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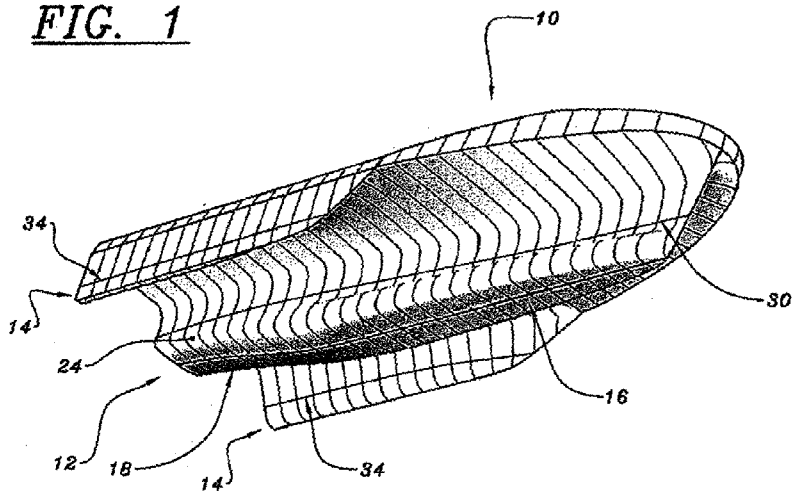
(54) **Title**: A MULTI-HULLED VESSEL

FIG. 1



(57) **Abstract**: A marine vessel is disclosed that comprises at least 3 hulls. At least one of the hulls has a first hull part and a second hull part, the first hull part corresponding to about 60% of the maximum underwater length of the at least one hull, and the second hull part corresponding to about 40% of the maximum underwater length of the at least one hull. A first ratio between a maximum underwater plan area at the first hull part and a waterline plan area at the first hull part at any navigable waterline is greater than about 2.0. A second ratio between a maximum underwater plan area at the second hull part and a waterline plan area at the second hull part at any navigable waterline is less than the greater of about half the first ratio or about 1.15. The waterline plan area at the second hull part is greater than the waterline plan area at the first hull part.

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A MULTI-HULLED VESSEL

Field of the Invention

This invention relates to a multi-hulled vessel of the type including at least 3 hulls.

Background of the Invention

A catamaran type vessel that has a relatively large plan area below the waterline in order to maintain the vessel afloat and a relatively small plan area at the waterline in order to minimize excitation of the vessel due to wave motion is often referred to as a Small Waterplane Area Twin Hull or SWATH vessel.

A common problem with SWATH hull forms is that relatively large changes in draft can occur when the vessel is at rest and the load supported by the vessel changes, for example when loading and unloading cargo.

While SWATH type vessels typically include control devices for controlling resonance type motions, such control devices rely on water flow to be an effective force generator and are therefore ineffective at low and zero speeds.

Conventional type hulls, either monohull or multi-hull, also experience draft changes when loading and unloading but to a lesser extent than SWATHs because of the relatively larger plan area at the waterline. A relatively large plan area at the waterline, however, causes this type of conventional hull to also have large

motions in waves. This is normally exacerbated at low and zero speeds and the largest motions normally occur at the bow.

In some circumstances, for example servicing of off-shore installations, significant changes in draft at rest can be particularly problematic and dangerous, because servicing personnel and associated tools and parts are required to be moved between the vessel and the off-shore installation. This is especially true of unmanned offshore installations such as wind farm turbine pylons that are not equipped with the cargo handling facilities that may be present on larger installations.

Summary of the Invention

In accordance with a first aspect of the present invention, there is provided a marine vessel comprising at least 3 hulls;

at least one of the hulls having a first hull part and a second hull part, the first hull part corresponding to about 60% of the maximum underwater length of the at least one hull, and the second hull part corresponding to the other about 40% of the maximum underwater length of the at least one hull;

wherein a first ratio between a maximum underwater plan area at the first hull part and a waterline plan area at the first hull part at any navigable waterline is greater than about 2.0;

wherein a second ratio between a maximum underwater plan area at the second hull part and a waterline plan area at the second hull part at any navigable waterline is

less than the greater of about half the first ratio or about 1.15; and

wherein the waterline plan area at the second hull part is greater than the waterline plan area at the first hull part.

