PATENT REQUEST: STANDARD PATENT

We, RHEIN-FLUGZEUGBAU GMBH being the person identified below as the Applicant, request the grant of a patent to the person identified below as the Nominated Person, for an invention described in the accompanying standard complete specification.

Full application details follow.

Applicant: RHEIN-FLUGZEUGBAU GMBH
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Nominated Person: RHEIN-FLUGZEUGBAU GMBH
Address: Flugplatz, 4050 Monchengladbach 1, Germany,
Invention Title: 'A RAM-WING BOAT'
Name of actual inventor: ING. HANS OTTO FISCHER

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<th>Application Number</th>
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DATED this 21st day of July, 1993

RHEIN-FLUGZEUGBAU GMBH
By its Patent Attorneys
R K MADDERN & ASSOCIATES

CRAIG L VINALL
NOTICE OF ENTITLEMENT

We, RHEIN-FLUGZEUGBAU GMBH

of Flugplatz, 4050 Monchengladbach 1, Germany,

being the applicant in respect of Application No.74001/91,

state the following:-

1. The person nominated for the grant of the patent:
   has entitlement from the actual inventor. The Applicant
   company is the Assignee of the actual inventor.

2. The person nominated for the grant of the patent:
   is the applicant of the basic application listed on
   the patent request form

   The basic application listed on the request form:
   is the first application made in a Convention country
   in respect of the invention.

DATED this 21st day of July, 1993.

RHEIN-FLUGZEUGBAU GMBH
By its Patent Attorneys
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1. A ram-wing boat that travels on a dynamic air cushion with a central support body, two low aspect ratio wings located at both sides of the central support body, a control surface, pontoons located under the wings, a thrust generator situated at the central support body and a cabin located on top of the support body, characterised in that the wings consist of a firm, shape-giving structure, an elastic ram-wing structure creating a plenum thereunder, extending from the trailing edges of said firm, shape-giving structure to the tail of the central support body, said elastic ram-wing structure being limited rearwardly by its trailing edges, supported by rigid support struts extending from the central support body to the trailing edges and flexible, single walled skirts which depend from the trailing edges of said elastic ram-wing structure and act to seal said plenum, said skirts being arranged to lie parallel to the water surface in the take-off and landing phases.
The following statement is a full description of this invention, including the best method of performing it known to us.
Abstract

The invention relates to a ram-wing boat which, as it gathers speed, rises out of the water and lifts off the surface of the water, and then travels on a dynamic air cushion. The lift-values are altered by sealing-means provided at the sides and rear for sealing the plenum, so that there are high lift values and low resistance values at take-off, and the lift and resistance values with increasing height above the surface of the water increase so greatly that the distance above the surface cannot exceed a third of the wing span.
This invention relates to a ram-wing boat that rises out of the water as it gathers speed, and then lifts off the surface of the water and rides on a dynamic air cushion, keeping within the ground-effect as a result of alteration of the lift-values.

The increased lift and reduced drag occurring when a wing approaches the ground is known in theory, and is used in what is known as "ram-wing machines' or "wing in ground effect" (WIG) craft. To obtain an efficacious ground effect, which is reflected in an improved lift/drag ratio, it is necessary to achieve the best possible conversion of the dynamic pressure into a static superpressure; this requires a ram plenum with its opening at the front and with the best possible sealing of the plenum at the sides and back. A craft based on this concept, which can be designed particularly well as a boat because of the even surface of the water, has to be as light as possible, yet must also be able to withstand the high loads caused by water impact during take-off and landing.

Because water is an 800-times denser medium than air, the resistances that have to be overcome at take-off are some 2 to 3 times greater than the air-resistance that has to be overcome in flight near the ground. Therefore the motive power requirement is determined by the power required for take-off. As this in turn depends essentially on the take-off weight, there is the possibility that when the weight is reduced, e.g. through the consumption of fuel or a reduced load, the craft may enter into free flight, rising above the ground effect, which operates at up to about \( \frac{1}{3} \) of the wing span or wing chord. Therefore boats of this type, if they have three-dimensional controls, are classified as aircraft and then require aircraft construction materials, aircraft power plants, and aircraft-pilot qualifications, with the resultant costs.

Also known in the art are "tandem airfoil boats", which are supposed to keep close to the surface due to a surface-
dependent lift distribution caused by the tandem wings, which are arranged one behind the other. Such boats are very limited in their manoeuvrability, as they cannot perform banking for turns, nor can their altitude be altered at will through the use of kinetic energy, in order to jump over obstacles. Furthermore, if they rise too high, which can happen due to wind gusts or operating error for example, and which leads to loss of stability because of the absence of the ground effect, they are then unable to return to normal operating height because of their lack of altitude control.

In order to avoid free flight with its disadvantages as described above, the invention proposes a ram-wing boat in which the drag occurring when an altitude of more than 1/3 of the wing span is reached is greater than the water resistance to be overcome during take-off. This prevents free flight, without requiring the assistance of artificial means such as altitude-dependent automatic controls or power reduction.

