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Catamaran Air Cushion Water Vehicle

The invention relates to a catamaran air cushion water vehicle comprising: two spaced apart floats which extend parallel to one another in the direction of travel, and 15 which each have a float region which is submerged during travel in a displacement mode and defines a displacement mode waterline, wherein the cross-sections of the floats become broader from the bottom to the top but wherein the floats are rigidly connected together at the top by 20 a deck structure; skirt means which are arranged at the stem and at the stern between the floats, which extend at least approximately to the water surface and, together with the floats, bound an air space between the base of the deck structure and the water surface; main propulsion units 25 which drive propulsion means arranged in the stern region of the floats; and fans which blow air sucked in from the outside into the bounded air space beneath the bottom of the deck structure in order to lift the water vehicle from travel in the displacement mode to travel in an air cushion 30 (hovercraft) mode.

Such water vehicles are for example known from US 4,469,334 and GB 11 84 062, and are particularly ideal for hovercraft operation because the floats or catamaran 35 hulls which are still somewhat submerged when travelling in the hovercraft mode represent a problemfree sealed lateral boundary for the air space of the air cushion.

(15)

1 Accordingly, resilient skirts which bound the relevant
air space at the front and at the rear only need to be
additionally provided between the floats at the stem and
at the stern.

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A disadvantage of such known catamaran air cushion water
vehicles (Naval Engineers Journal, May 1984, pages 77 to
93) is the fact that they are primarily laid out for
optimum hovercraft operation, whereas travel in the
10 displacement mode merely represents a state of travel
which is adopted during harbour manoeuvring, when the
air cushion propulsion fails, or in heavy seas, and is,
in the final resort, an undesired state of travel which
is only provided because it cannot be avoided in the
15 named situations. The main propulsion units are either
arranged extremely deep inside the floats, so that the
floats must also be made very broad in the lower region
and it is difficult to lead the shafts for the ship's
propeller out of the floats (FLIGHT International
20 Supplement, March 23rd, 1967, page 31; US-PS 3 559 608),
or are located above the floats, which results in
stability problems and a steep angle of the shaft for
the ship's propeller (Ship & Boat International, May
1982, page 48).

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The object underlying the present invention is now to
provide a catamaran air cushion craft for which travel
in the displacement mode is a state of travel which is
equally meritorious as travel the hovercraft mode, and
30 for which ideal conditions prevail both from the point
of view of economy and as also from the point of view of
stability and travel comfort.

Optimum running behaviour of a catamaran air cushion
35 water craft during travel in the displacement mode is in
particular of great significance when this water vehicle
is to be used as a warship because the water vehicle is



- 1 more difficult to locate from a distance when lowered
from the hovercraft mode to the displacement mode.

In order to solve this problem the invention provides
5 that the floats each have a hull section which is
broadened inwardly in step-like manner at least along a
substantial portion of their total length, with said hull
sections being disposed above the respectively associated
displacement mode waterline, with said hull sections
10 serving to accommodate the main propulsion units, and
with said deck structure being attached to the upper end
regions of said hull sections.

In other words the broadening of the hull should
15 primarily take place inwardly, i.e. into the space
between the hulls, whereby slamming during rough seas is
largely avoided. For this purpose the enlargement in
width towards the inside should first take place a
significant distance from the bow of the ship.

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The travel comfort and travel stability during travel in
the displacement mode are substantially more favourable
as a result of the greater distance of the deck
structure or the deck superstructure from the water
25 line, because substantially higher waves can now pass
beneath the deck structure during heavy seas.

Accordingly it is possible to travel at relatively high
speeds in the displacement mode even with relatively
heavy seas. The greater distance of the deck structure
30 from the water line is also favourable during travel in
the hovercraft mode because in this way a softer
springing of the water vehicle on the air cushion is
obtained.

35 A further advantage of the invention lies in the fact
that the deck structure which connects the two floats at
the top can be kept free from the relatively bulky and

1 also noise generating propulsion units. A largely smooth
and much larger deck surface is thus available for the
placement of other superstructures. The substantial and
in particular step-like broadening of the floats above
5 the water line for travel in the displacement mode is of
considerable significance for the safety of the water
vehicle because in this way it is not only possible to
provide in advantageous manner a great deal of space for
the housing of the propulsion units and further devices
10 but instead a quite considerable reserve buoyancy is
simultaneously present which is advantageous during
heavy seas and also in the event that the underwater
part of the floats become damaged.

15 The invention thus provides a catamaran air cushion
water vehicle which also has troublefree running
characteristics during travel in the displacement mode
and which also represents a full quality water vehicle
during travel in the displacement mode.

20 It is thus important for the invention that the upper,
pronouncedly broadened part of the floats, namely the
hull section which accommodates the engines, is not
submerged below the water line either during travel in
25 the hovercraft mode or during travel in the displacement
mode, unless it is washed around by waves of greater or
lesser height during heavy seas. In other words the
stroke between the displacement mode and the hovercraft
mode is substantially less than the total height of the
30 floats. For this reason the displacement mode float
region which is provided in accordance with the
invention must be made sufficiently voluminous that the
water displacement which it produces corresponds to the
total weight of the water vehicle. This admittedly
35 signifies a somewhat larger running resistance of the
floats during travel in the displacement mode, this has
however hardly any effect, because of the lower speed of

- 1 the ship during travel in the displacement mode. In air
cushion operation the relatively voluminous displacement
mode float regions are in any event largely above the
surface, so that their higher resistance can no longer
5 have disadvantageous effects.