In one embodiment, the first hull part is disposed forwardly of the vessel and the second hull part is disposed rearwardly of the vessel.

In one embodiment, the at least one hull has a continuous form such that the waterline plan area transitions gradually to the maximum underwater plan area.

In one embodiment, the at least one hull includes at least one appendage disposed so as to contribute to the maximum underwater plan area.

In one embodiment, the maximum width of the maximum underwater plan area at the first hull part is about the same as the maximum width of the waterline plan area at the second hull part.

In one embodiment, the vessel comprises 3 hulls. The at least one hull may be a central hull, and the vessel may include 2 side hulls, the total underwater volume of the side hulls constituting less than about 20% of the total underwater volume of the vessel at any navigable waterline.

In one embodiment, one or more of the hulls may be configured so as to generate lift in order to minimize resistance during use in transit.

In accordance with a second aspect of the present invention, there is provided a marine vessel comprising a substantially centrally disposed hull having a first hull part and a second hull part, and at least 2 other hulls;

wherein a first ratio between a maximum underwater plan area at the first hull part and a waterline plan area at the first hull part at any navigable waterline is greater than about 2.0;

wherein a second ratio between a maximum underwater plan area at the second hull part and a waterline plan area at the second hull part at any navigable waterline is less than the greater of about half the first ratio or about 1.15; and

wherein the width of the waterline plan area at the second hull part is greater than the width of the waterline plan area at the first hull part.

Brief Description of the Drawings

The present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a diagrammatic underside perspective view of a hull portion of a multi-hulled vessel in accordance with an embodiment of the present invention;

Figure 2 is a diagrammatic side view of the hull portion shown in Figure 1; and

Figure 3 is a underside plan view of the hull portion shown in Figures 1 and 2 showing respective waterline plan areas of a central hull and side hulls of the vessel.

Description of an Embodiment of the Invention

Referring to the drawings, there is shown a hull portion 10 of a marine vessel of the type including at least three hulls. In this example, the vessel is of trimaran type and accordingly includes three hulls.

The hull portion 10 in this example is configured so as to include a relatively large central hull 12 that supports most of the weight of the vessel, and two side hulls 14, often referred to as "amahs" or "amas", that support a relatively small proportion of the weight of the vessel and serve as floats to maintain the desired orientation of the vessel relative to the waterline.

However, it will be understood that other types of trimaran are envisaged. For example, a trimaran may be provided wherein the weight of the vessel is supported more evenly across the hulls, with the side hulls also serving to support a significant amount of the weight of the vessel as well as to maintain the desired orientation of the vessel relative to the waterline.

In the present embodiment, the side hulls 14 have a combined underwater volume that is at most about 20% of the total underwater volume of the hull portion 10. This type of vessel allows for favourable roll accelerations whilst still enabling a designer to retain suitable stability for safety regulations. Low vertical

accelerations occur at the bow by virtue of the shape of the central hull 12 and low roll accelerations occur by virtue of the small side hull configuration.

The central hull 12 is configured such that a frontmost part of the central hull 12 is of SWATH-like form, that is, having a relatively large plan area below the waterline and a relatively small plan area at the waterline, and a rearmost part of the central hull 12 is of non-SWATH like form, in this example of conventional form having a plan area that does not significantly change between a lowermost part of the hull and the waterline.

In the present example, the central hull 12 includes a first hull part, in this example a front hull portion 16, of SWATH-like form and a second hull part, in this example an aft hull portion 18, of non-SWATH like form, with the front and aft hull portions 16, 18 identified conceptually in the Figures by a virtual line 19 disposed at a location from the rear of the vessel corresponding to about 40% of the maximum underwater length (L) of the vessel. In addition, the width of the waterline plan area of the central hull 12 increases from the front hull portion 16 to the aft hull portion 18 such that the waterline plan area at the aft hull portion 18 is larger than the waterline plan area at the front hull portion 16.

