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Description

Catamaran Air Cushion Water Vehicle

The invention relates to a catamaran air cushion water vehicle in accordance with the preamble of claim 1.

In a catamaran air cushion water vehicle of this kind, known from Combat Craft, March 1984, pages 46 to 48, the upper float region which has the inwardly directed broadening and which receives the main propulsion units is located in major portion below the water line during travel in the displacement mode, such that the water masses flowing between the floats in the displacement mode are constricted, which leads to a considerable resistance to travel during travel in the displacement mode.

Consequently, the travel in displacement mode can be finally regarded as a non-desired travel condition with a catamaran air cushion water vehicle realized in this manner, and used for example only for harbour manoeuvres or in case of emergency. Because of the deep arrangement of the broadening formed by the hull section and the transition region, the free space between the water surface in the displacement mode and the deck structure is also reduced to such an extent that even with mild sea conditions there are additionally disadvantageous conditions for the travel in displacement mode because of wave impacts.

Finally, the height of the air cushion during travel in the hovercraft mode is comparatively small, which leads to a relatively hard and unelastic travel behaviour during travel

in the hovercraft mode. Because of the inner surfaces of the floats located just above the water line during travel in the hovercraft mode and projecting inwardly and upwardly under a relatively high, flat angle, the stability of the known catamaran air cushion water vehicle is further unsufficient in the case of heeling, since because of these inclined inner surfaces the lift center generated by the air cushion is displaced towards the side of the air cushion water vehicle which is already strongly raised, and produces therefore an additional significant heeling torque.

The object of the present invention is to realize a catamaran air cushion water vehicle of the kind mentioned at the beginning, which also allows a constant and in particular resistance-free and calm travel in the displacement mode, the travel behaviour, in particular the stability and the damping behaviour during travel in the hovercraft mode being simultaneously improved.

The features of the characterizing portion of claim 1 are provided to solve this problem.

According to the invention, the upper float region which comprises the broadening formed by the hull section with the transition region is located above the water line during travel in the displacement mode, such that the constriction existing in this region between the surfaces of the two floats is not flowed through by the water, and there is therefore no corresponding increase in resistance. Rather, even during travel in the displacement mode, only the relatively narrow float regions located below the broadening or the hull section, i.e. the lower float regions during travel in the displacement mode of the two floats penetrate into the water.

Owing to the step-like broadening in the transition region of the hull section above the lower displacement float region towards the interior, one obtains a space particularly well adapted for accommodating the main propulsion units preferably realized in the form of a container.

In this case it appears further advantageous when the hull section of the floats which accommodates the main propulsion unit and which begin only above the water line during travel in the displacement mode are significantly higher than in the prior art, such that the free space or air space between the water line during travel in the displacement mode and the underside of the deck structure is increased. In this way, the navigation behaviour of the catamaran air cushion water vehicle is significantly improved during travel in the displacement mode, since then much higher waves can flow under the deck structure during rough seas. It is thus possible to travel at still relatively high speeds during travel in the displacement mode in rough seas. During travel in the air cushion or hovercraft mode, the significantly higher air cushion ensures a smoother springing of the water vehicle on the air cushion.

Since the lower displacement float regions can be realized upwardly relatively narrow because of the displacements of the broadening, i.e. of the transition region of the hull section, the off-set of the lift center of the air cushion is significantly reduced during heeling of the water vehicle during travel in the hovercraft mode, such that the stability of the catamaran air cushion water vehicle is also improved during displacements in the hovercraft mode.

When the catamaran air cushion water vehicle of the invention is used as a warship, the possibility to effect a

transition of the water vehicle from the hovercraft mode to the displacement mode while maintaining a perfect travel behaviour in terms of manoeuverability, of economy, of stability and of travel comfort, constitutes a particular advantage since the water vehicle can be hardly located from a distance.

