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3,512,603

FLEXIBLE HULLS

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2 Sheets-Sheet 1

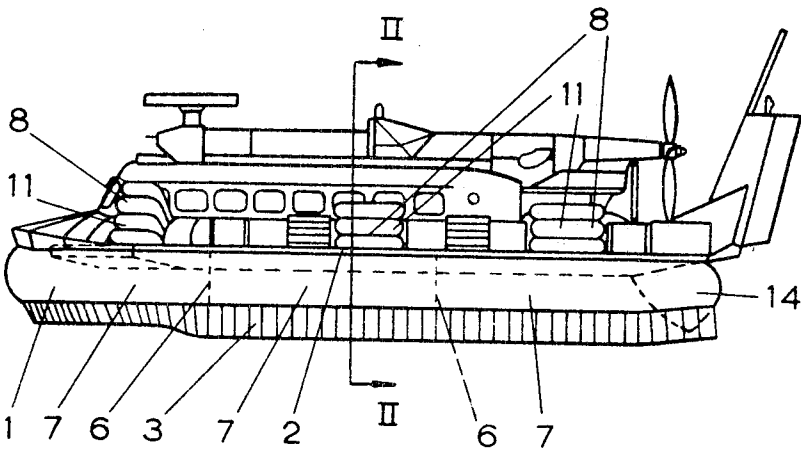


FIG. 1

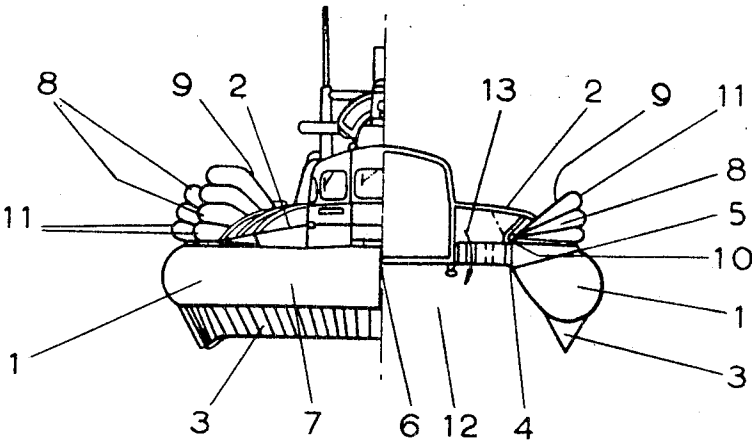


FIG. 2

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FLEXIBLE HULLS

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17 Claims

ABSTRACT OF THE DISCLOSURE

An air cushion vehicle has a flexible skirt assembly forming at least part of the cushion barrier. The skirt assembly includes an upper, inflatable flexible chamber and depending therefrom a plurality of juxtaposed discrete flexible segments. The skirt assembly has characteristics such that it has sufficient strength to withstand the outward forces generated by the cushion pressure, and vibration is reduced. These characteristics are achieved by maintaining a predetermined relationship between the height of the skirt assembly and the distance between its inner and outer attachment lines, by maintaining a predetermined relationship between the pressure in the flexible chamber and the pressure in the cushion, and through the provision of selectively variable volume accumulators in communication with the flexible chamber.

This invention relates to flexible skirt assemblies for air cushion vehicles. It is principally, but not exclusively, concerned with skirt assemblies in which a pressurised flexible chamber acts as part of the skirt assembly, and may also provide buoyancy and keel effect when the vehicle is acting as a displacement watercraft.

Flexible skirt assemblies may include an upper pressurised baglike member having a plurality of juxtaposed discrete flexible segments depending therefrom, and the upper pressurised baglike member may be divided into compartments pressurised to superatmospheric pressure.

The skirt assembly must have sufficient strength to withstand the outward forces generated by the pressurised fluid cushion or cushions. This strength, in the type of skirt assembly hereinbefore described, is dependent, in part, upon the skirt height, the distance between its inner and outer attachment points to the rigid structure of the vehicle and the pressure within the upper pressurised baglike member. There are, however, other factors to be considered in the design and construction of such a flexible skirt assembly, for example, the resonance frequency of the assembly and the water impact loads which it receives.

Because of the elasticity of pressurised air and the flexibility of the pressurised baglike member the skirt assembly has a natural vibratory period and if this period coincides with that of the vehicle as a whole the skirt may vibrate continually and reduce the performance of the vehicle. The likelihood of skirt vibration may be reduced by changing the distance between the skirt fixing points in relation to the skirt height, by changing the pressure in the baglike member in relation to the cushion pressure or by a combination of both changes.