It will therefore be understood that the front hull portion 16 has a relatively small waterline plan area, and the aft hull portion 18 has a relatively large waterline plan area. This contributes to providing a sea going vessel that is optimised for reduced vertical motions at low speeds especially near the forward end of the vessel,

while still retaining features for transit speeds.

The transit speeds would be individually suited to each vessel and operator. However, it would be expected to be greater than 15 knots and normally greater than 20 knots. Vessel speeds are often expressed by a non-dimensional number called a Froude number. The Froude number Fr is given by:

$$Fr = \frac{V}{\sqrt{gL'}}$$

Where V is the vessel speed, L' is the waterline length and g is the acceleration due to gravity.

The transit speeds for vessels according to embodiments of the invention would typically have an associated Froude number between about 0.4 and about 1.1, which corresponds to the speed range that is sometimes referred to as characteristic of semi-planing vessels.

As vessels travel through waves, the average resistance to forward motion increases with increasing wave height. The average resistance to forward motion is also proportional to vertical vessel motions. With the present vessels, such vertical motions are reduced at low speeds, and these reductions of motions may also be seen at transit speeds. With the present vessels, therefore, the increased resistance in waves as the wave height increases will be relatively small, thereby allowing for faster transit times in waves and generally more efficient operation.

It will be appreciated that the relatively small waterline plan area of the front hull portion 16 may result in a

fine angle of entrance at the bow. The fine entrance angle may reduce the waves produced by the bow at transit speeds and, as a consequence, will for example have less environmental impact if the vessel is travelling near shorelines.

In order to achieve the desired characteristics at low and zero speeds without unduly compromising transit speed properties, the shape of the central hull 12 is configured according to hull plan area ratios as follows.

The hull plan area ratios are determined by considering the plan areas at any navigable waterline and the maximum underwater plan area. The maximum underwater plan area is determined by the outer envelope of all the plan areas beneath the navigable waterline. Plan areas used to determine the hull plan area ratios in the present invention are shown in the plan view in Figure 3. As shown, for the central hull 12, a waterline plan area 30 increases in width from a frontmost part 40 of the vessel to a rearmost part 42 of the vessel. The maximum underwater plan area of the central hull 12 is marked by reference numeral 32, and the waterline plan areas for the side hulls 14 are marked by reference numeral 34.

For the front hull portion 16, a first ratio between the maximum underwater plan area at the front hull portion 16 and the waterline plan area at the front hull portion 16 at any navigable waterline is greater than about 2.0. For the aft hull portion 18, a second ratio between the maximum underwater plan area at the aft hull portion 18 and the waterline plan area at the aft hull portion 18 at any navigable waterline is less than the greater of half the first ratio or about 1.15. In this example, the aft

hull ratio is greater than 1.0 in order to allow for a faired hull shape. Where the front hull portion has a ratio significantly greater than 2.0 an increase in the aft area may be required to account for the fairing required for a smooth hull transition to this large forward ratio. As such, the aft ratio may increase to as much as about half the forward ratio to account for this additional fairing. It will be understood that a ratio of 1.0 has no SWATH like properties as the underwater area is no greater than the waterplane area.

While the above embodiment is described in relation to a trimaran having a relatively large central hull and relatively small side hulls, it will be understood that other implementations are possible. For example, an embodiment of the invention could comprise a multihull vessel wherein the hulls are of similar volume and shape to each other and the shape of each hull conforms to the plan view area ratios described above. This could include a trimaran vessel with 3 similar hulls where the side hulls have a combined underwater volume greater than 50% of the total underwater volume.

It will also be understood that variations that include multiple numbers of hulls greater than 3, in some embodiments an odd number of hulls such as 5 or 7, are also envisaged.

Moreover, while the above embodiment is described in relation to a vessel having at least a central hull with a frontmost part of SWATH like form, and a rearmost part of non-SWATH like form, it will be understood that these parts may be reversed; that is, the frontmost part of may

be of non-SWATH like form, and the rearmost part may be of SWATH like form. With this alternative arrangement, it will be understood that the aft hull portion may correspond to a region extending from the rear of the vessel corresponding to about 60% of the maximum underwater length (L) of the vessel.

