United States Patent

[11] 3,559,608

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[32] Priority **Mar. 14, 1966**
[33] **Great Britain**
[31] **11102/66**
Continuation-in-part of application Ser. No. 620,713, Mar. 6, 1967, now abandoned.

[54] **AIR-CUSHION VEHICLES**
23 Claims, 13 Drawing Figs.

[52] **U.S. Cl.** **114/67**
[51] **Int. Cl.** **B63b 1/38**
[50] **Field of Search** ..... 114/67.1, 61; 180/116, 126, (Inquired)

[56] **References Cited**

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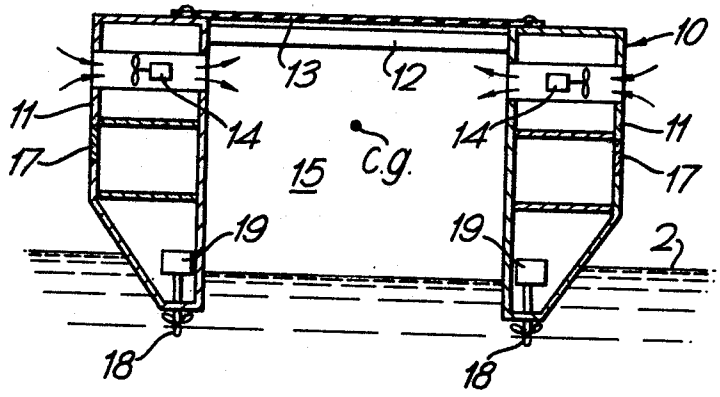
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ABSTRACT: An air-cushion vehicle in which the body comprises a laterally-spaced pair of body structures which contain the payload of the vehicle and which are rigidly interconnected and provide therebetween a substantially unobstructed cavity for the air-cushion, the cavity being enclosed by a membraneous canopy sealingly connected to the body structures.



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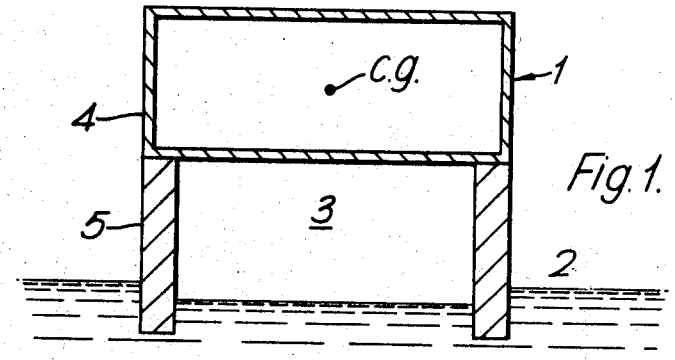


Fig. 1.

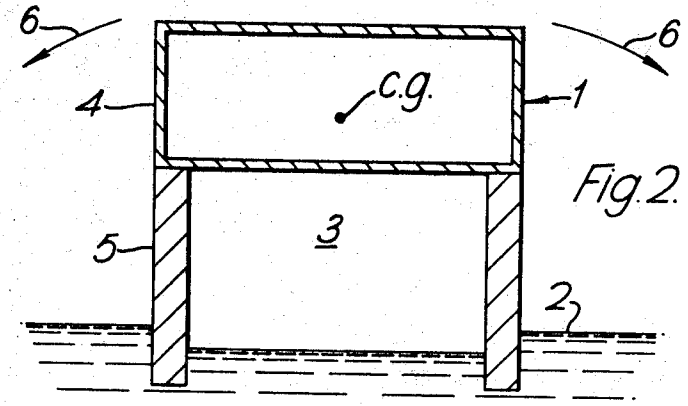


Fig. 2.

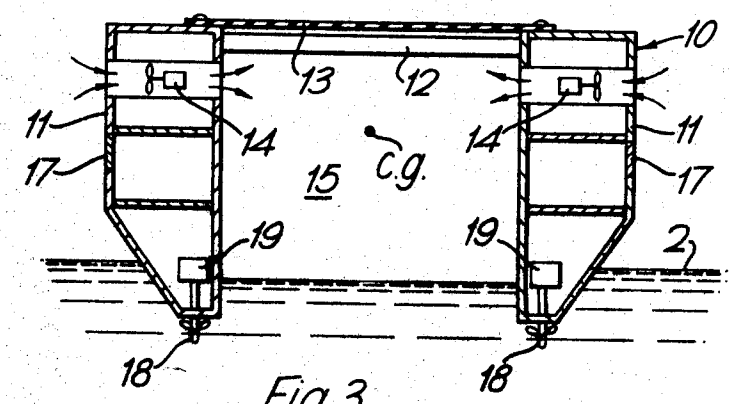


Fig. 3.