Additionally, for good overwave performance, when the skirt assembly is required to flex to conform to wave contours, a low pressure in the baglike member in relation to the cushion pressure is required, but for general skirt stability, when the plan area of the cushion is required to remain constant in spite of waves buffeting the skirt, a high pressure in the baglike member is required.

It has been found that to allow for these conflicting requirements and to construct an efficient flexible skirt

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assembly, the ratio of the distance between the upper attachment points of the flexible skirt assembly and the overall height of the skirt and also the ratio between the pressure within the pressurised baglike member and the cushion pressure must be within certain limits, and it is an object of the invention to define these limits.

According to the invention we provide a flexible skirt assembly for a vehicle which, during at least one phase of operation, receives support from at least one cushion of pressurised fluid, the skirt assembly forming at least part of a barrier to the cushion or cushions and including at least one upper, inflatable, flexible chamber and a plurality of juxtaposed, discrete, flexible segments depending from the upper chamber or chambers, wherein the upper, inflatable, flexible chamber or chambers is inflated by pressurised fluid to a pressure between 1.15 and 5 times the pressure of the cushion or cushions.

In another aspect of the invention we provide a flexible skirt assembly for a vehicle which, during at least one phase of operation, receives support from at least one cushion of pressurised fluid, the skirt assembly forming at least part of a barrier to the cushion or cushions and including at least one upper, inflatable, flexible chamber and a plurality of juxtaposed, discrete, flexible segments depending from the upper chamber or chambers, the upper, inflatable, flexible chamber including a sheet of flexible impermeable material attached at first and second points to structure carried by the vehicle to form a loop in a substantially vertical cross section, wherein the distance between the first and second points of attachment of the sheet is greater than 0.9 times the vertical distance between the underside of the rigid structure of the vehicle and the lower tip of the flexible skirt assembly and the pressure within the inflatable, flexible chamber is at least 1.15 times the cushion pressure.

The pressure in the inflatable, flexible chamber may be selectively variable within the 1.15–5 range.

The upper, inflatable, flexible chamber may include separate compartments at different peripheral locations around the vehicle and the pressures in each compartment may be different. Alternatively, any combination of compartments may be interconnected and each set of interconnected compartments may have pressures different from other sets.

Both the upper, inflatable, flexible chamber and the fluid cushion or cushions may be pressurised with air and the supply means for the upper, inflatable, flexible chamber may be separate from the supply means for the fluid cushion or cushions.

The characteristics of each compartment of the upper, inflatable, flexible chamber may be varied by the provision of an accumulator having a variable volume interconnected with each compartment, and the accumulator may be selectively operable.

The height of the discrete, flexible segments in relation to the total height of the flexible skirt assembly, and also the area of the fluid cushion, may be selectively varied by changing the ratio between the pressure in the inflatable, flexible chamber and the cushion pressure.

The flexible skirt assembly as hereinbefore described may form the complete lateral barrier to the fluid cushion or it may be used at the bow and side portions of a fluid cushion supported vehicle only. In the latter case a simple inflatable chamber or other suitable barrier means may complete the lateral fluid cushion barrier.

The pressurised compartments at the sides of the vehicle may provide buoyant support for the vehicle in the displacement role, and the portions of the skirt assembly at the bow and stern may be depressurised and retracted so that the vehicle assumes the form of a catamaran displacement craft.

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

FIG. 1 is a side elevation of a vehicle incorporating a flexible skirt assembly according to the invention,

FIG. 2 is a bow view of the vehicle illustrated in FIG. 1, on a different scale, in the air cushion supported role. The left side of the figure is a front elevation of the vehicle and the right side is a section on the line II—II of FIG. 1, and

FIG. 3 is a diagrammatic section, in a vertical plane, of the skirt assembly of the vehicle illustrating how the ratio of the height of the discrete segments to the total height of the skirt assembly and also the cushion area may be varied.

An upper, inflatable, flexible chamber 1 depends from the periphery of the rigid structure 2 of a vehicle and a plurality of discrete flexible segments 3 depend from the inflatable, flexible chamber 1.

The upper, inflatable, flexible chamber 1 includes a sheet of flexible impermeable material attached at a point 4 to the lower surface of the rigid structure 2 of the vehicle and at a point 5 carried by rigid struts. The chamber 1 is inflated with pressurised air so that the sheet takes the form of a loop between the attachment points 4 and 5. This loop is provided with releasable attachment means for the segments 3.

The chamber 1 is divided into separate airtight compartments 7 by flexible impermeable diaphragms 6. Interconnected with each compartment 7 is a variable volume air accumulator 8, which provides a selectively increased volume for each compartment 7.