It will also be appreciated that instead of or in addition to achieving motion damping by providing a continuous hull form that is relatively thin at the waterline and increases in width below the waterline, similar damping could be achieved using suitable appendages under the waterline attached to the hull. With this arrangement, it will be understood that the appendages are considered part of the hull form and contribute to the underwater plan area of the SWATH like hull form. Such appendages that are configured to contribute to increasing the underwater plan area and thereby contribute to motion damping are distinct from other appendages that do not provide a significant contribution to vertical motion damping, such as vertical rudders and structural support for propeller shafts.

Preferably the side hulls are significantly shorter in waterline length than the central hull. Typically, the waterline length of the side hulls is between about 30% to 60% of the waterline length of the central hull. With this shorter length, the side hulls are often located towards the aft portion of the central hull so that the waterplane area of the side hulls is longitudinally aligned with the larger waterline area of the central hull. It is of lesser importance to align the side hulls with the main hull if the side hulls only support a small

fraction of the vessel buoyancy, because typically the smaller buoyancy only has a small effect on vertical motions of the vessel.

It will be understood that the side hulls may also extend outside the extents of the main hull. This can be useful if the vessel is propelled by waterjets or has some other appendage aft of the main hull, since for example the side hulls may serve to protect the appendages.

The low roll accelerations inherent in good trimaran design can be further improved by utilizing motion control systems, for example of the type including roll fins or other motion control surfaces, anti-roll tanks, gyroscopic stabilizers or similar. These surfaces could also be configured to further reduce the vertical motions of the vessel as well as minimise roll motions.

In an example vessel according to an embodiment of the present invention, the maximum underwater length of the vessel is 32m. In a typical loading condition, the total volume displaced is about 105 cubic metres, with a combined side hull volume of 12 cubic metres split evenly between the two side hulls. The design transit speed is about 24 knots which for this vessel corresponds to a Froude number of 0.7. The total waterline plan area may be about 49.6 square metres, split at 60% of the maximum underwater length from the forward end of the vessel such that the waterline plan area at the front hull portion is about 17.8 square metres and the waterline plan area at the aft hull portion is about 31.8 square metres. The maximum underwater plan area in this example is about 75.6 square metres, split at 60% of the maximum underwater

length from the forward end of the vessel with 41.2 square metres in the front hull portion and 34.4 square metres in the aft hull portion. This produces a first ratio at the front hull portion between the maximum underwater plan area and the waterline plan area of 2.31, and a second ratio at the aft hull portion between the maximum underwater plan area and a waterline plan area of 1.08.

Modifications and variations as would be apparent to a skilled addressee are deemed to be within the scope of the present invention.

CLAIMS:

1. A marine vessel comprising at least 3 hulls;

at least one of the hulls having a first hull part and a second hull part, the first hull part corresponding to about 60% of the maximum underwater length of the at least one hull, and the second hull part corresponding to about 40% of the maximum underwater length of the at least one hull;

wherein a first ratio between a maximum underwater plan area at the first hull part and a waterline plan area at the first hull part at any navigable waterline is greater than about 2.0;

wherein a second ratio between a maximum underwater plan area at the second hull part and a waterline plan area at the second hull part at any navigable waterline is less than the greater of about half the first ratio or about 1.15; and

wherein the waterline plan area at the second hull part is greater than the waterline plan area at the first hull part.

2. . A marine vessel as claimed in claim 1, wherein the first hull part is disposed forwardly of the vessel and the second hull part is disposed rearwardly of the vessel.

3. A marine vessel as claimed in claim 1 or claim 2, wherein the at least one hull has a continuous form such that the waterline plan area transitions gradually to the maximum underwater plan area.

4. A marine vessel as claimed in claim 1 or claim 2, wherein the at least one hull includes at least one

appendage disposed so as to contribute to the maximum underwater plan area.

5. A marine vessel as claimed in any one of the preceding claims, wherein the maximum width of the maximum underwater plan area at the first hull part is about the same as the maximum width of the waterline plan area at the second hull part.

6. A marine vessel as claimed in any one of the preceding claims, wherin the vessel comprises 3 hulls.

7. A marine vessel as claimed in claim 6, wherein the at least one hull is a central hull, and the vessel comprises 2 side hulls, the total underwater volume of the side hulls constituting less than about 20% of the total underwater volume of the vessel at any navigable waterline.