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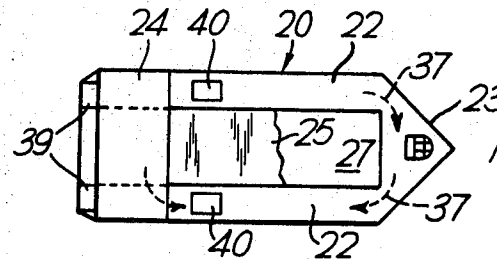


Fig.4.

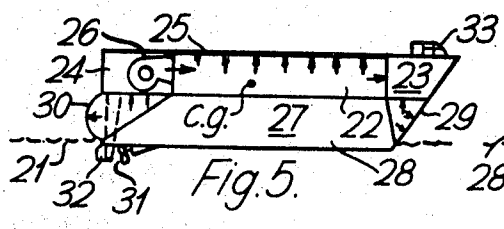


Fig.5.

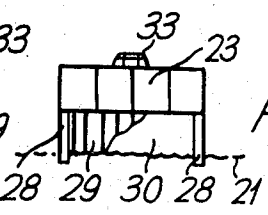


Fig.6.

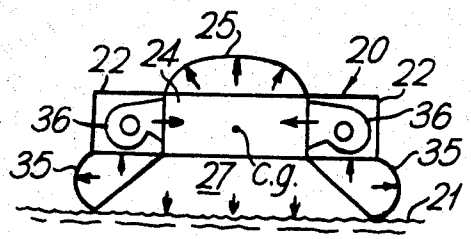
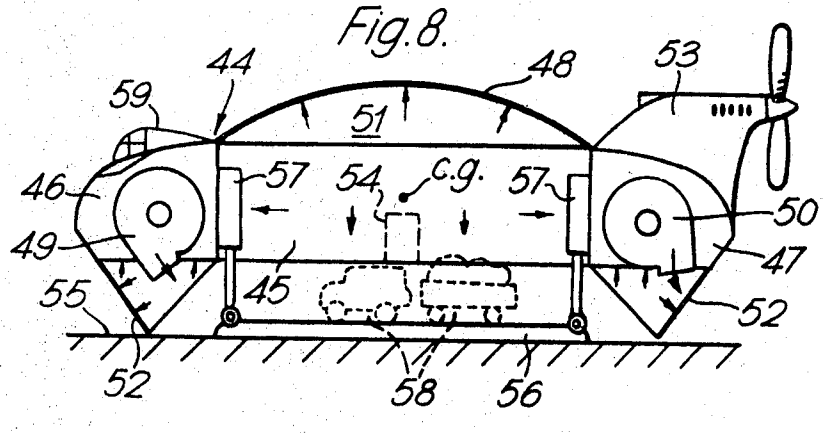


Fig.7.

Fig.8.



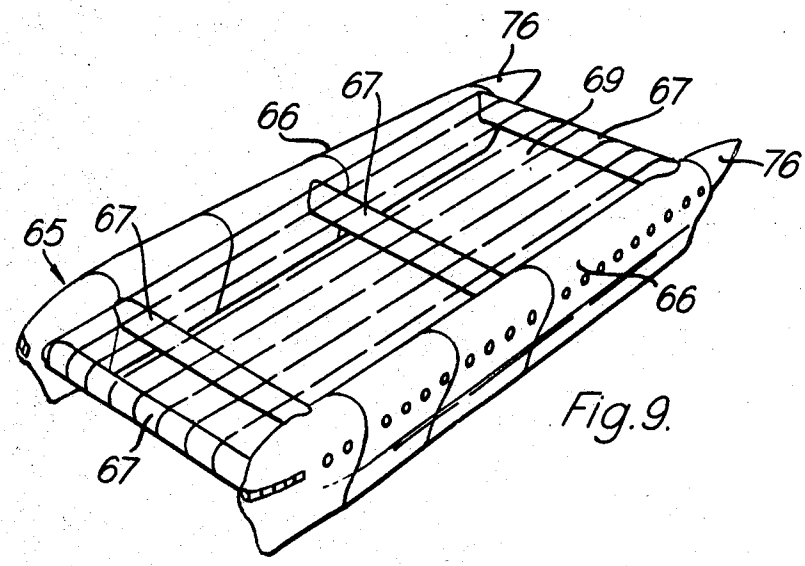
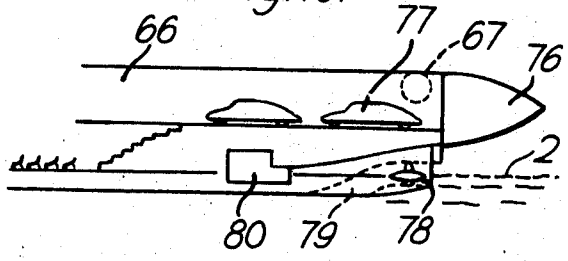


Fig. 9.

