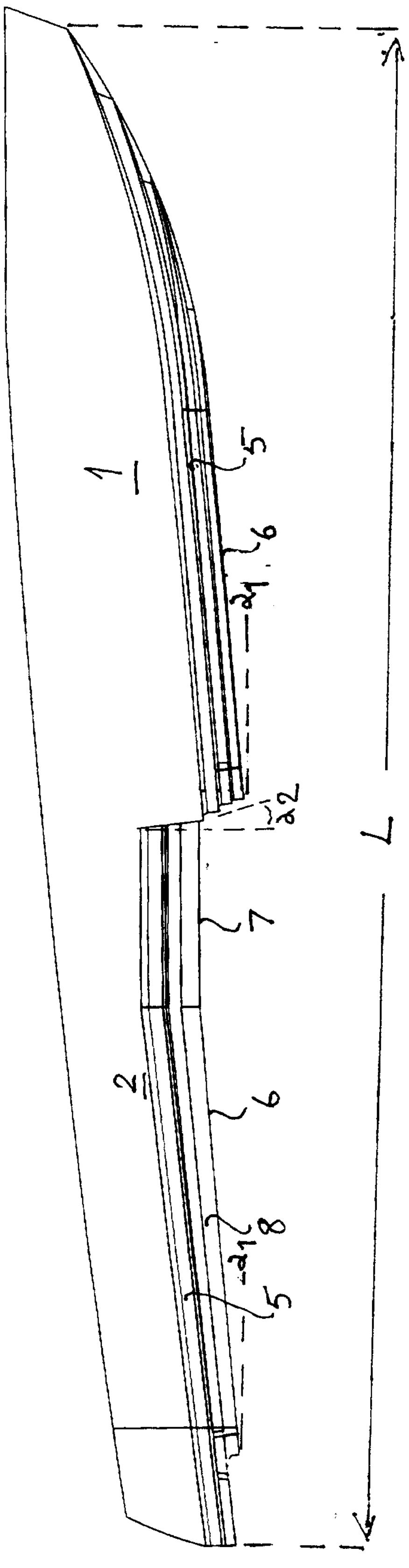

FIG. 1

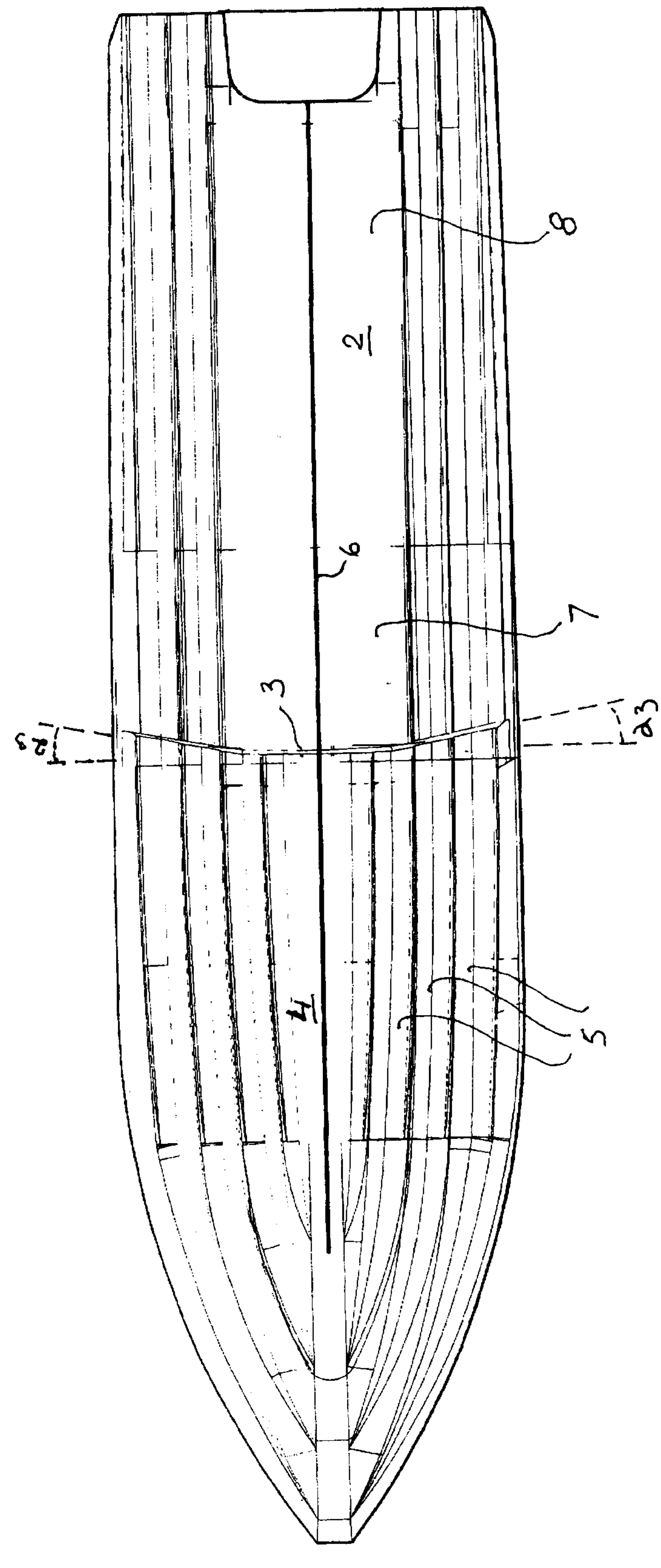

FIG. 2

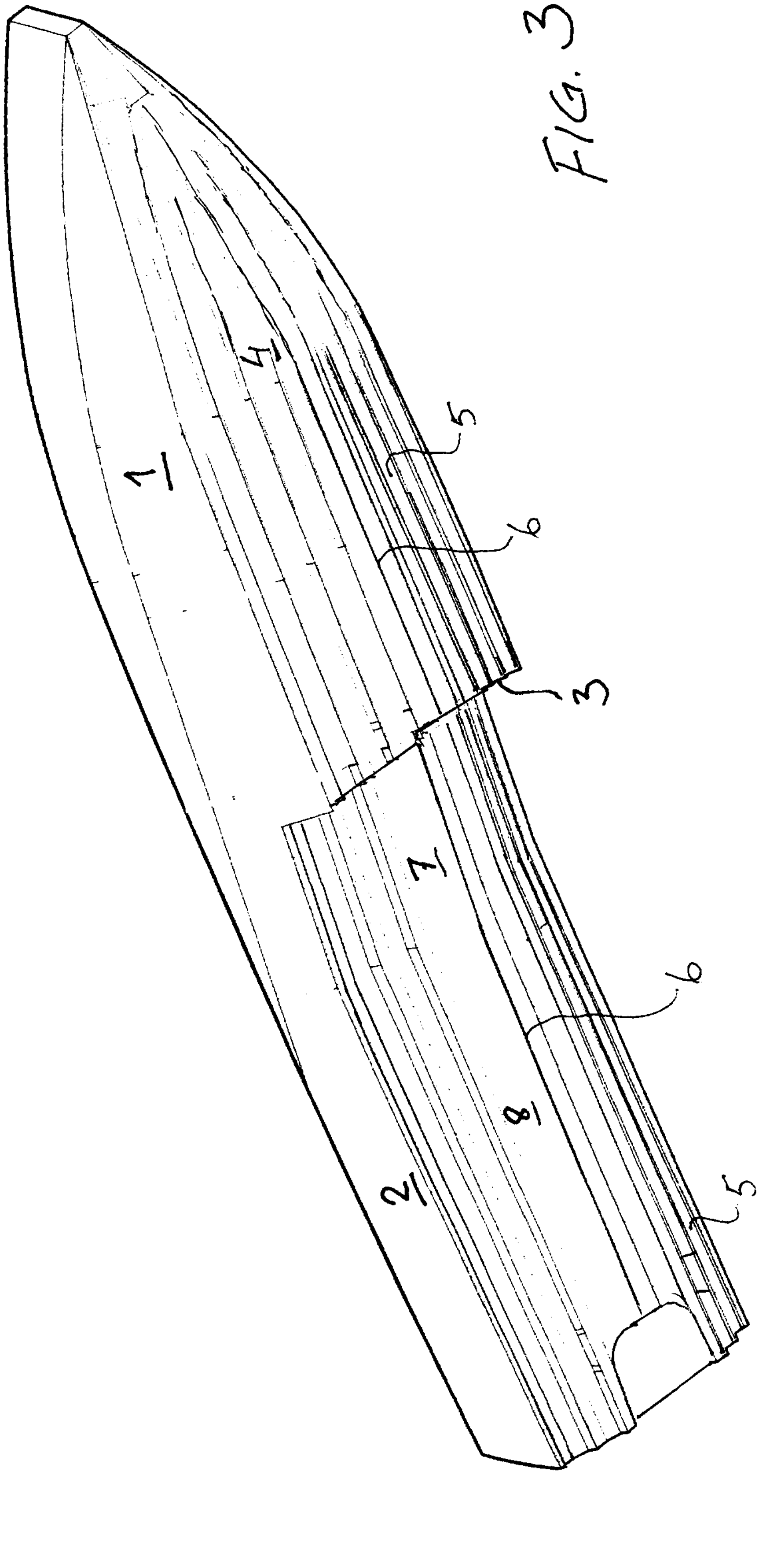

FIG. 3

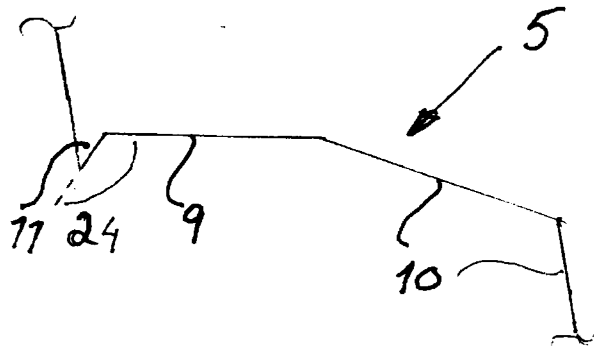

FIG. 4

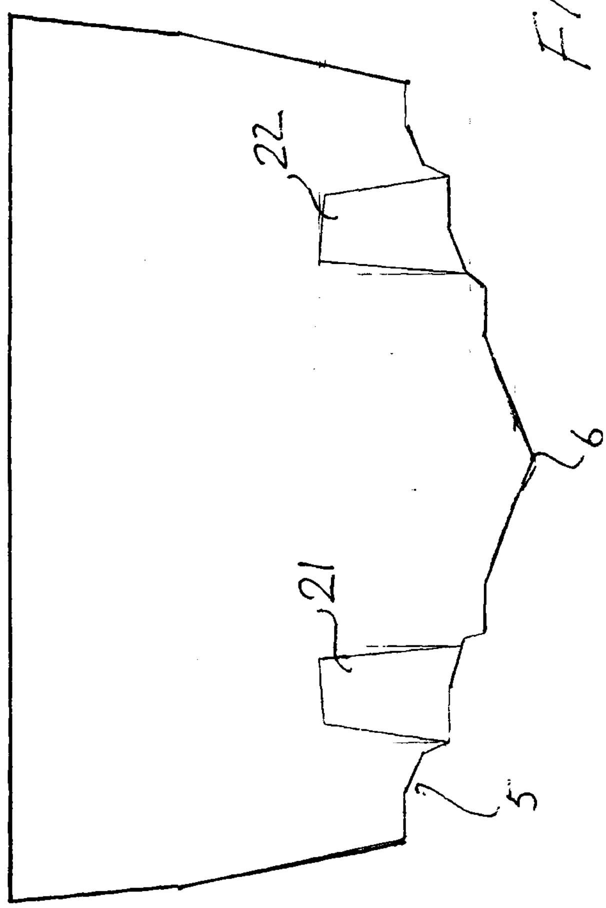

FIG. 5

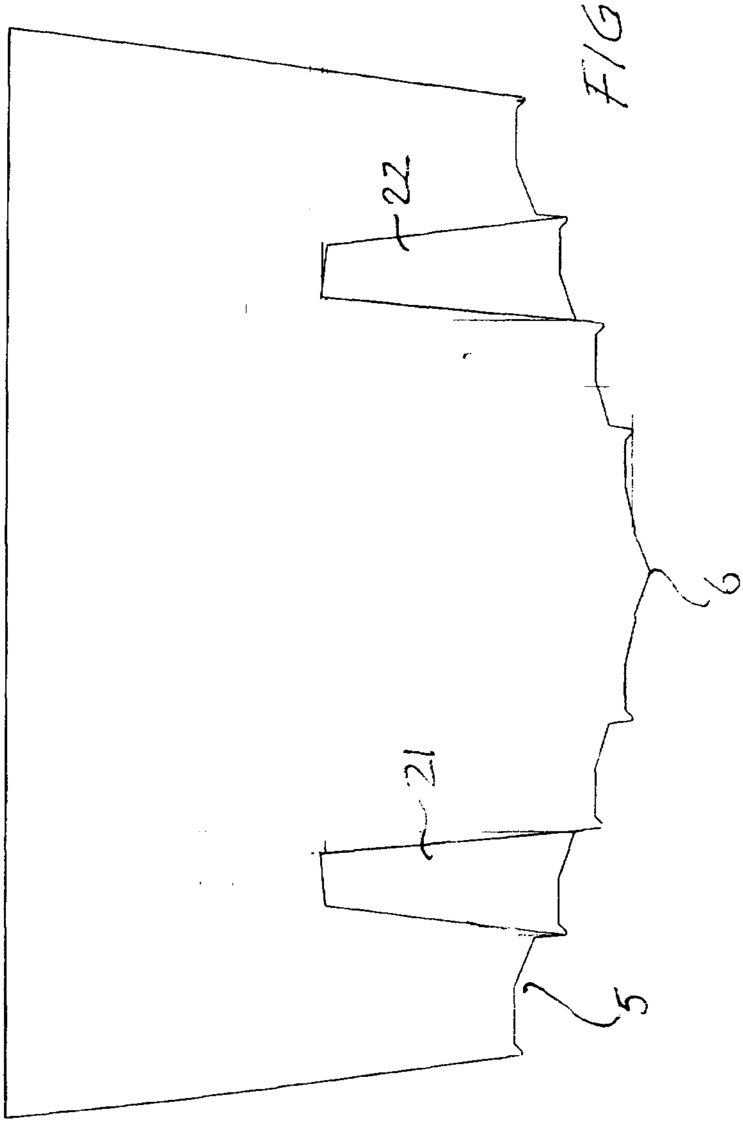

FIG. 6