8. A marine vessel as claimed in any one of the preceding claims, wherein a plurality of the hulls of the vessel but not all of the hulls each have a first hull part and a second hull part, the first hull part corresponding to about 60% of the maximum underwater length of the at least one hull, and the second hull part corresponding to about 40% of the maximum underwater length of the at least one hull;

wherein a first ratio between a maximum underwater plan area at the first hull part and a waterline plan area at the first hull part at any navigable waterline is greater than about 2.0;

wherein a second ratio between a maximum underwater plan area at the second hull part and a waterline plan

area at the second hull part at any navigable waterline is less than the greater of about half the first ratio or about 1.15; and

wherein the waterline plan area at the second hull part is greater than the waterline plan area at the first hull part.

9. A marine vessel as claimed in any one of claims 1 to 7, wherein each hull of the vessel has a first hull part and a second hull part, the first hull part corresponding to about 60% of the maximum underwater length of the at least one hull, and the second hull part corresponding to about 40% of the maximum underwater length of the at least one hull;

wherein a first ratio between a maximum underwater plan area at the first hull part and a waterline plan area at the first hull part at any navigable waterline is greater than about 2.0;

wherein a second ratio between a maximum underwater plan area at the second hull part and a waterline plan area at the second hull part at any navigable waterline is less than the greater of about half the first ratio or about 1.15; and

wherein the waterline plan area at the second hull part is greater than the waterline plan area at the first hull part.

10. A marine vessel as claimed in any one of the preceding claims, wherein one or more of the hulls is configured so as to generate lift during use.

11. A marine vessel comprising a substantially centrally disposed hull having a first hull part and a second hull part, and at least 2 other hulls;

wherein a first ratio between a maximum underwater plan area at the first hull part and a waterline plan area at the first hull part at any navigable waterline is greater than about 2.0;

wherein a second ratio between a maximum underwater plan area at the second hull part and a waterline plan area at the second hull part at any navigable waterline is less than the greater of about 1.15 or about half the first ratio; and

wherein the waterline plan area at the second hull part is greater than the waterline plan area at the first hull part.

12. A marine vessel as claimed in claim 11, wherein the first hull part is disposed forwardly of the vessel and the second hull part is disposed rearwardly of the vessel.

13. A marine vessel as claimed in claim 11 or claim 12, wherein the centrally disposed hull has a continuous form such that the waterline plan area transitions gradually to the maximum underwater plan area.

14. A marine vessel as claimed in claim 11 or claim 12, wherein the centrally disposed hull includes at least one appendage disposed so as to contribute to the maximum underwater plan area.

15. A marine vessel as claimed in any one of claims 11 to 14, wherein the maximum width of the maximum underwater plan area at the first hull part is about the same as the

maximum width of the waterline plan area at the second hull part.

16. A marine vessel as claimed in claim 6, wherein the vessel comprises 2 side hulls, the total underwater volume of the side hulls constituting less than about 20% of the total underwater volume of the vessel at any navigable waterline.

17. A marine vessel as claimed in any one of claims 11 to 16, wherein the first hull part corresponds to about 60% of the maximum underwater length of the at least one hull, and the second hull part corresponds to about 40% of the maximum underwater length of the at least one hull.