A particular advantage of the new concept of the present
invention is the fact that a particular water vehicle in
accordance with the invention can be converted in the
10 shortest possible time for example from operation as a
fast patrol boat to operation as a mine layer or as a
mine sweeper, whereby an increase in weight of from 100
to 200 tons must frequently be taken into account. In
this respect the high reserve buoyancy of the floats is
15 favourable because a slightly deeper submersion of the
floats which occurs with an increase in weight means
that heigher weights can be accepted in the simplest
manner without the floating position of the water
vehicle being substantially changed during travel in the
20 displacement mode. The distance of the water line from
the deck structure thus also remains largely unchanged
even with substantially increased loading of the deck
structure. The large reserve buoyancy of the hull
sections also has the advantage that the water vehicle
25 largely retain the same displacement mode running
characteristics even with large fluctuations in the
weights of deck structure or of apparatus arranged
thereon.

- 30 Fuel or water can be accommodated in the displacement
mode float regions.

It is particularly advantageous if each hull section
extends over almost the full length of the ship and
35 accommodates, in addition to the main propulsion units,
also further units such as fan drive units,
electrogenerators, air conditioning systems and water

1 preparation systems.

The main propulsion units should be arranged half-way along the ship for reasons of obtaining troublefree
5 trimming. This can be readily realised as a result of the accommodation of the propulsion aggregates in the upper region of the floats in accordance with the invention. For this purpose the said hull sections expediently have their largest widths half-way along the
10 ship.

In order to obtain favourable behaviour in rough seas, and to maintain high speeds when travelling in the displacement mode even in the event of heavy seas, the
15 invention provides, in accordance with a particularly preferred embodiment that the said hull sections become continuously narrower in the stem direction starting from the largest width, and in particular become narrower linearly, and finally no longer merge in
20 step-like manner but instead continuously into the displacement mode float region.

In order to provide a lot of reserve buoyancy and a lot of housing space the said hull sections should however
25 substantially retain the largest width in the direction of the stern.

An advantageous practical embodiment is characterised in that the height of the said hull sections half-way along
30 the ship amounts to 0.8 to 1.2 times the height of the displacement mode float region, and is in particular approximately the same as the height of the displacement mode float region.

35 A very favourable reserve buoyancy associated with a great deal of additional housing space results if the width of each float half-way along the ship at the

- 1 transition from the displacement mode float region to
the associated hull section increases by 30 to 70%,
preferably by 40 to 60% and in particular by
approximately 50% in substantially step-like manner,
5 preferably via gently rounded or inclined transition
regions of low height.

A further embodiment is so arranged that the floats
increase in width outwardly substantially continuously
10 and preferably in small steps. The steps serve to reduce
the wetted surface and thus the resistance.

Furthermore, it is advantageous if the transition region
from each displacement mode float region to the hull
15 section extends at an angle of approximately 20° to 40°
and in particular at an angle of about 30° to the
horizontal, which makes it possible for the vehicle to
settle more softly in heavy seas, i.e. makes sea travel
more comfortable.

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It is of particular significance that the inner walls of
the floats extend substantially parallel to one another
from the stem to the stern.

- 25 Whereas the outer sides of the shipward vehicle have a
curved profile in the longitudinal direction, the inner
sides of the floats should be parallel to a first
approximation in order to keep mutual influences between
the floats small. The floats represent a very slender
30 hull with parallel lines over at least two thirds of the
total length.

The broadening of the hull in the upper region of the
floats at the inner side is, viewed from the point of
35 view of its shape, an additional half hull of the
polygonal frame type.

A further advantageous embodiment is so constructed that

- 1 the keel line of the floats rises slightly from the stem to the stern, and indeed preferably linearly at an angle of 1 to 3° and in particular of approximately 2°.
- 5 In this way the higher buoyancy obtained in the rear region through broadening of the floats can be compensated for in order to obtain a horizontal floating position.
- 10 It is of importance for the safety of the ship that, in accordance with a further advantageous embodiment, the floats are subdivided by at least one, preferably by several decks, into buoyancy chambers which are sealed relative to one another. A deck should in particular be
- 15 located in the transition zone from the displacement mode float region to the associated hull section of each float.

If now one of the floats is damaged under water, and

20 thus becomes leaky, for example due to the explosion of a mine or the like, the floats in the region of the hull sections take over the float function and the vehicle still remains fully floating and manoeuvrable.

- 25 The invention can be used with particular advantage with an arrangement of the propulsion units of the type described in DE-OS 34 26 333. In this case the arrangement should, in accordance with the invention, be such that the main propulsion units, and optionally also
- 30 the fan drive units, are constructed as containers which are suspended at their top side from the deck structure and, at their lower side, are merely braced sideways and in the longitudinal direction against the structure of the floats.

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A further object of the invention is to substantially improve the buoyancy effect of the air cushion without

1 increasing the energy supply. For this purpose a further
embodiment of the invention, which can also be used with
advantage without the previously described features,
provides that the exhaust ducts of the combustion
5 engines of the main propulsion units, and in particular
also for the fan drive units, and preferably also of any
generators, open into the space bounded by the floats
and the skirts, in particular into the air space which
is located above the water surface during travel in the
10 displacement mode, with the air cushion pressure being
smaller than or the same as the exhaust gas pressure of
the attached combustion engines.

The exhaust gas pressure of the combustion engines for
15 the various drive units, which are preferably
constructed as Diesel engines, is thus additionally
exploited in advantageous manner to provide the air
cushion. This is possible, because the exhaust gas
pressure of normal Diesel engines lies in the order of
20 magnitude of 1800 mm of water column which is larger
than the buoyancy pressure generally present in the air
cushion.

In principle, all combustion engines can be connected in
25 this manner to the air space between the floats, it is
however primarily just the two main drive motors which
are so connected.