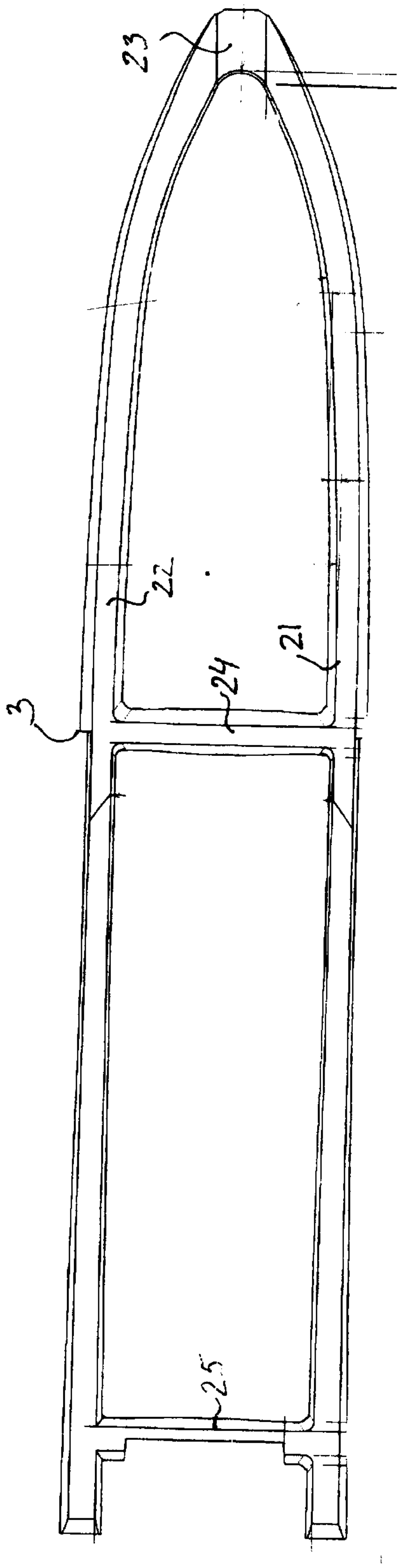

FIG. 7

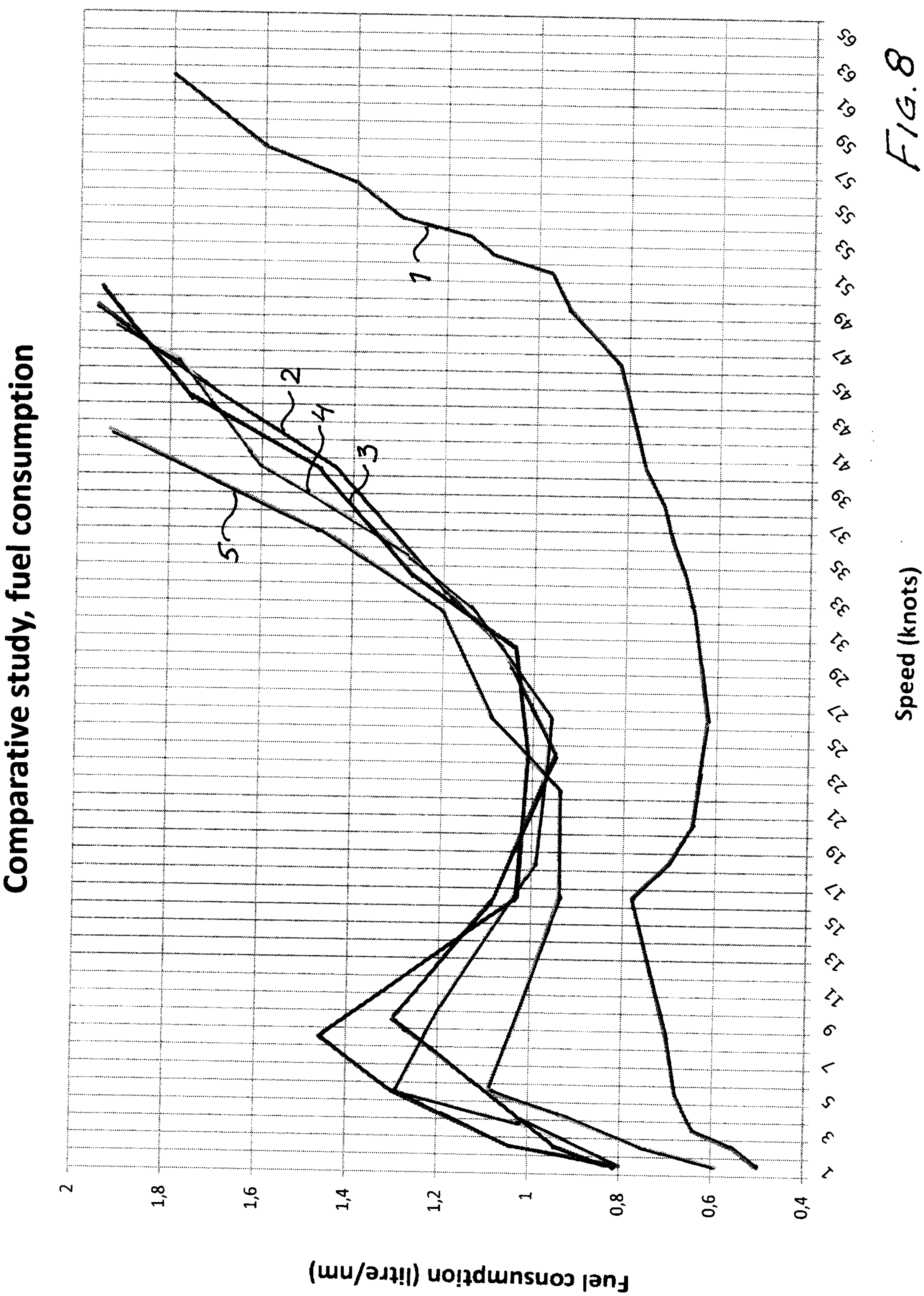
Comparative study, fuel consumption
Fuel consumption (litre/nm)
Speed (knots)
2
1,8
1,6
1,4
1,2
1
0,8
0,6
0,4
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65
1
2
3
4
5

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2016/000059

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: B63B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6666160 B1 (OERNEBLAD STEN), 23 December 2003 (2003-12-23); abstract; column 2, line 3 - line 39; column 3, line 6 - column 4, line 22; column 6, line 16 - line 39; column 7, line 47 - line 49; column 9, line 19 - line 31; figures 1-4; claims 1,2,7,9	1, 4-6
Y		2, 3
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Y	US 20050160960 A1 (BATISTA CARMELO ET AL), 28 July 2005 (2005-07-28); figures 5,6	2, 3
A		1, 4-6
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☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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Date of the actual completion of the international search	Date of mailing of the international search report
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