The step-like broadening of the floats in the transition region of the hull section above the water line during travel in the displacement mode is particularly significant for the safety of the water vehicle, since in this way not only much place is achieved for the accommodation of propulsion units and further apparatuses, but there is also simultaneously a much higher buoyancy reserve, which is advantageous in case of rough seas and also in the event that the under water part of the floats, i.e. the displacement float regions, become damaged.

In accordance with the invention, the stroke between the displacement mode and the hovercraft mode is substantially less than the total height of the floats. The step-like broadening in the form of the transition region of the hull section in the upper region of the floats and at their inner side has the form of an additional shipbody of the bent frame type.

The arrangement according to the invention of the hull section inwardly broadened in a step-like manner by means of the transition region above the water line during travel in the displacement mode provides the further advantage that during transition from the travel in the displacement mode to travel in the hovercraft mode there is no need to firstly overcome a high resistance between the floats. The relatively narrow displacement float regions exhibit in the travel direction only a comparatively small displacement

surface and the water can also flow between the floats without further constriction. This leads during the acceleration that on the one hand a reduced power is sufficient for this purpose, and on the other hand that higher acceleration values can be attained, which is particularly significant for warships.

A further advantage of the present invention is the fact that a fast patrol boat constructed in accordance with the invention can be inverted in the shortest possible time for example 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 (caused by the step-like broadened hull section and which becomes effective by small draught increase) is 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 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 step-like broadened hull sections above the water line in displacement mode also has the advantage that the water vehicle largely retain the same displacement mode running characteristics even with large fluctuations in the weights of deck structure or of apparatus arranged thereon.

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

It is particularly advantageous if each hull section extends in accordance with claim 2 over almost the full length of

the ship and accommodates, in addition to the main propulsion units, also further units such as fan drive units, electrogenerators, air conditioning systems and water preparation systems.

The main propulsion units should be arranged in accordance with claim 3 half-way along the ship for reasons of obtaining troublefree 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, thus in the hull section. For this purpose the said hull sections expediently have their largest widths half-way along the 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 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 advantageously become narrower linearly, and finally no longer merge in 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 substantially retain the largest width in the direction of the stern, in accordance with claim 5.

An advantageous practical embodiment in accordance with claim 6 is characterized in that the height of the said hull sections half-way along the ship amounts to 0.8 to 1.2 times the height of the displacement mode float region, and is advantageously approximately the same as the height of the displacement mode float region, such that during travel in

the displacement mode there exists a free space above the water line and up to the deck structure, in correspondence with the draught.

A very favourable reserve buoyancy associated with a great deal of additional housing space results in accordance with claims 7 and 8 if the width of each float half-way along the ship at the 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 50 % in substantially step-like manner, preferably via gently rounded or inclined transition regions of low height, for deflecting the water inwardly in case of wave impact.

A further embodiment in accordance with claim 9 is so arranged that the floats increase in width outwardly substantially continuously and preferably in small steps. The steps serve to reduce the wetted surface and thus the resistance.

Furthermore, it is advantageous in accordance with claim 10 if the transition region from each displacement mode float region to the hull section extends at an angle of approximately 20 to 40° and particularly advantageously to 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.

It is of particular significance, as indicated in claim 11, that the inner walls of the floats extend substantially parallel to one another from the stem to the stern. 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 and

to avoid the constriction of water masses flowing between the latter. The floats represent a very slender hull with parallel lines over at least two thirds of the total length.

In the variant in accordance with claim 12, the partial parallel extension of the inner walls is so small that there occurs no noticeable resistance increase. Thereby, an excessive bulging of the floats on the outer sides is avoided.

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

A further advantageous embodiment in accordance with claim 12 is so constructed that the keel line of the floats arises slightly from the stem to the stern, and indeed preferably linearly at an angle of 1 to 3° and in particular of approximately 2°.

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.

It is of importance for the safety of the ship that, in accordance with a further advantageous embodiment as in claims 14 and 15, 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 located in the transition zone from the displacement mode float region to the associated hull section of each float, whereby achieving an intermediate floor for the attachment of the main propulsion units among others, as a further advantage.