As a result of the invention it is however not only the
30 exhaust gas pressure but in particular also the volume
of exhaust gas which emerges from the combustion engines
which is exploited to provide the air cushion. In this
way the lifting capacity of the air cushion can be
increased by about 10%.

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A further advantage which is obtained by the exhaust gas
ducting of the invention, and which is particularly

1 important in warships, is the fact that the exhaust
gases are greatly cooled by mixing them with air and
also with water spray before they emerge from the rear
skirt. In this way the emitted infrared radiation is
5 considerably reduced and thus the location of a ship of
this kind as a result of infrared radiation is made
substantially more difficult. The omission of exhaust
gas ducts through the deck structure also represents a
substantial advantage of this embodiment.

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The opening of the exhaust ducts above the water line is
preferred because in this way less hull noise is
transferred to the body of water, so that sonar location
of the vehicle is made more difficult.

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Catamaran water vehicles with stabilizer fins arranged
on the floats at the inside are already known
(DE-OS 23 12 488).

20 A further object of the invention is however not only to
obtain a dynamic stabilisation of the water vehicle
without the fins which are necessary for this purpose
being exposed to damage, particular during manoeuvring
in harbours, but also to achieve additional effects
25 using the stabilizer fins.

In order to satisfy this object the invention provides
that stabilizer fins which are pivotable about
transverse axes are arranged at the lower end region of
30 the floats at the inside, with the stabilizer fins being
so controlled that they assist the transition from
travel in the displacement mode into travel in the air
cushion mode and/or the exceeding of a critical speed
range during travel in the hovercraft mode at higher
35 speeds. In particular a pair of stabilizer fins should
be provided at the stem. Stabilising fins can optionally
be provided in the stern region of the ship.

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The fact that the stabilizer fins extend inwardly into the space between the catamaran floats means that they move on the one hand in more uniformly flowing water and
5 on the other hand that the danger of them being damaged is considerably reduced. The control takes place not only for pitch damping but rather in particular also as a buoyancy aid in the transition from travel in the displacement mode to travel in the hovercraft mode. In
10 this way the lifting engines can be relieved and a power saving is made possible, in addition to exploiting the exhaust gas pressure of the Diesel engines. The combination of the air cushion with a certain lifting force of the stabilising fins, which are designed as
15 lift generating wings, has shown itself to be particularly favourable.

The stabilising fins have also proved to be favourable when a critical speed range lying about 25 knots is to
20 be exceeded during travel in the hovercraft mode. This critical speed range can be overcome with a small expenditure of energy by controlling the stabilizer fins at the stern in particular.

25 A particularly favourable stabilising fin arrangement is characterised in that one pair of stabilising fins is provided in the first third of the floats, and in particular in the first quarter of the floats, and two
30 pairs of stabilising fins in the last quarter of the floats - as viewed from stem to stern.

The control of the stabilising fins takes place primarily in such a way that the excursions of the
35 stabilising fins (angle of deflection) which are called up to stabilise the ship's movements are superimposed on the excursions which are required to lift the ship's hull during the transition into the hovercraft mode, or

1 to achieve a certain permanent lift.

The stabilisation by means of the stabilising fins is primarily provided for operation in the hovercraft mode, 5 the stabilisation can however also be used in accordance with the invention in expedient manner to make travel in the displacement mode substantially calmer and more stable.

10 A particular problem with hovercraft is the arrangement of sonar devices because the floats naturally operate, depending on the mode of travel, with very different drafts. A sonar apparatus which can be extended sideways out of the ship's hull and downwardly is already known 15 (Combat Craft, May 1983, page 101). Because of the out of center arrangement a one-sided moment is exerted on the ship when the sonar device is submerged below the water surface. A centrally extendable sonar apparatus is known from GB-PS 12 53 382.

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The invention seeks to provide an arrangement of the sonar device which is particularly suited for the catamaran air cushion water vehicle of the invention and which also takes on further functions. In this respect 25 the invention starts from the concept of a water vehicle wherein a downwardly extendable and retractable column carrying a sonar device at its lower end is arranged on the deck structure between the floats, with the lower end of the column being submersible below the water 30 surface both during travel in the displacement mode and during travel in the hovercraft mode.

In order to satisfy this object provision is made, in accordance with the invention, for a stabilising fin 35 arrangement at the lower end region of the column which preferably continuously lies beneath the water surface during travel in the displacement mode. The column is in

1 particular telescopically extendable and retractable.

It is particular expedient if in the retracted state of the column its lower end is located under water during
5 travel in the displacement mode. The sonar device is thus continuously in its working position during travel in the displacement mode. The sonar device only emerges from the water surface during travel in the hovercraft mode, can however be brought back into its operating
10 position by extending the column.

Thus, in accordance with the invention, the column of the sonar device is additionally exploited as a stabilising element. A three point support in
15 conjunction with the movable stabilising fins is particularly advantageous for this arrangement, with the stabilising fin arrangement at the lower end of the sonar column however generally not being adjustable, i.e. executing a purely static stabilising function.

20 In order to be able to transmit or receive from different directions the sonar device is expediently angularly adjustable. Furthermore, it is expedient if the stroke of the sonar device is larger than the height
25 difference between travel in the displacement mode and travel in the hovercraft mode and indeed is preferably 40 to 60% and in particular approximately 50% greater than this height difference. In this way different depths of the sonar device below the water surface can
30 be selected so that ideal matching to the requirements of a particular sonar oscillator is possible.

The column should be arranged at the center between the floats whereby moments which impair the course stability
35 of the moving ship can be effectively avoided.



