Oct. 17, 1967 R. S. JONES 3,347,329

GROUND EFFECT VEHICLES

Original Filed March 22, 1962

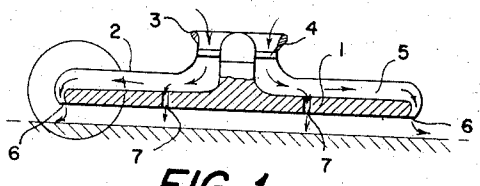


FIG. 1

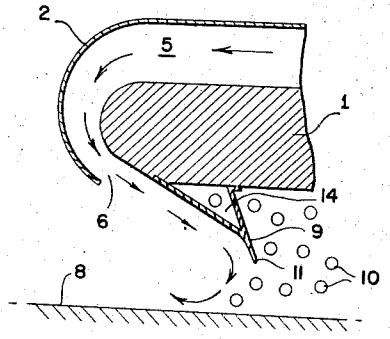


FIG. 2

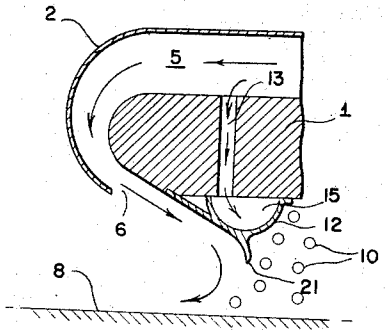


FIG. 3

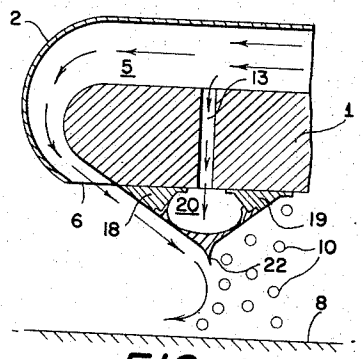


FIG. 4

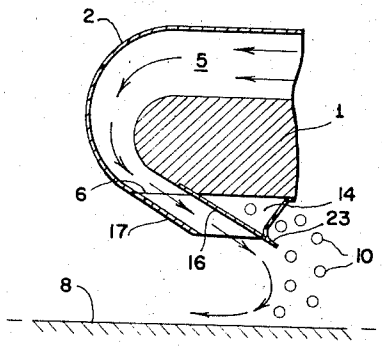


FIG. 5

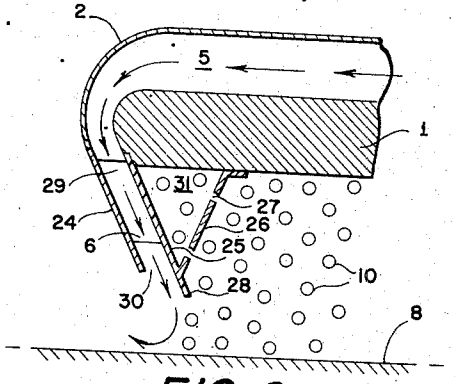


FIG. 6

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United States Patent Office 3,347,329
Patented Oct. 17, 1967

3,347,329

GROUND EFFECT VEHICLES

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Original application Mar. 22, 1962, Ser. No. 181,758, now Patent No. 3,252,535, dated May 24, 1966. Divided and this application May 5, 1965, Ser. No. 453,253
7 Claims. (Cl. 180—7)

The present application is a division of copending application Ser. No. 181,758, filed March 22, 1962, now Patent No. 3,252,535, issued May 24, 1966.

This invention relates to amphibious ground effect vehicles and more particularly to ground effect vehicles which have their lift jets or stabilizing jets flexibly extended below the rigid jet structure of the vehicle in order to improve their efficiency and operating heights.

This invention is primarily concerned with ground effect vehicles using peripheral jet systems, but need not be confined to this one concept, as it can be employed in other concepts, such as side wall vehicles, where any of the lift jets or stabilizing jets are flexibly extended.

Flexible extension of the lift jets of vehicles employing peripheral jet systems involves flexible "skirting" extending both the inner and outer walls of the rigid jet. The two "skirts" are attached to each other by strengthening and shaping ties or diaphragms placed transversely between the opposed flexible walls within the duct. The complete arrangement forms a trunking which the diaphragms divide into sections rather like the note separators in the mouth piece of a mouth organ.

These flexible trunk extensions, from which the cushion forming fluid emerges in the form of air or other gaseous mixture, are designed to deflect momentarily upon impact with wave crests or other objects, in order to avoid damage to the jet system.