Fig. 10.



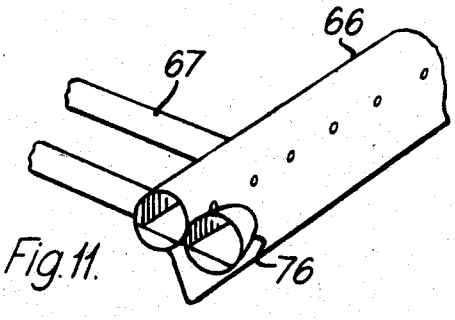


Fig. 11.

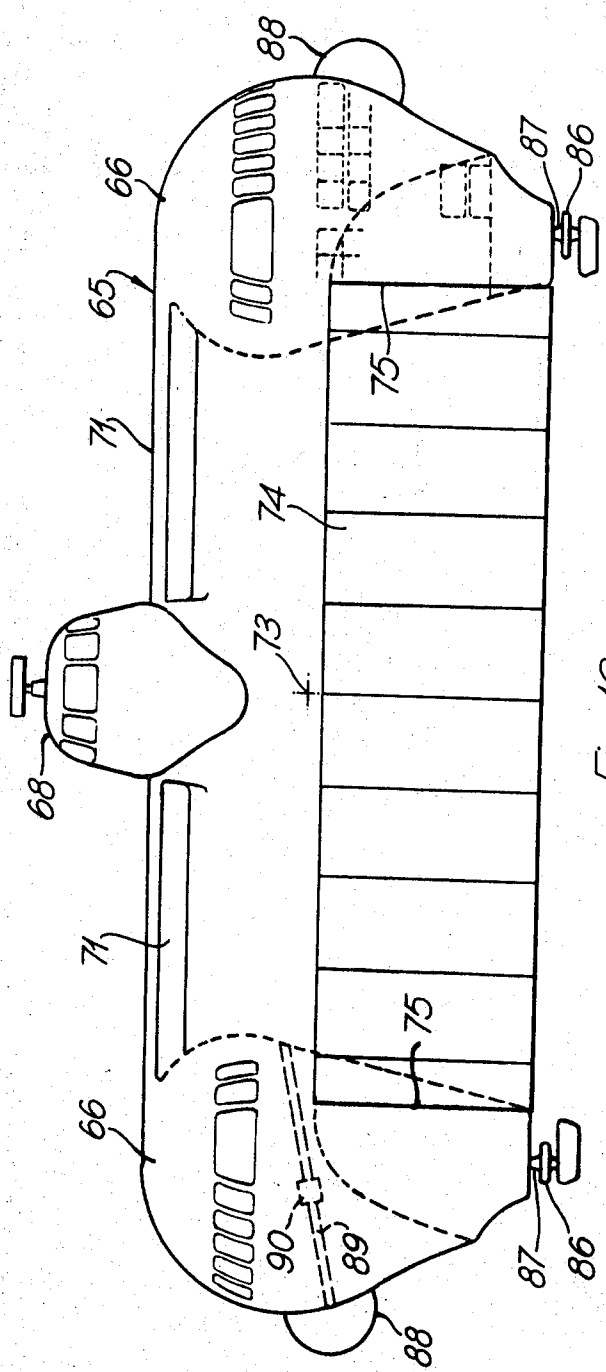


Fig. 12.