Each accumulator 8 consists of a rigid upper rectangular member 9 hinged to the rigid structure of the vehicle at points 10 and flexible impermeable sheets 11 interconnecting the free edges of the member 9 and the rigid part of the vehicle. The sheets 11 are restrained by internal tension members so that they assume a convoluted shape. The position of the rigid member 9 about its hinge points 10 is controlled by any suitable method, for example, cables in tension, to achieve a required rate of variation of internal pressure with volume for a compartment 7 of the inflatable, flexible chamber 1.

Each compartment 7, together with its associated accumulator 8, is supplied with pressurised air from a source separate from the air cushion supply, and the ratio between the air pressure in the compartments 7 and in the air cushion space 12 is arranged to be within the range 1.15 to 5.0. Means for generating and distributing pressurised air to the compartments 7 and means for controlling the pressure of the air so that it remains at a constant pressure with respect to the air cushion pressure are well known in fluid mechanics, and are usually incorporated in the air supply arrangements. Therefore, such means are not described herein.

The air cushion is supplied by pressurised air from a lift fan (not shown), and flows through ducts, as indicated by the arrow 13, to the air cushion space 12. Alternatively, the pressurised air may be led, through flexible ducts, to the tops of the segments 3 and thence to the cushion space 12.

FIGS. 1 and 2 show the skirt assembly divided into six compartments, two on each side of the vehicle and two around the bow of the vehicle. The lateral boundary of the air cushion is completed by a stern skirt 14 which may be similar to the bow and side skirts already described. Alternatively, the stern skirt 14 may be a simple pressurised flexible member without depending segments, or may be any other suitable flexible barrier.

FIG. 3 shows how the plan area of the air cushion is variable by varying the ratio of the pressure in the compartments 7 to the pressure in the air cushion area, signified hereafter in the specification as P_b/P_c . Similarly,

it shows how the height of the skirt assembly and the proportion of the height of the discrete segments can be varied.

The pressure in the air cushion space 12 generates a force represented by the arrow 15 which is restricted by the strength of the skirt assembly, and the configuration of the skirt assembly depends upon a balance of these two factors. When P_b/P_c is high, for example 2.5, the outline of the skirt assembly is as shown by the long dashed lines 16 and the lateral position of the lower tip of the skirt assembly is on the vertical line 17. When P_b/P_c is low, for example 1.3, the outline of the skirt assembly is as shown by the short dashed lines 18 and the lateral position of the lower tip of the skirt assembly has moved to the vertical line 19. The distance X between the lines 17 and 19, therefore, represents an increase in the plan dimensions of the air cushion. Thus an increase in the plan area of the air cushion is obtained by reducing the P_b/P_c ratio.

When P_b/P_c is high (long dashed outline 16) the vertical distance between the underside of the rigid part of the vehicle, represented by the skirt attachment point 4, and the lower tip of the skirt assembly, is Y1. The height of the same skirt assembly may be reduced by reducing P_b/P_c (short dashed outline 18), so that the height of the skirt assembly becomes Y2. In these examples, the change in the vertical heights Y3 and Y4 of the segments is much less than the change of the overall skirt assembly heights Y1 and Y2, so that in the high P_b/P_c case the segment height Y3 is 50% of the skirt assembly height Y1, and in the low P_b/P_c case the segment height Y4 is 70% of the skirt assembly height Y2.

The skirting assembly is arranged so that the distance W between the skirt attachment points 4 and 5 is greater than 0.9 times the vertical distance between the underside of the rigid structure of the vehicle and the lower tip of the skirt assembly.

When the skirting assembly acts as one or more buoyant hulls to support the vehicle in the displacement role, there is no cushion pressure, and the P_b/P_c ratio becomes infinity. In this condition, each compartment assumes the circular configuration indicated by the chain lines 20, and, when the vehicle moves through the water, the action of the water causes the segments 3 to fold against the surface of the compartments.

In another embodiment of the invention the compartments at the sides of the vehicle have no segments depending therefrom and the compartments are of a size which, in cooperation with the parts of the skirting assembly at the bow and stern, provide an even hemline.

The skirting assembly at the bow and the stern of the vehicle is arranged to be depressurised and retracted so that, when the vehicle is in a displacement water craft phase, it is supported by the compartments at each side, and the bow and stern skirt assemblies are clear of the water.

We claim as our invention:

1. In combination with a vehicle which, during at least one phase of operation, receives support from at least one cushion of pressurized fluid, a flexible skirt assembly forming at least part of a barrier to the cushion, and including at least one upper, inflatable, flexible chamber and a plurality of juxtaposed, discrete, flexible segments depending from the upper chamber, wherein the upper inflatable, flexible chamber is inflated by pressurized fluid to a pressure between 1.15 and 5 times the pressure of the cushion.