1 The sonar device can, in accordance with the invention,
be active or passive. The stabilising fin arrangement
can also consist of a lift generating wing section which
as a whole is of circular shape. The sonar oscillator
5 can either sit between the lift generating vanes or be
built into the optionally circular structure of the
wing.

The sonar column should be submerged as little as
10 possible below the water surface for the prevailing
operating mode in order to avoid deleterious effects on
the running resistance as far as is possible.

The sonar devices are used for searching for submarines
15 and mines. The arrangement between the floats is also of
particular advantage because the individual hulls or
floats are too slender for a bow or hull installation.

Whereas a conventional sonar device requires a vertical
20 stroke of 3 to 4 m, which also impairs the stability of
the variable length column which must be correspondingly
constructed, it is possible, in accordance with the
invention, to use a substantially lower stroke which is
merely sufficient to compensate for the height variation
25 between travel in the displacement mode and in the
hovercraft mode. The decisive feature in this respect is
the fact that the sonar device remains continuously
submersed in water during travel in the displacement
mode. In this way the stroke can be substantially
30 reduced.

Whereas, during travel in the displacement mode the
speed lies at around 20 knots the speed of the ship
during operation in the hovercraft mode can be up to
35 40 knots.

- 1 In this respect the retractability of the sonar device so as to reduce the resistance is of particular significance.
- 5 A particular disadvantage of a known catamaran air cushion craft is the fact that the skirts provided at the stem and at the stern to bound the air cushion air space are continuously submersed below the water surface during travel in the displacement mode. In this way the
- 10 running resistance during travel in the displacement mode is considerably increased and the skirts are subject to rapid wear. This also applies to a catamaran water vehicle in accordance with CH-PS 495 248 in which the skirts are pivotable and are arranged to float on
- 15 the water surface.

In order to reduce the running resistance and to achieve troublefree running characteristics also when operating in the displacement mode the stem and/or stern skirts

20 can be moved out of their operating position for travel in the hovercraft mode, and can in particular be elevated, and preferably rearwardly pivoted, to such an extent that during travel in the displacement mode they no longer or only unimportantly contact the water

25 surface, at least in calm water.

This can be achieved in two ways. If one is concerned with a water vehicle in which a front skirt is formed by resilient pockets which are folded rearwardly and

30 rounded at the front, which are secured at the top to the deck structure and which are preferably flowed over by the lifting air from above during travel in the hovercraft mode, then the invention provides that pivot arms which extend substantially from the top downwardly

35 are secured in the front region of the pockets, are pivotable rearwardly about an upper transverse shaft and, on being pivoted, pivot the regions of the elastic

1 pockets which would come into contact with the water
surface during travel in the displacement mode upwardly
away from the water surface.

5 A further possibility is that the upper mounting of the
pockets remains unchanged when they are pivoted upwardly
and that the pockets are resiliently deformed. In the
latter case a chamber should be provided above the front
skirt to accommodate the elevated skirt.

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In order to ensure troublefree sealing during hovercraft
operation the stern skirt should extend into lateral
internal recesses of the floats.

15 If one is concerned with a hovercraft in which the rear
skirt consists of resilient pockets which extend
parallel to one another and are arranged substantially
behind one another, then the construction is preferably
such, in accordance with the invention, that the pockets
20 are connected to a source of air pressure and are
selectively inflated or relieved of pressure.

The ability to draw in the skirts during travel in the
displacement mode however not only reduces the running
25 resistance but also considerably reduces the wear of the
skirts. High speeds of 20 knots can only be obtained by
complete elimination of the running resistance created
by the skirts. The pivotability of the rear skirts can
be achieved relatively simply by a transversely
30 extending cushion construction and by a linkage
(actuation pneumatic) similar to that used for the hood
of a pram.

The ability to pivot the front skirt away from its
35 operating position means that it is necessary to provide
a special space to accommodate the skirt in the upwardly
pivoted state. In order to fold away the front skirt one

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1 can however also exploit the fact that the individual
resilient pockets are from their very nature
sufficiently resilient that they can yield to heavy
blows in rough seas. This flexibility can also be
5 exploited in such a way that the front skirt is so
resiliently deformed, by the action of mechanical
adjustment means, that all regions of the skirt are
brought above the water surface during travel in the
displacement mode without the provision of special
10 folding means.

In general a part of the air flow for generating the air
cushion is expelled in the area of the skirts in order
to stabilise the resilient skirts through the
15 corresponding pressure.

Instead of making the skirts so that they can be pivoted
upwardly they can also be made so that they can be drawn
in.
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The drawing in of the resiliently arranged skirts could
for example be achieved by lines arranged at their ends,
with the lines being capable of being drawn in by
suitable winches in order to swing the skirts upwardly.
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The skirts are preferably adjustable and fixable in
various intermediate positions between the position for
pure displacement travel and the position for pure
hovercraft travel. In this manner various states of
30 travel between pure displacement travel and pure
hovercraft travel can be realised, with the various
intermediate positions being dependent on the state of
the sea, or on the available draft, and also being
selectable in dependence on how high the vehicle is
35 allowed to project above the water surface from the
point of view of possible detection by the opponent.

1 The invention is particularly suitable for water
vehicles with a weight of 700 to 1000 tons (for example
mine layers).

5 It is particularly suited for fast patrol boats in the
speed range from 300 to 500 tons with it being possible
to achieve speeds of up to approximately 40 knots when
operating the hovercraft mode while speeds of 20 knots
can be achieved in the displacement mode.