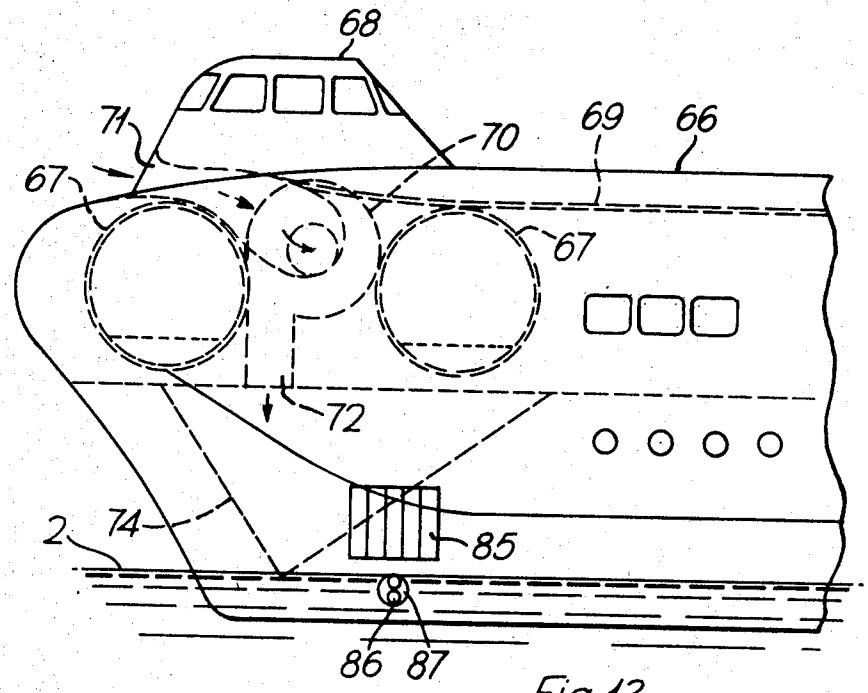


Fig. 13.

AIR-CUSHION VEHICLES

This is a continuation-in-part of Application Ser. No. 620,713 filed 6th Mar., 1967 (now abandoned).

This invention relates to gas-cushion vehicles, that is to say, to vehicles for travelling over a surface and which, in operation, are supported above that surface, at least in part, by a cushion of pressurized gas, for example, air, formed and contained beneath the vehicle.

One form of gas-cushion vehicle is the "sidewall" type, comprising a vehicle body and a laterally-spaced pair of "sidewall" structures extending longitudinally along the sides of the vehicle body and depending therefrom so as to contain the sides of the vehicle-supporting cushion. In the case of "sidewall" vehicles for operation over water, the "sidewalls" thereof are usually of rigid construction and, in operation of the vehicle, dip into the water so as to provide a cushion-gas seal.

"Sidewall" vehicles for operation over water are designed to travel over waves, the heights of which are substantially the same as the heights of the largest waves to be expected. Hitherto, such vehicles have only been called upon and consequently have only been designed for operation over waves of relatively small height, say 3 to 4 feet.

To allow "sidewall" vehicles to operate over large waves, say 10 to 16 feet, a cushion is required of substantially the same height as the waves. However, merely enlarging the height of the cushion introduces a serious problem in that the center of gravity of the vehicle is raised correspondingly and thus the vehicle can become unstable.

According to the present invention, a gas-cushion vehicle comprises a pair of laterally-spaced body structures adapted to carry payload, structural means extending between the body structures so as to interconnect said body structures, sheeting means covering the space between said body structures so as to form a membraneous barrier between said space and the atmosphere above, and means for forming a vehicle-supporting cushion of pressurized gas within said space.

Embodiments of the invention will now be described by way of example with reference to the accompanying drawing wherein:

FIG. 1 is a front end view, in section, of a known form of "sidewall" gas-cushion vehicle,

FIG. 2 illustrates a modification of the vehicle of FIG. 1,

FIG. 3 is a front end-view, in section, of one form of "sidewall" gas-cushion vehicle constructed according to the invention,

FIGS. 4, 5 and 6 are respectively a plan longitudinal section, and stern elevation views of another embodiment of the invention,

FIG. 7 is a diagrammatic cross section of an embodiment similar to that of FIG. 4 and 5,

FIG. 8 is a longitudinal section of yet another embodiment of the invention,

FIG. 9 is a perspective view of yet another embodiment,

FIG. 10 is a diagrammatic longitudinal section through the rear part of one of the body structures of the vehicle of FIG. 9,

FIG. 11 illustrates, in an open position, a front access door of a modified form of the vehicle shown in FIG. 9, and

FIGS. 12 and 13 are respectively front and side views of the vehicle of FIG. 9, to an enlarged scale.

FIG. 1 shown shows a "sidewall" gas-cushion vehicle 1 of known form travelling over a water surface 2 and supported thereover by a cushion 3 of pressurized air formed and contained beneath the vehicle body 4. The sides of the vehicle-supporting cushion 3 are contained by a laterally-spaced pair of "sidewall" structures 5 of rigid construction which extend longitudinally in substantially parallel array along the sides of the vehicle body 4 and depend therefrom to dip into the water 2 and preserve a cushion-air seal.