However, during the development trials on such a vehicle, it was found that when a wave is struck by the vehicle water can be scooped into the jet orifices. As the water strikes the flexible reinforcing diaphragms, not only does it apply considerable drag, but sometimes causes the trunking to split open. This effect is particularly undesirable when only one side of the machine is struck, and could be dangerous if occurring at high speeds. One method of eliminating this problem is by reshaping, repositioning or by making other such modifications to the diaphragms or to the trunking itself. Modified diaphragm structure is disclosed in copending application Serial No. 250,881, filed January 11, 1963.

It is an object of the present invention to provide means to prevent water from being scooped into the jet orifices.

The performance of the ground effect vehicle is improved when the lift jet or peripheral jet is inwardly directed and therefore when the duct from which the jet issues is inwardly directed. Accordingly, it is easier for water is moving from the inside to the outside of the vehicle. There is little danger of water entering inwardly directed ducts when approaching from the outside.

According to the present invention the inner wall of the walls forming the jet system of the kind set forth is flexibly extended, whereby the inner wall extends below the outer wall. When water is moving from the interior to the exterior of the vehicle, the lower portion of the inner wall or skirt deflects upon impact with a wave and acts as a flap closing the gap between the inner skirt and the outer skirt, thereby preventing water from entering the duct formed by the inner and outer skirts, thus preventing the water from reaching the jet orifices.

Such an arrangement is provided at the stern of the vehicle to provide for the normal situation in which the vehicle is traveling forward. When passing over a wave,

the rearmost inner skirt will be deflected against the rearmost outer skirt as described above. Such an arrangement is also provided on the side skirts of the vehicle to counteract the tendency of one side to scoop up water when the vehicle is struck on the opposite side by cross seas or by a cross wind. The bow portion of the inner skirt is also made longer than its corresponding outer skirt to provide for the situation in which the vehicle is traveling astern. This situation may arise either by accident or by design. For example, by suitably altering the flow of air in the peripheral lift jets, the vehicle may be made to move in a rearward direction. Furthermore, when the vehicle is traveling in a forward direction, and strikes the water, such an impact will cause the vehicle to turn rapidly through approximately 180°.

Thus, the present invention not only provides for prevention of the water from entering the ducts and jet orifices when the vehicle is under controlled movement, but also when the seas, winds, or other such forces cause the vehicle to suddenly and unexpectedly move in a direction different from that intended.

The present invention will now be described as employed in several different skirting arrangements, and with reference to the attached drawings in which:

FIGURE 1 is a diagrammatic section of a typical ground-effect machine of the peripheral jet type;

FIGURE 2 is an enlarged section through one edge of the peripheral jet shown circled in FIGURE 1 and provided with a flexible inner skirt, said skirt having an inflated portion;

FIGURE 3 is an enlarged section view through one edge of the peripheral jet as in FIGURE 2, showing a modified form of the skirt;

FIGURE 4 is an enlarged section view as in FIGURE 2 and showing a further modification of the inner skirt;

FIGURE 5 is an enlarged section view as in FIGURE 2 showing a ground effect machine having both an inner and outer flexible skirt; and

FIGURE 6 is an enlarged section view through one edge of the peripheral jet as in FIGURE 2, and showing a further modified form of the skirt.

Referring now to FIGURE 1, the ground effect machine illustrated comprises a structure **1**, the upper parts of which are enclosed by an outer casing **2**. The lower edge of the outer casing **2** forms a periphery of the base structure of the machine. The top center portion of the casing **2** constitutes an air intake **3** in which a compressor **4** generates compressed air and drives it through a duct **5** terminating in a peripheral jet nozzle **6**. A secondary annular stabilizing jet **7** is additionally connected to the duct **5**. The ground or water line is indicated by the hatch line beneath the machine and as further indicated by the numeral **8**.

An inner skirt **9** of flexible material such as rubber, or rubberized fabric, plastic, or nylon is attached to the base of the machine as shown in FIGURE 2. The skirt **9** forms a downward extension to the inner wall of the peripheral jets **6**. That air which is discharged from the peripheral jets **6** builds up a cushion of pressurized air beneath the machine, which is indicated by the globules **10**. The inner skirt **9** forms a pressure separator between the downward jet **6** and the air cushion and retards the escape of air outwardly from the cushion. Formed in the skirt **9** is an inflated portion **14**. This inflated portion acts as a buffer against impact and provides additional buoyancy when the vehicle is floating on water.