10

The invention will now be described in the following in
more detail with reference to the drawings which show:

Fig. 1 a partly sectioned side view of a catamaran
15 air cushion water vehicle in accordance with
the invention,

Fig. 2 a partly sectioned plan view of the water
vehicle of Fig. 1, wherein only the port
20 half is illustrated because the starboard
half is of completely symmetrical construction
thereto,

Fig. 3 a schematic end on view of the water
25 vehicle of Figs. 1 and 2
with the starboard half showing the
lines of the stem of the ship and the port
half showing the lines of the stern of the
ship,

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Fig. 4 an enlarged view analogous to Fig. 3 to
symmetrically illustrate the arrangement
of various units in accordance with the
invention,

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Fig. 5 a schematic side view of a first embodiment
of the front skirt of the air cushion water

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1 vehicle of the invention,

Fig. 6 a schematic sectional view of the lines
VI-VI of Fig. 5,

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Fig. 7 a schematic partly sectioned side view of
a further embodiment of the front skirt of
a catamaran air cushion water vehicle in
accordance with the invention,

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Fig. 8 a schematic side view of an upwardly pivotable
stern skirt for the catamaran air cushion
water vehicle of the invention in the
operative position for the air cushion mode,
and

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Fig. 9 the same view as Fig. 8, however with the
rear skirt being shown in the upwardly
pivoted state.

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As seen in Figs. 1 to 3 the two floats 111 of a catamaran
air cushion water vehicle in accordance with the
invention have frames 0, 3, 6, 12, 18, 24 in the stern
part of the ship and frames 30, 36, 42, 48, 54 in the
stem part of the ship (forecastle).

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Stringer lines a, b, c, d, e, f are provided at the
outer side of the floats 111. Stringer lines I, II, III
and IV are provided on the inner side of the floats 111.

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The keel line is designated with the reference numeral
120.

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As seen in Figs. 1 to 4 a deck structure 113, which can
for example include a hull base 139 and a main deck 140
arranged spaced above it, extends between the upper ends
or sides of the floats 111. The main deck 140 is for

1 example surrounded by a breastwork or railing 141.

As seen in Fig. 4 further superstructures 143 and 144 can be provided on the main deck 140.

5

In accordance with the invention the two floats 111 are subdivided in accordance with Figs. 1 to 4 into a lower displacement mode float region 115 and a hull section 112 which is arranged above it.

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The precise lines of the hull section 112 which accommodates the machinery and of the displacement mode float region 115 can be seen in particular from Figs. 1 to 3. As seen in these figures the floats 111 become
15 broader in the displacement mode float region 115 at a relatively narrow angle with small steps 118 being provided at the outer sides which serve stabilisation purposes and to reduce the resistance.

20 At the inner side of each float there is however a transition region 117 which defines a clear step between the displacement mode float region 115 and the hull section 112, i.e. the hull section 112 is substantially broadened towards the inside relative to the
25 displacement mode float region 115, the word inside will be understood to mean here in the direction towards the space between the two floats. As, in accordance with Figs. 3 and 4, each hull section 112 also extends beyond the outer side than the displacement mode float region
30 115, as a result of the inclined shape of the outer walls, a broad accommodation chamber is formed in the upper half of each float 111 for accommodating the main propulsion units 114. As seen in Fig. 4 the main propulsion units are constructed as containers and are
35 suspended via damping support elements 145 by their upper sides from the structure of the floats 111 and/or from the deck structure 113.

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In the lower region the propulsion units 114 are simply braced by means of shock dampers 146 in the lateral direction and in the longitudinal direction (not illustrated) against the structure of the floats 111.

As seen in Fig. 1 the main propulsion aggregates 114 are housed half-way along the ship within the upper region of the floats 111. Drive shafts 147 which are only schematically illustrated in Figs. 1 and 4 act on the propellers 148 which are arranged at the ends of the floats 111.

Fan drive units or aggregates 116 are accommodated inside the hull sections 112 of the floats 111 in front of the main propulsion units 114. These fan drive units suck in air from the outside which is then expelled through outlet openings, which are illustrated, into the air space 125 (Figs. 3, 4) which is bounded at the sides by the floats 111, and at the front and at the rear by resilient skirts 123, 124 (Fig. 1).

It is important that the inner walls 119 of the floats 111 extend substantially parallel to one another in accordance with Fig. 2, at least from the region of the center of the ship to the stern. In the region of the forecastle the walls 119 extend slightly conically towards one another from the outside towards the inside.

The keel line 120 includes a small angle α of approximately 2° with the horizontal as shown in Fig. 1.

As seen in Fig. 4 the displacement mode float region 115 of each of the floats 111 is subdivided by two decks 121 into two buoyancy chambers which are sealed relative to one another. At the top the displacement mode float regions are sealingly closed by a deck 121'. The hull

1 section 112 only commences above this deck.

The subdivision of the floats via the decks 121, 121' ensures that if one of the buoyancy chambers should
5 become leaky then the remaining buoyancy chambers can still generate at least sufficient buoyancy that the water vehicle as a whole remains able to float.

As seen in Fig. 4 the exhaust ducts 122 of the main
10 propulsion units 114, which contain Diesel engines, are led to the inner walls 119 of the floats 111 where they emerge into the air space 125 substantially above the water line WLO for travel in the displacement mode.

15 The catamaran air cushion craft of Figs. 1 to 4 floats during travel in the displacement mode at the water line WLO (Fig. 4), i.e. during travel in the displacement mode in calm water the hull sections 112 of the floats 111 lie above the water surface WLO. A distance of 1 to
20 3, in particular of approximately 2 m thus remains between the water line WLO and the deck structure 113 for its base 139. The water vehicle can now travel as a normal catamaran with the deck structure being largely protected against flooding as a result of waves by the
25 high free space between the water line WLO and the hull base 139.