18. A marine vessel substantially as hereinbefore described with reference to the accompanying drawings.

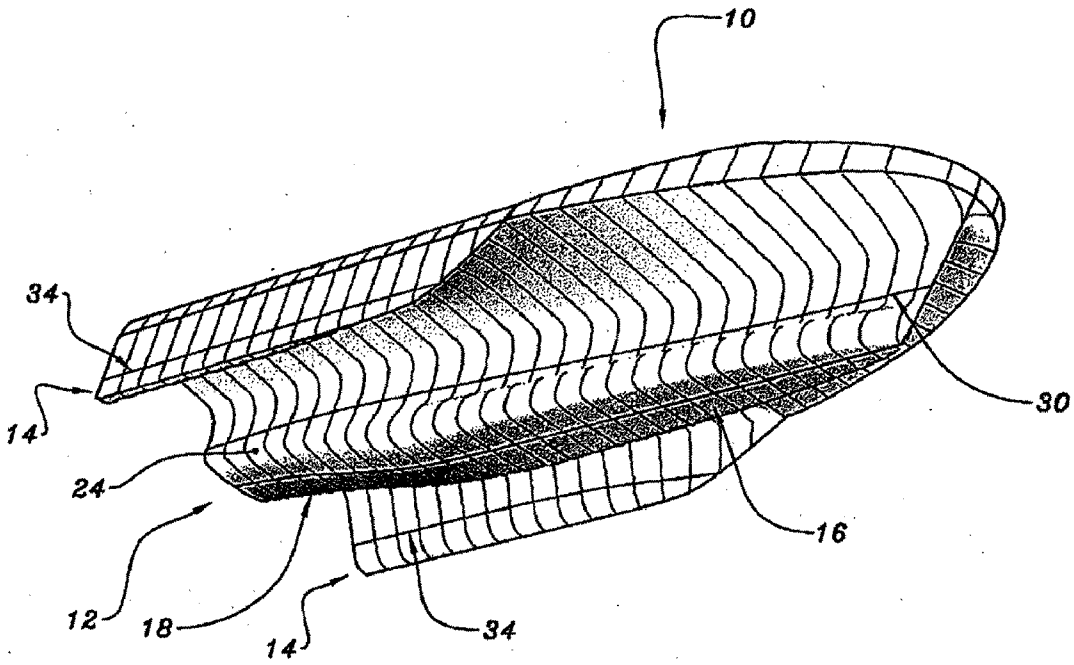

FIG. 1

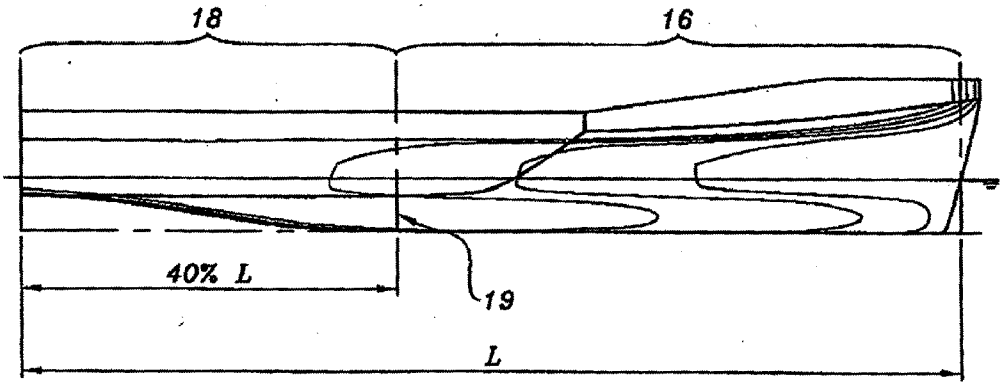

FIG. 2

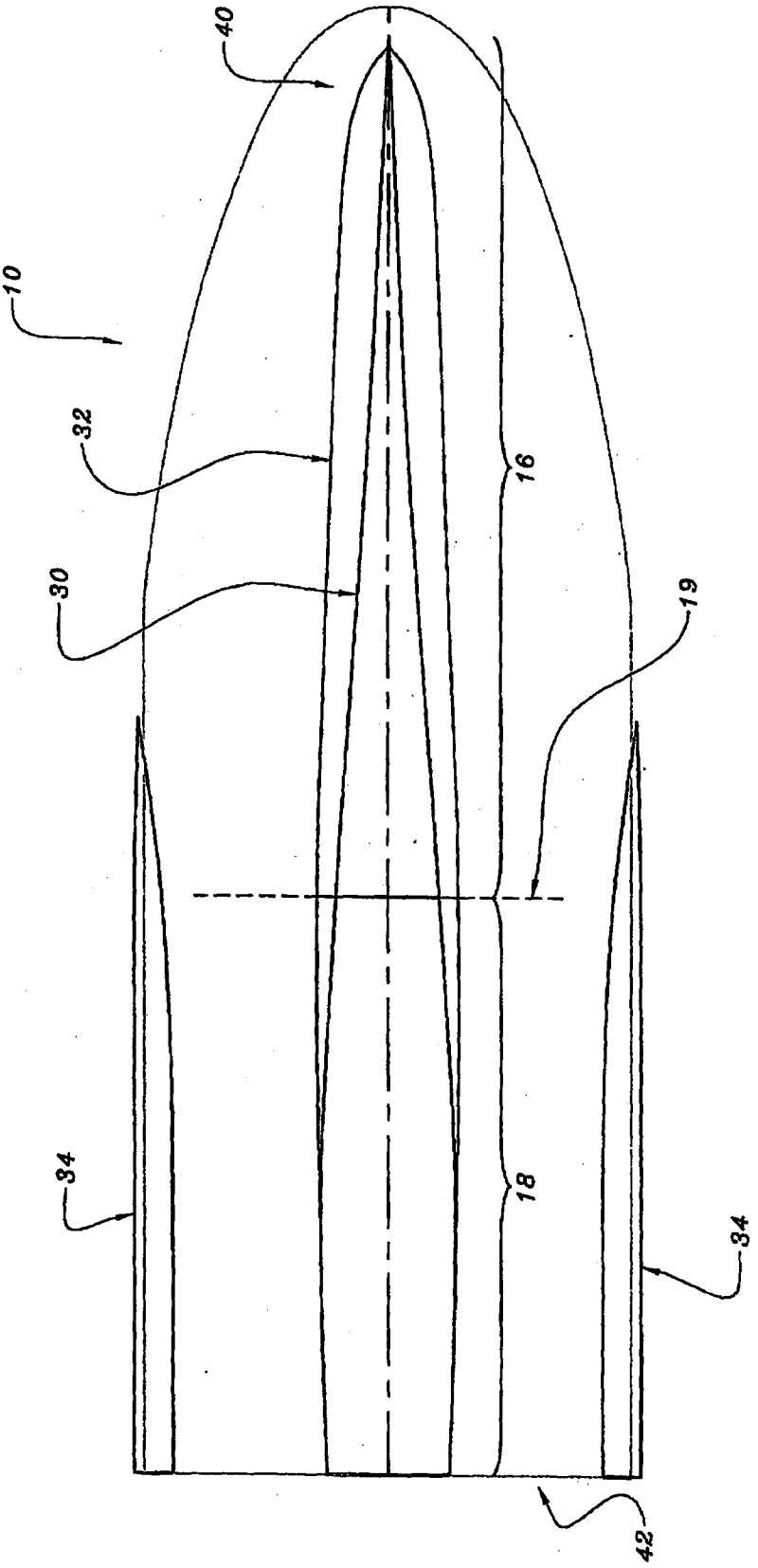

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2012/000710

A. CLASSIFICATION OF SUBJECT MATTER

B63B 1/12 (2006.01)

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)

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPODOC, WPI: IPC, EC; B63B 1/10, 1/12, 1/14 and keywords (Trimaran, Multi Hull, Swath, Ratio and similar terms)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

[X] Further documents are listed in the continuation of Box C [X] 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

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 August 2012	21 August 2012

Name and mailing address of the ISA/AU

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INTERNATIONAL SEARCH REPORT		International application No.
C (Continuation).	DOCUMENTS CONSIDERED TO BE RELEVANT	**PCT/AU2012/000710**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2008/0210149 A1 (GOUBAULT et al) 04 September 2008	
A	WO 1994/020359 A1 (WINTRIA AB) 15 September 1994	

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2012/000710

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: **18**
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
The claim does not comply with Rule 6.2(a) because it relies on references to the description and/or drawings.

3. ☐ Claims Nos:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/AU2012/000710**

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document/s Cited in Search Report		**Patent Family Member/s**	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
US 2008/0210149 A1	04 Sep 2008	EP 1917180 A1	07 May 2008
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		NO 953551 A	08 Nov 1995
		NO 305159 B1	12 Apr 1999
		SE 9300842 A	12 Sep 1994
		WO 9420359 A1	15 Sep 1994

End of Annex

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.