Depending from the inflated portion **14** is extension **11** of the inner skirt **9**. This depending portion **11** is flexible, as is all of skirt **9**, and is deflected by water moving outwardly from the interior portion of the vehicle, thus preventing the water from entering the peripheral jet **6**. Not

only does the extended portion **11** of the skirt **9** deflect when struck by water, but also the remainder of the skirt **9** deflects to a limited extent. The effect of this deflection is to prevent the water from entering the jet nozzles. As one can see from FIGURE 2, due to the inward inclination of jet **6**, water moving in the aforementioned direction would easily enter the jet **6** if it were not for the skirt **9**.

Referring now to FIGURE 3, we see a modified form of the inner skirt. The inner skirt, indicated by **12** in FIGURE 3, again forms an extension of the inner wall of the peripheral jet **6**. As in FIGURE 2, an inflated portion **15** is formed in the inner skirt **12**. This inflated portion, however, is not a permanent one as was **14** in FIGURE 2, but is fed by the compressed air delivered from the compressor **4**. A passageway **13** in the structure **1** connects the inflated portion **15** with the duct **5**. Thus, a portion of the air traveling through the duct **5** to the peripheral jet **6** is carried by the passageway **13** to the inner portion **15** of the inner skirt, thereby inflating said inner portion **15**. Depending from this inflated portion is the lower portion **21** of the skirt **12**. This lower portion **21** when struck by a wave traveling outwardly from the inner portion of the vehicle is deflected in the same manner as is lower portion **11** of the embodiment shown in FIGURE 2. Thus, a barrier is provided to prevent the water from entering the peripheral jet **6**. The embodiment shown in FIGURE 3 is perhaps more flexible, and thus provides a more effective barrier to the water than the embodiment of FIGURE 2, due to the fact that the inflated portion **15** is not permanently inflated. Thus, when a wave strikes the inner skirt **12** air may be forced from the inflated portion **15** through passageway **13** thus deflating the portion **15** somewhat, thereby making it flexible. It may be noted that valves may be provided in the passageways **13** to allow air to enter and leave the inflated area as desired.

Referring now to FIGURE 4, a further modification of the inner skirt is disclosed. In this embodiment there is provided an inner skirt having an inflated portion **20** which is fed by passageways **13** in the same manner as the previous embodiment. Once again, valves may be employed in the passageways **13** to control the flow of air. Depending from the inflated portion **20** is the lower portion **22** of the inner skirt. This lower portion **22** acts in the same manner when struck by water as did the lower portions **11** and **21** in the two previous embodiments. Thus, a barrier is provided between the peripheral jet **6** and the water. This modification embodies two members **18** and **19** made from metal or like rigid materials to form an annular channel around the base of the vehicle into which the skirt can collapse when deflated, thus preventing a great deal of wear on the flexible skirt.

The three embodiments discussed thus far have been restricted to ground effect vehicles having merely a flexibly extended inner skirt. The following modifications also embody the present invention and relate to ground effect vehicles having both a flexible inner and outer skirt.

Referring now to FIGURE 5, there is illustrated a flexible jet nozzle having an inner skirt **16** similar to that disclosed in the embodiment shown in FIGURE 2. The flexible jet nozzle of FIGURE 5, however, employs also an outer flexible skirt **17**, thus providing a flexible jet nozzle both walls of which extend below the main body **1** of the vehicle. The flexible inner wall **16** employs an inflated portion **14** to act as a buffer when the vehicle returns to the ground or to provide additional buoyancy when the vehicle is floating on water. Depending from this inflated portion **14** is the lower portion **23** of the flexible inner skirt **16**. The inner skrt **16** and its lower portion **23**, when struck by water traveling from the interior of the vehicle, are deflected to substantially close the peripheral jet nozzle **6**, thus preventing water from entering therein. Vehicles having an outer wall such as **17** of the embodiment shown in FIGURE 5, have the advantage over vehicles having no such outer wall in that it has much smaller openings for the peripheral jet **6**, whereby the inner wall is more effective when deflected in keeping the water out of the trunking formed by the inner and outer skirts. Although no embodiment is shown having an inner wall similar to that disclosed by FIGURE 3 but also having an outer wall, it is to be understood that the present invention can be employed in such an arrangement.