2. A flexible skirt assembly as claimed in claim 1, wherein the upper, inflatable, flexible chamber and the fluid cushion are pressurized with air.

3. A flexible skirt assembly as claimed in claim 2, wherein pressurized air supply means for the upper inflatable, flexible chamber is separate from pressurized air supply means for the fluid cushion.

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4. A flexible skirt assembly as claimed in claim 3, wherein pressurized air for the fluid cushion is conducted through flexible ducts to the tops of the segments.

5. A flexible skirt assembly as claimed in claim 1, wherein the pressurized compartments at the sides of the vehicle provide buoyant support when there is no fluid cushion support, and the portions of the skirt assembly at the bow and stern are depressurized and retracted so that the vehicle assumes the form of a displacement, catamaran craft.

6. A flexible skirt assembly for a vehicle which, during at least one phase of operation, receives support from at least one cushion of pressurized fluid, the skirt assembly forming at least part of a barrier to the cushion and including at least one upper inflatable, flexible chamber and a plurality of juxtaposed, discrete, flexible segments depending from the upper chamber, the upper inflatable, flexible chamber including a sheet of flexible impermeable material attached at first and second points to structure carried by the vehicle to form a depending loop in a substantial vertical cross section, wherein the distance between the first and second points of attachment of the sheet is greater than 0.9 times the vertical distance between the underside of the rigid structure of the vehicle at the lowermost of said points of attachment and the lower tip of the flexible skirt assembly, and the pressure within the inflatable, flexible chamber is at least 1.15 times the cushion pressure.

7. A flexible skirt assembly as claimed in claim 6, wherein the pressure in the inflatable, flexible chamber is selectively variable within the range 1.15 times the cushion pressure to 5 times the cushion pressure.

8. A flexible skirt assembly as claimed in claim 6, wherein the upper, inflatable, flexible chamber includes separate compartments at different peripheral locations around the vehicle.

9. A flexible skirt assembly as claimed in claim 8, wherein at least one separate compartment is inflated to a pressure different from the other compartments.

10. A flexible skirt assembly as claimed in claim 8, wherein a combination of compartments is interconnected and at least one combination is inflated to a pressure different from the other combinations.

11. A flexible skirt assembly as claimed in claim 8, wherein each compartment is provided with a selectively variable volume accumulator in communication therewith.

12. A flexible skirt assembly as claimed in claim 11, wherein the variable volume accumulator includes a rigid

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rectangular member pivotally attached, along one of its rectangular sides, to a rigid part of the vehicle, and flexible impermeable sheets interconnecting the free edges of the rigid rectangular member and the rigid structure of the vehicle.

13. A flexible skirt assembly as claimed in claim 12, wherein the impermeable sheets are restrained by internal tension members so that they assume a convoluted shape.

14. A flexible skirt assembly as claimed in claim 13, wherein the position of the rigid rectangular member provides a required rate of variation of internal pressure with volume for the compartment.

15. A flexible skirt assembly as claimed in claim 8, wherein the height of the discrete, flexible segments in relation to the total height of the flexible skirt assembly is selectively variable by varying the ratio between the pressure in the inflatable, flexible chamber and the cushion pressure.

16. A flexible skirt assembly as claimed in claim 8, wherein the area of the fluid cushion is selectively variable by varying the ratio between the pressure in the inflatable, flexible chamber and the cushion pressure.

17. A vehicle which, in one phase of its operation, receives support from at least one cushion of pressurized fluid, at least part of the lateral boundary of the cushion area being defined by a flexible skirt assembly including an inflatable, flexible chamber divided into a plurality of compartments attached to the rigid part of the vehicle at inner and outer points, wherein the distance between the inner and outer attachment points is greater than 0.9 times the vertical distance between the underside of the rigid structure of the vehicle at the lowermost of said points of attachment and the lowest part of the flexible skirt assembly, and at least one compartment is in connection with a variable volume fluid accumulator, the pressure within the compartments and accumulator being between 1.15 and 5 times the pressure of the cushion.

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Disclaimer

3,512,603.—*Peter R. Crewe* and *Michael Ivan Manning*, Yeovil, Somerset, England. FLEXIBLE HULLS, Patent dated May 19, 1970. Disclaimer filed Jan. 9, 1986, by the assignee, *British Hovercraft Corp. Ltd.*

Hereby enters this disclaimer to claims 1 through 7 of said patent.
[*Official Gazette March 11, 1986.*]