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

An arrangement in accordance with claim 16 is particularly advantageous. In this case the arrangement should, in accordance with the invention, be such that the main propulsion units, and optionally also 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.

The buoyancy effect of the air cushion can be improved without increasing the energy supply, if in accordance with claim 17 in a further embodiment of the invention, the exhaust ducts of the combustion engines of the main propulsion units, and in particular also of 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 displacement mode, with the air cushion pressure being smaller than or the same as the exhaust gas pressure of the attached combustion engines. In this way, the exhaust ducts can be further kept particularly short.

The exhaust gas pressure of the combustion engines for 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 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 this manner to the air space between the floats, it is however primarily just the two main drive units which are so connected.

As a result of the invention it is however not only the 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 %.

A further advantage which is obtained by the exhaust gas ducting of the invention, and which is particularly important in warships, is the fact that the exhaust gases are greatly cooled in mixing them with air and also with water spray before they emerge from the rear skirt. In this way the emitted infrared radiation is 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.

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.

Catamaran water vehicles with stabilizer fins arranged on the floats at the inside are already known (DE-OS 23 12 488), which allow, in an arrangement according to claims 18 to 20 not only to obtain a dynamic stabilisation

of the water vehicle without the fins which are necessary for this purpose being expose to damage, particular during manoeuvring in harbours, but also to achieve additional effects.

Thus, stabilizer fins which are pivotable about transverse axes are arranged at the lower end region of 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 speeds. In particular a pair of stabilizer fins should be provided at the stem. Stabilizer fins can optionally be provided in the stern region of the ship.

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 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 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 stabilizer fins, which are designed as lift generating wings, has shown itself to be particularly favourable.

The stabilizer fins have also proved to be favourable when a critical speed range lying about 25 knots is to 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.

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

The control of the stabilizer fins takes place primarily in such a way that the excursions of the stabilizer fins (angle of deflection) which are called up to stabilize 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 to achieve a certain permanent lift.

The stabilisation by means of the stabilizer fins is primarily provided for operation in the hovercraft mode, 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.

Particularly advantageous arrangements of the catamaran air cushion water vehicle are described in claims 21 to 24, wherein a downwardly extendable and retractable telescopic 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 during travel in the hovercraft mode and being always located under water during travel in the displacement mode. The sonar device is thus continuously in its working position somewhat below the water line of displacement mode 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 position by extending the telescopic column.

The column is additionally exploited as a stabilising element by means of stabilising fins located in the region of the retracted column lying below the water line of displacement mode. A three point support in conjunction with the movable stabilising fins is particularly advantageous for this arrangement, with the stabilising fin arrangement at the lower end of the column however generally not being adjustable, i.e. executing a purely static stabilising function.

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 difference between travel in the displacement mode and travel in the hovercraft mode and indeed is advantageously 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 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 of the moving ship can be effectively avoided.

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 can either sit between the lift generating vanes or be built into the optionally circular structure of the wing.

The column should be submerged as little as 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 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 installations.

Whereas a conventional sonar device requires a vertical 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 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 submerged in water during travel in the displacement mode. In this way the stroke can be substantially 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 40 knots.

In this respect the retractability of the sonar device so as to reduce the resistance is of particular significance.

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 submerged below the water surface during travel in the displacement mode. In this way the running resistance

during travel in the displacement mode is considerably increased and the skirts are subject to rapid wear. This also applied to a catamaran water vehicle in which the skirts are pivotable and are arranged to float on the water surface.

In order to reduce the running resistance and to achieve troublefree running characteristics also when operating in the displacement mode claim 25 provides that the stem and/or stern skirts 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 surface, at least in calm water.

It is particularly advantageous if, according to claim 26, the stem skirt can be upwardly pivoted to such an extent that it does not project in the air space between the bottom of the deck structure and the water line during travel in the displacement mode.