FIGURE 6 illustrates a further modification of the invention. The rigid base platform **1** of the ground effect vehicle is provided with a peripheral jet skirting system, comprising inner and outer flexible skirts **24** and **25**. These skirts form a trunk having a jet passageway **6** for the air supplied by the ducts **5**. The jet passageways **6** are provided with cross diaphragms **29** to provide a plurality of flexible jet orifices **30**. These cross-diaphragms may be arranged at an angle to the vertical axis of the vehicle, thus providing a rake to the jet blast which thus provides a component of thrust to move the vehicle. The cross-diaphragms are generally provided with a rearwardly directed slant thus providing a forward thrust to the vehicle. The wall **26** of the inner skirt **25** is employed to prevent the jet system from flexing outwardly due to the influence of air cushion, indicated by the globules **10**. The wall **26** being directly connected to the inner skirt **25** prevents the inner skirt from being deflected outwardly and the cross-diaphragms **29** being attached to the inner skirt and the outer skirt keeps the outer skirt **24** from also being deflected outwardly. The openings **27** in the wall **26** provide means for the ingress and egress of air from the air cushion into the space **31** formed by the inner skirt **25** and the wall **26**.

Depending from the point where the wall **26** connects to the inner skirt **25**, is the lower portion of the inner skirt **28**. This lower portion **28** is deflected by water moving outwardly from the interior of the vehicle as in the previous embodiments to substantially close off the peripheral jet orifices **30**. The cross-diaphragms **29** are sufficiently flexible to allow the inner skirt and the outer skirt to move toward each other, while they are sufficiently strong to prevent the inner and outer skirts from moving away from each other a distance greater than the width of the cross-diaphragms.

Thus it is seen from the above descriptions that by employing a flexible inner skirt of a length greater than that of the outer skirt, or by employing a flexible inner skirt with no outer skirt, and by proportioning the inner skirt and its extended portion whereby upon deflection, they sufficiently cover the air jet, the problem of water entering the air jets or ducts is substantially eliminated. It is understood, of course, that once the wave or water has passed, the pressurized air will force the jets open once again to their width prior to the impact with the water.

Preferably, in the present invention the flexible skirt extending below the rigid base structure has the inner flexible skirt extending below the outer flexible skirt and at the jet orifice the inner skirt extends below the outer skirt by a distance at least equal to the width of the jet from the inner to the outer skirt but not greater than 1.5 times the width of the jet.

In embodiments where the air or gas blast of the jet system is provided with rake-back relative to the fore and aft axis of the ground effect vehicle, at those parts constituting the sides, to provide a component of thrust for forward propulsion, the jet blast is preferably directed rearwardly at angles not less than 20° nor more than 40° to the vertical.

Where cross-diaphragms are provided between the flexible skirts within the air or gas passage, they preferably terminate above and clear of the jet orifice by a distance not less than the width of the jet orifice, measured from the jet orifice end of the outer flexible skirt.

The embodiments described and shown herein are mere-

ly presented by way of example and are in no way intended to limit the present invention. The present invention may, of course, be employed in any device having flexibly extended jet passageways or orifices and variations and modifications can be effected without departing from the spirit and scope of the invention as defined in the appended claims.

I claim:

1. In a ground effect vehicle, a base structure, a jet system for generating a pressurized air cushion, said jet system including at least one annular jet orifice on said base, said jet orifice having inner and outer walls and flexible means forming an extension of the inner wall of the jet, the inner wall extending below the outer wall, said flexible means being entirely disposed within the boundary defined by the periphery of the base, the free peripheral end of the jet orifice being flexible permitting the jet system to fold locally to pass over an obstacle.

2. In a ground effect vehicle according to claim 1 wherein said inner wall extends beneath the outer wall a distance at least equal to the width of the jet orifice and less than 1.5 times the width of the orifice.

3. In a ground effect vehicle according to claim 1 wherein said flexible means forming an extension of the inner wall includes an integrally formed air chamber, said air chamber acting as a buffer against impact.

4. In a ground effect vehicle according to claim 3 and further including a passageway interconnecting said air chamber and the jet system.

5. A ground effect vehicle of the class described comprising, in combination, a base, means for generating an air cushion beneath the base, said means including an annular peripheral jet orifice having inner and outer walls, flexible skirting connected to said jet orifice and forming extensions of the inner and outer walls of the jet orifice, the inner wall extension extending beneath the outer wall extension, cross-diaphragms disposed between the flexible skirts, said diaphragms terminating above and clear of the jet orifice by a distance not less than the width of the jet orifice.

6. A ground effect vehicle according to claim 5 wherein the diaphragms are inclined towards the rear of the vehicle at angles between 20° and 40°.

7. A ground effect vehicle comprising, in combination, a base structure, a jet system for generating a pressurized air cushion, said jet system including at least one annular jet on said base, said jet having inner and outer walls and flexible means forming an extension of the inner wall of the jet, the inner wall extending below the outer wall, said flexible means extending inwardly from the periphery of the base and being entirely disposed within the boundary defined by the periphery of the base.

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