The object of the invention is to create a configuration and sealing-means that will prevent aerodynamic free flight thanks to a greater increase in resistance than that existing at take-off. This is achieved by having an extremely small wing span and large wing chord, known as the aspect ratio, which causes the induced resistance to increase with increasing altitude. At the same time, however, it is necessary to achieve a reduction in the resistance at take-off.

With a design such as this there are structural problems, which are solved by the features of this invention.

In its broadest form, the invention comprises a ram-wing boat that travels on a dynamic air cushion with a central support body, two low aspect ratio wings located at both sides of the central support body, a control surface, pontoons located under the wings, a thrust generator situated at the central
support body and a cabin located on top of the support body, characterised in that the wings consist of a firm, shape-giving structure, an elastic ram-wing structure creating a plenum thereunder, extending from the trailing edges of said firm, shape-giving structure to the tail of the central support body, said elastic ram-wing structure being limited rearwardly by its trailing edges, supported by rigid support struts extending from the central support body to the trailing edges and flexible, single walled skirts which depend from the trailing edges of said elastic ram-wing structure and act to seal said plenum, said skirts being arranged to lie parallel to the water surface in the take-off and landing phases.

In order to keep the take-off speed as low as possible, the main plane structure, which represents the large structural volume, should be as light as possible yet sufficiently strong to withstand water loads. For this reason the rear structure, particularly with small craft, is preferably not the usual rib and spar structure covered with a rigid material, but rather an elastic structure with a flexible covering. To achieve high lift values, a single-sided sail is
as shown in German Patent 2547945, but rather a double covering is used, in order to achieve an optimal profile. This brings with it the risk of water getting into the wing, which has to lie on the water at take-off to create a seal; if water did get into the wing, this would not only lead to a weight increase but would also displace the centre of gravity in an unsymmetrical and uncontrollable manner.

This is not impossible with a double covering - or even with a built-up structure - if damage occurs, particularly considering that in the static displacement mode the entire length of the trailing edge has to lie beneath the surface of the water so that a seal remains when surfacing occurs during hydroplaning.

Fig. 1 shows a general view of the ram-wing boat.

Fig. 2 shows the main plane structure according to the invention. The nose of the wing consists of a firm, shape-giving structure made of e.g. wood, plastic, or metal. The trailing edge consists of a pretensioned cable with a flexible covering or a rigid rear strip in the case of a rigid covering. To support the trailing edge, which lies in the water at take-off and landing and is therefore exposed to water impact, rigid support struts are used. These are required, particularly when a cable is used for the trailing edge, to prevent ballooning and thus pressure loss when the wing is under dynamic pressure.

There is a flexible skirt at the trailing edge. In the static displacement mode, this skirt penetrates downwards through the surface of the water. Since this skirt is only single-sided, there is no possibility of water getting into the hollow space that would otherwise exist.

The flexible skirt is supported by shock-absorbing struts which prevent flutter during flight but permit the skirt to deflect when impacted by water; the shock absorption stiffness is selected so that during rapid travel through the water, e.g. during take-off, the skirt lies parallel on the
water, thus markedly reducing the take-off resistance. This is necessary to keep the power requirement during this phase as low as possible, so as to prevent free flight (as described at the beginning), thus avoiding classification as an aircraft.

Fig. 3 shows the position of the skirt 5 and the shock absorbing strut 6 in the static displacement mode.

Fig. 4 shows the take-off and landing phases with the skirt deflected into the parallel position, out of the water pressure.

Fig. 5 shows flight near the surface, with the sealing and shock-absorbing effect of the skirt. The number 7 indicates the surface of the water in each case. With this arrangement, high loadings on the load bearing structure due to contact with the water (e.g. waves) is avoided, thus contributing to further weight reduction and increased safety.

In order to achieve the necessary minimization of power plant output at take-off and while flying near the surface, so as to prevent free flight, it is also necessary to provide lateral sealing, and there must be an extremely large increase in resistance when an adequate altitude above the water is exceeded. This is achieved by the great increase in induced resistance with the extremely low aspect ratio (span/area). This resistance exceeds the air resistance of the whole boat and is effective in preventing the boat from reaching flying altitudes higher than about $\frac{1}{3}$ of its wing span.

Therefore in flight near the surface up to a selected height, the build-up of the dynamic air cushion requires sealing-means at the wing tips as well, which in boats are designed as support-floats to prevent capsizing.

In order to achieve displacement corresponding to the weight of the laden boat when in the static flotation mode, it is essential for the hull and support-floats or pontoons to sit
in the water. Their draught must be kept as shallow as possible to enable surface-effect flight with the least possible gap between the trailing edge of the wing and the water surface, while keeping the resistance in the take-off phase as low as possible. Therefore immersion of the components forming the trailing edge must be minimized during take-off and flight.