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 rounded at the front, which are secured at the top of the deck structure and which are preferably flowed over by the lifting air from above during travel in the hovercraft mode.

Claim 27 provides that pivot arms which extend substantially from the top downwardly are secured in the front region of the pockets, are pivotable rearwardly about an upper transverse shaft and, on being pivoted, pivot the region of the elastic pockets which would come into contact with the

water surface during travel in the displacement mode upwardly away from the water surface.

A further possibility in accordance with claim 28 is that the upper mounting of the pockets remain unchanged when they are pivoted upwardly and that the pockets are resiliently deformed. In all cases a chamber should be advantageously provided above the front skirt to accommodate the elevated skirt, as described in claim 29.

In order to ensure troublefree sealing during hovercraft operation the stern skirt should extend into lateral internal recesses of the floats, in accordance with claim 30.

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 claim 31, that the pockets 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 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 extending cushion construction and by a linkage with pneumatic actuation similar to that used for the hood of a pram.

The ability to pivot the front skirt away from its operating position means that it is expedient to provide a special

state to accommodate the skirt in the upwardly pivoted state. In order to fold away the front skirt one 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 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 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 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.

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 or raise the skirts upwardly.

In accordance with claim 32, 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 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 allowed to project above the water surface from the point of view of possible detection by the opponent.

The invention is particularly advantageously applicable to catamaran air cushion vehicles with a weight of 700 to 1000 tons (for example mine layers).

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.

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 air cushion water vehicle,
- Fig. 2 a partly sectioned plan view of the water vehicle of Fig. 1, wherein only the port half is illustrated because the starboard half is of completely symmetrical construction thereto,
- Fig. 3 a schematic end on view of the water 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,
- Fig. 4 an enlarged view analogous to Fig. 3 to symmetrically illustrate the arrangement of various units,

- Fig. 5 a schematic side view of a first embodiment of the front skirt of the air cushion water vehicle,
- Fig. 6 a schematic sectional view of the lines VI-VI of Fig. 5,
- Fig. 7 a schematic partly sectioned side view of a further embodiment of the front skirt of a catamaran air cushion water vehicle,
- Fig. 8 a schematic side view of an upwardly pivotable stern skirt for the catamaran air cushion water vehicle in the operative position for the air cushion mode, and
- Fig. 9 the same view as Fig. 8, however with the rear skirt being shown in the upwardly pivoted state.

As seen in Figs. 1 to 3 the two floats 11 of a catamaran air cushion water vehicle in accordance with the invention have frames 0, 3, 6, 9, 12, 15, 18, 21, 24, 27 in the stern part of the ship and frames 30, 33, 36, 39, 42, 45, 48, 51, 54 in the stem part of the ship (forecastle).

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.

The keel line is designated with the reference numeral 120.

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 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.

The two floats 111 comprise in accordance with Figs. 1 to 4 a lower displacement mode float region 115 lying above the water line WLO during travel in displacement mode and an upper float region as a hull section 112 which is arranged above the water line WLO in displacement mode.

The precise lines of the floats 111 and thus of the hull sections 112 which accommodates the machinery and of the displacement mode float region 115 can be seen in Figs. 1 to 3. As seen in these figures the floats 111 become broader in the lower 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.

At the inner side of each float there is however a step-like transition region 117 which defines a clear step between the displacement mode float region 115, which has an inner wall 119 (Fig. 4) only slightly inclined to the vertical, and the hull section 112, i.e. the hull section 112, which as upper float region represents a broadening, is substantially broadened towards the inside relative to the lower displacement mode float region 115. As, in accordance with Figs. 3 and 4, each hull section 112 also extends beyond the outer side farther than the displacement mode float region 115, as a result of the inclined shape of the outer walls, a broad accommodation chamber having a significantly higher width 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 suspended via damping support elements 115 by their upper sides from the structure of the floats 111 and/or from the deck structure 113.