The low arrangement of the main propulsion units 114 make it possible to keep the inclination of the drive
30 shafts 147 (Fig. 1) relatively low, which is also assisted by the arrangement of the propulsion units approximately at the middle of the ship.

By sinking the propulsion units 114, 116 into the floats one obtains a largely free deck surface on which other
35 suitable superstructures can be housed.

- 1 As the exhaust gases flowing through the exhaust ducts
122 also flow between the catamarans 111 during travel
in the displacement mode they are well mixed with air
and optionally with water spray before they emerge at
5 the stern of the vehicle, so that they emerge strongly
cooled from the ship's hull and thus make infrared
detection substantially more difficult.

- As seen in Figs. 1, 2 and 4 stabilizer fins 127 which
10 are pivotable about transverse axes 127 are provided
right at the bottom at the inner side of the floats 111.
The stabilizer fins can be actuated from a central
control unit both in the sense of an anti-roll action
and also in the sense of an anti-pitching action.
15 Moreover, the stabilising fins 126 can be slightly
inclined for the purpose of a simple transition of the
water vehicle from operation in the displacement mode to
operation in the hovercraft mode. As seen in Fig. 1 the
stabilising fins 126 are provided in the front regions
20 of the floats 111.

- When the water vehicle is to be operated in the
hovercraft mode the ventilator units 116 (Fig. 1) are
switched on whereupon the air sucked in from the outside
25 is forced in manner not shown into the air space 125.
The air pressure and the quantity of the air are
calculated in such a way that the vehicle is now lifted
up to the waterline WL1 (Fig. 4), with the displacement
mode float regions 115 of the floats 111 only being
30 submersed to a small degree below the water surface, so
that on the one hand a stabilising effect is achieved
and so that on the other hand the drive propellers 148
are still sufficiently deeply submerged below the water
surface and can thus generate the required propulsive
35 thrust.

1 The exhaust gases of the main propulsion units 114 which
emerge from the exhaust ducts 122 into the air space 125
and optionally also the fan propulsion units 116 and any
Diesel generators assist in lifting the water craft. The
5 stabilising fins 126 can be so inclined that they also
contribute to the buoyancy which is in particular
important for a easy transition from travelling in the
displacement mode to travelling in the hovercraft mode
because then the units provided for generating the air
10 cushion can be made somewhat less powerful.

In accordance with Figs. 1, 2 and 4 a sonar device 138
is arranged in the front region of the water vehicle on
the deck structure 113 at the center between the floats
15 111. The sonar device has a central telescopic column
129 which projects downwardly from the hull base 139
and the sonar device 128 which can be actively and/or
passively operated is located at the lower end of the
central telescopic column. Alongside the sonar device
20 the column 129 has stabilising fins 130 at its lower
end. The stabilising fins can have a lifting wing
profile and can also be made circular with the sonar
device 128 at the center.

25 When travelling in the displacement mode the column 129
is fully retracted in accordance with Fig. 1, with the
sonar device 128 and the stabilising fins 130 being
submersed slightly below the water line WLO and being
operational.

30

In the extended state the telescopic column 129 adopts
the position shown in Fig. 4 in which the sonar device
128 and the stabilising fins 130 are also submerged
below the water line WL1 for hovercraft operation when
35 travelling in the hovercraft mode.

- 1 In accordance with Fig. 5 the front skirt 123 of the
catamaran air cushion craft consists of individual
resilient pockets 131 which are manufactured of a
resilient material, for example reinforced rubber, and
5 which each have reinforcements at their upper edges and
a connection lug at their centers.

Numerous resilient pockets 131 of this kind are arranged
alongside one another in order to form the skirt 123
10 (Fig. 6).

As seen in Fig. 5 the pockets 131 open at the top at an
intermediate floor 151 which is provided with holes 149.
Air is blown through the intermediate floor 151 in the
15 direction of the arrows 150 from the fans (which are not
illustrated) during hovercraft operation. This not only
generates the air cushion but also so stiffens the
resilient pockets 131 that they adopt the position which
can be seen from Fig. 5.

20 In accordance with the invention, and as shown in Figs.
5 and 6, pivotal arms 132 are arranged in the front
rounded regions of the pockets 131 and are fixedly
connected with the pocket material. At the top the pivot
25 arms 132 are mounted on a transverse throughshaft 133
about which the skirt 123 as a whole can be rearwardly
pivoted so that the pockets 131 adopt the rearwardly
pivoted position shown in broken lines in Fig. 5. The
decisive feature is the fact that the resilient pockets
30 131 are hereby lifted above the water line WLO during
travel in the displacement mode so that in this case the
front skirt 123 no longer contacts the water surface, at
least in calm water, which signifies a substantial
reduction of the running resistance. The pivotal
35 movement can be affected by means of a cable 155 which
acts at the lower edge of the skirt 123, or by a
hydraulic cylinder or pulling device 155' which acts on



1 the pivot arms 132.

The resilient pockets 131 of the front skirt 123 can also be pivoted further upwardly if the intermediate
5 floor 151 together with the holes 149 is also pivoted upwardly together with it. In each case a room 134 must be provided above the skirt 123 to accommodate it. In the extreme case the skirts 123 can be pivoted upwardly sufficiently far that they no longer project into the
10 air space 125 between the floor of the hull and the water line WLO which results in an ideal reduction in resistance even during heavy sea movement. Furthermore, in the embodiment of Fig. 7, provision is made for a hydraulic device 155' to act on a pivotal arm 133' in
15 order to pivotally move the skirt 123.