To achieve this, there is a vertical leeboard, hinged to the front of each outer pontoon and designed so that it rests on the water when the boat is in the floating state - thereby not increasing the draught and hence not increasing the water resistance either. However, when the craft is hydroplaning or flying in the surface effect, the leeboards can hang down so as to seal the sides of the plenum. This arrangement also means that contact with the water on one side (e.g. due to waves) does not give rise to acceleration loads and acceleration torques.

This arrangement in accordance with the invention also enables the necessary banking for tight turns, without losing the air cushion seal on the side with the raised wing. To achieve banking, ailerons are provided on the wing tips; their effectiveness in proximity to the surface is limited by the fact that the wing that is to be lowered comes closer to the surface and thus compresses the air cushion, which hinders banking and leads to a requirement for large ailerons with the corresponding weights, resistances, and actuators. In addition, part of the dynamic lift on the raised-wing side is lost, thus reducing the total lift, which leads to contact with the water, which can only be avoided by operating the elevator at the same time. Here again this requires aircraft-pilot skills and goes against classification as a boat.

Fig. 6 shows one embodiment of the design of the lateral sealing of the air cushion according to the invention.

The pontoon 8, with step 9, outer wing 10, and aileron 11, has a leeboard 12 that can be swung out by gravitational force, with a flange-mounted float 13 on it, and is freely
pivoted on a bolt 14. These parts are rigidly mounted on the wing 15.

This diagrammatic representation corresponds to the static displacement mode in which the pontoon 8 is partially submerged up to the trailing edge.

Fig. 7 shows the same displacement mode as in fig. 6, but viewed from in front.

Fig. 8 shows the situation in surface-effect flight, in which the leeboard is swung out by gravity till it is blocked by a stop, thus providing an outer seal for the plenum. If contact with the water occurs, e.g. due to waves, the float 13 will cause deflection of the leeboard, thus preventing loads from being applied to the structure.

Fig. 9 shows the same surface-effect flight situation, viewed from the front.

Fig. 10 shows the sealing effect during a turn, due to the leeboard hanging out on one side.

In another advantageous design, the two sealing means are combined so that the rear skirt can be controlled by the lateral leeboard either through a mechanical linkage or via control elements; this is possible because the hanging-down leeboard can be used as a clearance determiner. It is also possible for the boat driver to control the skirt and/or the leeboards by hand.

With a ram-wing boat of this design it becomes possible to use such a craft as a true boat for which no special permission is required. Free flight due to a high power requirement for take-off is prevented by the configuration according to the invention, which means that the craft can be classified as a boat rather than as an aircraft.
THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A ram-wing boat that travels on a dynamic air cushion with a central support body, two low aspect ratio wings located at both sides of the central support body, a control surface, pontoons located under the wings, a thrust generator situated at the central support body and a cabin located on top of the support body, characterised in that the wings (15) consist of a firm, shape-giving structure (1), an elastic ram-wing structure creating a plenum thereunder, extending from the trailing edges of said firm, shape-giving structure (1) to the tail of the central support body, said elastic ram-wing structure being limited rearwardly by its trailing edges (2), supported by rigid support struts (3) extending from the central support body (16) to the trailing edges (2) and flexible, single walled skirts (5) which depend from the trailing edges of said elastic ram-wing structure and act to seal said plenum, said skirts being arranged to lie parallel to the water surface in the take-off and landing phases.

2. Ram-wing boat according to claim 1, characterised in that the trailing edges (2) consist of a pretensioned cable and the elastic ram-wing structure (4) comprises a flexible double covering.

3. Ram-wing boat according to claim 1 or 2, characterised in that there are provided shock-absorbing support elements (6) between the trailing edges (2) and the skirts (5), which allow deflection of said skirts (5).

4. Ram-wing boat according to claim 3, characterised in that the stiffness of the shock-absorbing support elements (6) is such that they give when water or wave impacts occur, allowing deflection of said skirts (5).

5. Ram-wing boat according to any one of claims 1 to 4, characterised in that the pontoons (8) laterally seal the
plenum by gravity actuated leeboards (12), said leeboards having floats (13) along their lower edges.

6. Ram-wing boat according to claim 5, characterised in that the leeboards (12) are freely pivoted about a pivot (14) which is rigidly mounted on the wing (15).

7. Ram-wing boat according to claim 5 or 6, characterised in that said skirts (5) are controlled mechanically or by kinetic devices, the position of said skirts (5) being dependent on the position of the lateral leeboards (12).

8. Ram-wing boat according to claim 7, characterised in that said skirts (5) and/or the lateral leeboards (12) can be controlled manually.

9. Ram-wing boat according to any preceding claim, characterised in that the ratio of the wing span to the spanned area and the power of the thrust generator (17) are such that the ram-wing boat is unable to attain free flight.

10. Ram-wing boat according to any preceding claim substantially as hereinbefore described with reference to and as illustrated in the accompanying representations.

Dated this 21st day of July 1993.

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