In the lower region the main propulsion units 114 are simply braced by means of shock dampers 114 in the lateral direction and in the longitudinal direction (not illustrated) against the floats 111 by means of an intermediate floor formed by a deck 121'.

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 inside the hull section 112. Drive shafts 147 which are only schematically illustrated in Figs. 1 and 4 act on the propeller 148 which are arranged at the ends of the floats 111 and form the propulsion units.

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 inner 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 lower 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 115 are sealingly closed by a deck 121'. The hull 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 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 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.

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 as upper regions of the floats 111 lie above the water surface WLO. A distance of 1 to 3, in particular of approximately 2 m thus remains between the water line in displacement mode WLO and the deck structure 113 for its base 139. The water vehicle can now travel in displacement mode as a normal catamaran with the deck structure being largely protected against flooding as a result of waves by the high free space between the water line WLO in the displacement mode and the hull base 139.

In hovercraft displacement mode, the water-vehicle is located over the water line WLO1 in hovercraft mode (Fig.4).

The low arrangement of the main propulsion units 114 make it possible to keep the inclination of the drive shafts 147 (Fig. 1) relatively low, which is also assisted by the arrangement of the propulsion units 114, 116 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 suitable superstructures 143, 144 can be housed.

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 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 126 which are pivotable about transverse axes 127 are provided right at the bottom at the inner sides 119 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. Moreover, the stabilizer 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 stabilizer fins 126 are provided in the front regions of the floats 111.

When the water vehicle is to be operated in the hovercraft mode the ventilator propulsion units 116 (Fig. 1) are switched on whereupon the air sucked in from the outside 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 water line WL1 in hovercraft mode (Fig. 4), with the lower displacement mode float regions 115 of the floats 111 only being 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 as propulsion means are still sufficiently deeply submerged below the water surface and can thus generate the required propulsive thrust.

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 stabilizer 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 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 111. The sonar device 128 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 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.

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 in displacement mode and being operational.

In the extended state the 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 in hovercraft mode when travelling in the hovercraft mode.

In accordance with Fig. 5 the front skirt 123 of the catamaran air cushion water craft consists of individual resilient pockets 131 which are manufactured of a resilient material, for example reinforced rubber, and which each have reinforcement 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 stem skirt 123 (Fig. 6).

As seen in Fig. 5 the elastic 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 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.

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 arms 132 are mounted on a transverse throughshaft 133 about which the stem 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 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 movement can be affected by means of a cable 155 which acts at the lower edge of the front skirt 123, or by a hydraulic cylinder or pulling device 155', which acts on the pivot arms 132.

The resilient pockets 131 of the front skirt 123 can also be pivoted further upwardly if the intermediate 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 front skirt 123 to accommodate it. It is mostly advantageous when the front skirts 123 are pivoted upwardly sufficiently far that they no longer project into the air space 125 between the floor 135 of the hull and the water line WLO in displacement mode 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 order to pivotally move the front 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 Figs. 1, 2 and 8. The stern 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 means of pneumatic or hydraulic take in cable drive 152 (Fig. 8). The cables 152' act on the lower end of the stern skirt 124.

In order to provide the pockets 137 which are arranged 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.

The resilient pockets 137 are inflated into the position shown in Figs. 1 and 8 by connecting them to a source of 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 cable drive 152 into the position shown in 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 resistance during travel in the displacement mode and cannot be damaged.

As seen in Fig. 2 the stern skirt 124 extends laterally into recesses 136 of the floats 111 whereby good sealing against the undesired escape of air during hovercraft operation is obtained in this region.

It should also be pointed out that the skirts 123, 124 terminate somewhat above the water surface during hovercraft 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 123, 124 can also be kept very low during travel in the 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.