A transversely extending resilient skirt 124 is likewise provided in the stern region of the catamaran air cushion craft of the invention, as can be seen from
20 Figs. 1, 2 and 8. The resilient skirt 124 consists of resilient pockets 137 which are arranged behind (and above) one another and which can be displaced essentially about a transverse axis 135 (Figs. 1 and 2) into the retracted position of Fig. 9, for example by
25 means of pneumatic or hydraulic take in cable drive 152 (Fig. 8). The cables 152' act on the lower end of the skirt 124.

In order to provide the pockets which are arranged
30 behind one another in Fig. 8 with adequate stability in conjunction with good resilience the frontmost wall 153 of the frontmost pocket 137 is provided with a synthetic or plastic support 153' so that it is of somewhat stiffer construction.

35

The resilient pockets 137 are inflated into the position shown in Figs. 1 and 8 by connecting them to a source of



1 pressurised air (arrow in Figs. 8, 9) which endows them
with the required stiffness. By letting out the air,
i.e. by lowering the pressure and taking in the cable
152' by means of the drive 152 into position shown in
5 Fig. 9 the pockets 137 can be upwardly swung completely
out of the zone of the air space 125 so that it lies
clearly above the water line WLO for travel in the
displacement mode during travel in the displacement mode
and thus likewise does not contribute to the running
10 resistance during travel in the displacement mode and
cannot be damaged.

As seen in Fig. 2 the stern skirt extends laterally into
recesses 136 of the floats 111 whereby good sealing
15 against the undesired escape of air during hovercraft
operation is obtained in this region.

It should also be pointed out that the skirts terminate
somewhat above the water surface during hovercraft
20 operation, i.e. that a small gap remains between the
lower edges of the skirts and the water surface whereby
a particularly low running resistance is obtained while
travelling in the hovercraft mode, and the wear of the
skirts can also be kept very low during travel in the
25 hovercraft mode.

The length of the ship illustrated in Figs. 1 to 3
amounts to ca. 55 m, the width to ca. 16 m and the
draught to ca. 4 m.

30 It will be understood that the reference numerals in the
claims are included purely to make the claims easier to
follow and that they shall not be considered to have
any restrictive effect on the scope of the claims.

35



1 Claims:

1. Catamaran air cushion water vehicle comprising:
two spaced apart floats which extend parallel to one
5 another in the direction of travel, and which have a
float region (115) which is submerged during travel in a
displacement mode and defines a displacement travel
waterline (WLO), wherein the cross-sections of the floats
become broader from the bottom to the top and wherein
10 the floats are rigidly connected together at the top by
a deck structure;
skirt means which are arranged at the stem and at the
stern between the floats, which extend at least approx-
imately to the water surface and, together with the
15 floats, bound an air space between the base of the deck
structure and the water surface; main propulsion units
which drive propulsion means arranged in the stern region
of the floats; and fans which blow air sucked in from the
outside into the bounded air space, beneath the bottom of
20 the deck structure in order to lift the water vehicle
from travel in the displacement mode to travel in an air
cushion (hovercraft) mode; characterised in that the
floats (111) each have a hull section (112) which is
broadened inwardly in step-like manner, at least along a
25 substantial portion of their total length, with said hull
sections being disposed above the respectively associated
displacement mode waterline (WLO), with said hull sect-
ions (112) serving to accommodate the main propulsion
units (114), and with said deck structure (113) being
30 attached to the upper end regions of said hull sections
(112).
2. A water vehicle in accordance with claim 1, characterised
in that the hull-section (112) extends over almost the
35 full length of the ship and accommodates, in addition to
the main propulsion units (114), also further units, such
as fan drive units (116), electrogenerators, air-con-
ditioning systems, and water preparation systems.



- 1 3. A water vehicle in accordance with claim 1 or claim 2,
characterised in that the main propulsion units (114)
are arranged half-way along the ship.
- 5 4. A water vehicle in accordance with one of the preceding
claims, characterised in that the hull sections (112)
have their largest widths half-way along the ship.
- 10 5. A water vehicle in accordance with claim 4, character-
ised in that the hull sections (112) become continuously
narrower in the stem direction (forward direction) start-
ing from the largest width, and in particular become
narrower linearly, and finally no longer merge in step-
like manner but instead continuously into the associated
15 displacement mode float region (115).
- 20 6. A water vehicle in accordance with claim 4 or claim 5,
characterised in that the hull sections (112) substan-
tially retain the largest width in the stem direction
(rearward direction).
- 25 7. A water vehicle in accordance with one of the preceding
claims, characterised in that the height of the said
hull sections (112) half-way along the ship amounts
to 0.8 to 1.2 times the height of the associated dis-
placement mode float region (115) and is in particular
approximately the same as the height of the displacement
mode float region (115).
- 30 8. A water vehicle in accordance with one of the preceding
claims, characterised in that the width of each float
(111) half-way along the ship at the transition from the
displacement mode float region (115) to the hull section
(112) increases by 30 to 70%, preferably by 40 to 60% and
35 in particular by approximately 50% in substantially step-
like manner, preferably via gently rounded or inclined
transition



1 regions (117) of low height.

9. A water vehicle in accordance with one of the preceding claims, characterised in that the floats (111) increase in width outwardly substantially continuously and preferably in small steps (118).

10. A water vehicle in accordance with one of the preceding claims, characterised in that the transition region (117) from each displacement mode float region (115) to the associated hull section (112) extends at an angle of 20 to 40° and in particular at an angle of approximately 30° to the horizontal.

11. A water vehicle in accordance with one of the preceding claims, characterised in that the inner walls (119) of the displacement mode float region (115) extends substantially parallel to one another from the stem to the stern.

12. A water vehicle in accordance with one of the preceding claims, characterised in that the keel line (120) of the floats (111) rises slightly from the stem to the stern and indeed preferably linearly at an angle of 1 to 3° and in particular of approximately 2°.