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CLAIMS:

1. Catamaran air cushion water vehicle comprising: two spaced apart floats (111) which extend parallel to one another in the direction of travel, and include each a displacement mode float region (115), which extends into the water during travel in the displacement mode and defines a water line (WLO) for travel in the displacement mode, wherein the cross-sections of the floats become broader from the bottom to the top and wherein the floats are rigidly connected together at the top by a deck structure; resilient skirts (123, 124) 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 (125) between the bottom of the deck structure and the water surface; main propulsion units (114) which drive propulsion means (148) arranged in the stern region of the floats; and fans (116) 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 and therefore up to the water line of travel in the air cushion (hovercraft) mode; wherein the floats each have a bulge projecting substantially inwardly formed by a hull section (112) having a transition region (117) at least along a substantial portion of their total length, with the bulges serving to accomodate the main



propulsion units and with the deck structure being attached to the upper end regions of the hull sections, characterized in that the transition region (117) to the hull section (112) starts in a step-like manner above the water line (WLO) during travel in the displacement mode and defines a substantial step.

2. A water vehicle in accordance with claim 1, characterized in that the hull-section (112) having the step-like transition region (117) above the water line (WLO) during travel in the displacement mode extends over almost the full length of the ship and accomodates, in addition to the main propulsion units (114), also further units, such as fan drive units (116), electrogenerators, air-conditioning systems, and water preparation systems.
3. A water vehicle in accordance with claim 1 or claim 2, characterized in that the hull sections (112) having the step-like transition region (117) have their largest widths half-way along the ship; and in that the main propulsion units (114) are arranted at this place.
4. A water vehicle in accordance with claim 3, characterized in that the transition region (117) starts only at a given distance from the stem and its width constantly increases rearwardly up to the reaching of the greatest width.
5. A water vehicle in accordance with claim 3 or claim 4, characterized in that the transition region (117) and therefore the hull sections (112) substantially retain the largest width in the stern direction (rearward direction).



6. A water vehicle in accordance with one of the preceding claims, characterized in that the height of each hull sections (112) having the transistion region (117) half-way along the ship amounts to 0.8 to 1.2 times the height of the lower displacement mode float region (115) which extends below the water line (WLO) during travel in the displacement mode.
7. A water vehicle in accordance with one of the preceding claims, characterized in that half-way along the ship, the transition region (117) has such a size that the width of each float (111) increases by 30 to 70 % at the transition from the lower displacement mode float region (115) to the hull section (112).
8. A water vehicle in accordance with one of the preceding claims, characterized in that the bottom of the transition region (117) extends in a gently rounded or inclined manner.
9. A water vehicle in accordance with one of the preceding claims, characterized in that the floats (111) increase in width outwardly substantially continuously or in small steps (118).
10. A water vehicle in accordance with one of the preceding claims, characterized in that the bottom of the transition region (117) extends at an angle of 20 to 40° to the horizontal from the exterior towards the interior.
11. A water vehicle in accordance with one of the preceding claims, characterized in that the inner walls (119) of the lower displacement mode float region (115) located below the water line (WLO) during travel in the



displacement mode extend substantially parallel to one another from the stem to the stern.

12. A water vehicle in accordance with one of claims 1 to 10, characterized in that the inner walls (119) of the lower displacement mode float region (115) extend from the exterior conically slightly inwardly towards each other and extend thereafter substantially parallel to each other up to the stern.
13. A water vehicle in accordance with one of the preceding claims, characterized in that the keel line of the floats (111) rises slightly from the stem to the stern.
14. A water vehicle in accordance with one of the preceding claims, characterized in that the floats (111) are subdivided by at least one deck (121, 121') into buoyancy chambers which are sealed relative to one another.
15. A water vehicle in accordance with claim 14, characterized in that a deck (121') for the subdivision of two buoyancy chambers located above and sealed relative to one another is located in the transition region (117) from the lower displacement mode float region (115) to the hull section (112).
16. A water vehicle in accordance with one of the preceding claims, characterized in that the main propulsion units (114) and optionally also the fan drive units (116) are constructed as containers which are 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.