13. A water vehicle in accordance with one of the preceding claims, characterised in that the floats (111) are subdivided by at least one and preferably by several decks (121, 121') into buoyancy chambers which are sealed relative to one another.

14. A water vehicle in accordance with claim 13, characterised in that a deck (121') is located in the transition region (117) from the displacement mode float region (115) to the hull section (112).



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15. A water vehicle in accordance with one of the preceding claims, characterised in that the main propulsion units (114) and optionally also the fan drive units (116) are constructed as containers which are
5 suspended at their top side on the deck structure (113) and/or float structure and at their lower side are merely braced sideways and in the longitudinal direction against the structure of the floats.
- 10 16. A water vehicle, in particular in accordance with one of the preceding claims, characterised in that the exhaust ducts (122) of the combustion engines for the main propulsion units (114), and in particular also for
15 the fan drive units (116), preferably also of any generators, open into the space bounded by the floats (111) and the skirts (123, 124), in particular into the air space (125) which is located above the water surface during travel in the displacement mode, with the air cushion pressure being smaller or the same as the
20 exhaust gas pressure of the attached combustion engines.
17. A water vehicle in particular in accordance with one of the preceding claims, characterised in that stabilizer fins (126) which are pivotable about
25 transverse axes (127) are arranged in the lower end region of the floats (111) at the inside, i.e. between the floats, with the stabilizer fins being so controlled that they assist the transition from travel in the displacement mode into the air cushion mode and/or
30 assist the exceeding of a critical speed range during travel in the hovercraft mode at higher speeds.
18. A water vehicle in accordance with claim 17, characterised in that a pair of stabilizer fins (126) is
35 provided at the stem which are so controlled that they assist the transition from travel in the displacement mode into travel in the hovercraft mode and/or assist



(45)

1 the exceeding of a critical speed range during travel in
the hovercraft mode at higher speeds.

19. A water vehicle in accordance with claim 17 or claim
5 18, characterised in that a further pair of stabilising
fins are providing in the stern region of the floats
(111) and are so controlled that they assist the
transition from travel in the displacement mode to
travel in the hovercraft mode and/or assist the
10 exceeding of a critical speed range during travel in the
hovercraft mode at higher speeds.

20. A water vehicle, in particular in accordance with
one of the preceding claims, wherein a downwardly
15 extendable and retractable column carrying a sonar
device at its lower end is arranged on the deck
structure between the floats, with the lower end of the
column being submersible below the water surface both
during travel in the displacement mode and during travel
20 in the hovercraft mode, characterised in that a
stabilising fin arrangement (13) is provided at the
lower end region of the column (129) which preferably
continuously lies beneath the water surface during
travel in the displacement mode.

25 21. A water vehicle in accordance with claim 20,
characterised in that the column (129) is telescopically
extendable and retractable.

30 22. A water vehicle in accordance with claim 20 or claim
21, characterised in that, in the retracted state of the
column (129), its lower end is located under water
during travel in the displacement mode.

35 23. A water vehicle in accordance with one of the claims
20 to 22, characterised in that the sonar device (128)
is angularly adjustable.



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24. A water vehicle in accordance with one of the claims 20 to 23, characterised in that the stroke (H) of the sonar device (128) is larger than the height difference
5 between travel in the displacement mode and travel in the hovercraft mode, and indeed is preferably 40 to 60% and in particular approximately 50% greater than this height difference.

10 25. A water vehicle in accordance with one of the claims 20 to 24, characterised in that the column (129) is arranged at the center between the floats (111).

15 26. A water vehicle, in particular in accordance with one of the preceding claims, characterised in that the stem and/or stern skirts (123; 124) can be moved out of their operating position for travel in the hovercraft mode, and can in particular be elevated and preferably rearwardly pivoted, to such an extent, that during
20 travel in the displacement mode they no longer or only unimportantly contact the water surface, at least in calm water.

25 27. A water vehicle in accordance with claim 26, wherein the front skirt is formed by resilient pockets which are folded rearwardly and rounded at the front, which are secured at the top to the deck structure and which are preferably flowed over by the lift air from above during travel in the hovercraft mode, characterised in that
30 pivot arms (132) which extend substantially from the top downwardly are secured in the front region of the pockets (131), are pivotable rearwardly about an upper transverse shaft (133) and, on being pivoted, pivot the regions of the elastic pockets which come into contact
35 with the water surface during travel in the displacement mode upwardly away from the water surface.



- 1 28. A water vehicle in accordance with claim 26 or claim
27, characterised in that, when being upwardly pivoted
the upper mounting of the pockets (131) remains
unchanged and the pockets are resiliently deformed.
- 5 29. A water vehicle in accordance with claim 26 or claim
27, characterised in that a chamber (134) is provided
above the front skirt (123) for accommodating the
elevated skirt (123).
- 10 30. A water vehicle in accordance with claim 26,
characterised in that the stern skirt (124) extends into
lateral internal recesses (136) of the floats (111),
with the side end faces being sealed relative to the
15 sidewalls of the recesses (136).
- 20 31. A water vehicle in accordance with claim 26 or claim
30, wherein the stern skirts consist of resilient
pockets which extend parallel to one another and are
arranged substantially behind one another, characterised
in that the pockets (13) are attached to a source of air
pressure and are selectively inflated or relieved of
pressure.
- 25 32. A water vehicle in accordance with one of the claims
26 to 31, characterised in that the skirts (123, 124)
can be moved into and fixed in intermediate positions
between the position for travel in the pure displacement
mode and the position for travel in the pure hovercraft
30 mode.
- 35 33. A water vehicle substantially as herein described
with reference to and as shown in the accompanying
drawings.