17. A water vehicle in accordance with one of the preceding claims, characterized in that the exhaust ducts (122) of the combustion engines for the main propulsion units (114), and/or for the fan drive units (116), as well as of any generators, open into the air space (125) bounded by the floats (111) and the skirts (123, 124) which is located above the water surface, with the air cushion pressure being smaller or the same as the exhaust gas pressure of the exhaust ducts (122).
18. A water vehicle in accordance with one of the preceding claims, characterized in that stabilizer fins (126) which are pivotable about transverse axes (127) are arranged in the lower end region of the floats (111) at the inside, 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 assist the exceeding of a critical speed range during travel in the hovercraft mode at higher speeds.
19. A water vehicle in accordance with claim 18, characterized in that a pair of stabilizer fins (126) is provided at the stem.
20. A water vehicle in accordance with claim 19, characterized in that a further pair of stabilising fins are provided in the stern region of the floats (111).
21. A water vehicle in accordance with one of the preceding claims, characterized in that a telescopically extendable and retractable column (129), carrying a sonar device (128) at its lower end is arranged on the deck structure (113) between the floats (111), with the lower end of the column extending in the retracted state



to approximately below the water line during travel in the displacement mode (WLO).

22. A water vehicle in accordance with claim 21, characterized in that a stabilising fin arrangement (130) is provided at the lower end region of the retracted column (129) which lies below the water line (WLO) during travel in the displacement mode.
23. A water vehicle in accordance with one of the claims 21 or 22, characterized in that the stroke (H) of the sonar device (128) is larger than the height difference between travel in the displacement mode and travel in the hovercraft mode.
24. A water vehicle in accordance with one of the claims 21, 22 or 23, characterized in that the sonar device (128) is mounted angularly adjustable at the lower end of the column (129).
25. A water vehicle in accordance with one of the preceding claims, characterized in that the stem and/or stern skirts (123; 124) can be moved out of their operation position for travel in the hovercraft mode, to such an extent, that during travel in the displacement mode they no longer or only unimportantly contact the water surface, at least in calm water.
26. A water vehicle in accordance with one of the preceding claims, characterized in that the stem skirt (123) can be upwardly pivoted to such an extent that it does not project in the air space (125) between the bottom (139) of the deck structure (113) and the water line (WLO) during travel in the displacement mode.



27. A water vehicle in accordance with claim 25 or 26, characterized in that the stem skirt (123) is formed by resilient pockets (13) arranged next to each other, which are folded rearwardly and rounded at the front, which are secured at the top to the deck structure (113) and which are optionally flowed over by the lift air from above during travel in the hovercraft mode; and in that 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 resilient pockets (131) which come into contact with the water surface during travel in the displacement mode upwardly away from the water surface.
28. A water vehicle in accordance with claim 25 or 26, characterized in that the stem skirt (123) is formed by resilient pockets (131) arranged next to each other, which are folded rearwardly and rounded at the front, which are secured at the top to the deck structure (113) and which are optionally flowed over by the lift air from above during travel in the hovercraft mode; and in that on being upwardly pivoted the upper mounting of the pockets (131) remains unchanged and the pockets (131) are resiliently deformed.
29. A water vehicle in accordance with one of the claims 25 to 28, characterized in that a chamber (134) is provided above the front skirt (123) for accomodating the elevated skirt (123).
30. A water vehicle in accordance with one of the claims 25 to 29, characterized in that the stern skirt (124) extends into lateral internal recesses (136) of the



floats (111), with the side end faces of the stern skirt (124) being optionally sealed relative to the sidewalls of the recesses (136).

31. A water vehicle in accordance with one of the claims 25 to 30, characterized in that the stern skirt (124) consists of resilient pockets (137) which extend parallel to one another and are arranged substantially behind one another, the pockets (137) being connected to a source of air pressure and are selectively inflated or relieved of pressure.
32. A water vehicle in accordance with one of the claims 25 to 31, characterized 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 their active position for travel in the hovercraft mode.