As is the case of previously-known sidewall gas-cushion vehicles, the payload of the vehicle 1 is contained within the vehicle body 4 so that the center of gravity *e.g.* of the vehicle is disposed within the vehicle body.

With reference to FIG. 2, if it is desired to increase the height of the cushion 3, the depth of the sidewalls 5 may be increased correspondingly. However, this results in an increase of the height of the *c.g.* above the water 2 and the vehicle now tends to become unstable in that it tends to roll from side to side, as indicated by the arrows 6.

FIG. 3 shows a sidewall gas-cushion vehicle 10 according to the invention, comprising a pair of laterally-spaced rigid body structures 11 of buoyant construction and of hollow, elongated form extending longitudinally in substantially parallel array and adapted to carry the payload of the vehicle, structural means in the form of spaced members 12 extending between the fore-and-aft ends of the body structures 11 so as to interconnect them and flexible sheeting means 13 covering the space between the structures 11 and attached thereto in a sealing manner so as to form a membraneous barrier between the space and the atmosphere above, and axial fan means 14 disposed in horizontal ducts for forming a cushion 15 of pressurized air within the space. The sheeting 13 is subjected to pure tension and can thus be made of thin, lightweight flexible material.

The ends of the cushion 15 are contained by flexible skirt means (not shown) as are the ends of the cushions 3 of FIGS. 1 and 2. Access to and exit from the interiors of the body structures 11, which are of multideck construction, is by way of doorways 17 formed in the outer side surfaces of the structures. The vehicle 10 is propelled by conventional waterscrew propellers 18 driven by engines 19 disposed in the body structures 11.

As the payload of the vehicle 10 is carried within the "sidewall" body structures 11, the center of gravity (*c.g.*) of the vehicle is now disposed within the cushion 15. The design of the vehicle 10 is such that its *c.g.* will also be disposed within the cushion 15 even if the vehicle is carrying little or no payload.

With reference now to FIGS. 4 to 6, a sidewall gas-cushion vehicle 20 shown travelling over a water surface 21 comprises a pair of laterally-spaced body structures 22 of hollow, elongated form adapted to carry payload and structural means in the form of bow and stern body members 23, 24 extending laterally between the fore-and-aft ends respectively of the body structures 22 so as to both interconnect and space the latter. The body structures 22 and body members 23, 24 unite to form a hollow, annular structure of rigid construction which defines a rectangular, cushion-containing cavity. A flexible sheet 25 is sealingly attached to the upper surface of the annular structure so as to cover the space between the body structures 22 and the bow and stern members 23, 24 thereof (i.e. the rectangular cavity) and so as to form a membraneous barrier between this spaced and the atmosphere above. Fan means 26 supply pressurized air to the space between the structures 22 so as to form a vehicle-supporting cushion 27 within the space. The center of gravity *c.g.* of the vehicle 20 is disposed within the cushion space.

In further detail, the sides of the cushion 27 are contained by a pair of buoyant wall structures 28 of rigid construction which extend longitudinally in substantially parallel array along the sides of the body structures 22 and depend therefrom so as to dip into the water 21 and preserve a cushion-air seal. The front and rear ends of the cushion 27 are contained by flexible skirts 29, 30 of the form disclosed by U.S. Pat. 3,420,330 and 3,291,237 respectively. Both skirts 29, 30 are open to the cushion 27 and are inflated by air therefrom. The vehicle 20 is propelled over the water 21 by conventional water screws 31 mounted beneath the rear ends of the sidewalls 28 and driven by engines (not shown) housed within the forward parts of the body structures 22. The vehicle 1 is steered by conventional rudders 32 also mounted beneath the sidewalls 28. The vehicle is provided with a forwardly-mounted control cabin 33.

With reference to FIG. 7, the vehicle 20 may be modified by replacing the rigid sidewalls 28 with inflatable flexible skirts 35 similar to rear skirt 30 of FIG. 5. The FIG. also shows how

the space occupied by the cushion 27 may be enlarged, i.e. by making the flexible sheeting 25 of concave form with the concavity facing the cushion.

In the arrangement shown in FIG. 7, the fan 26 (FIG. 5) is either replaced or augmented by a pair of fans 36 housed in the body structures 22.

In the arrangements shown in FIGS. 4 to 7, the vehicle 20 is supported by cushion air acting on the underside of the flexible sheeting 25 and on the underside of the annular structure defined by the body structures 22 and end parts 23, 24. The sheeting 25 is in pure tension and can thus be made of thin, lightweight material.

The whole of the annular structure is hollow so as to accommodate payload and the structure, being boxlike, is very strong and is capable of withstanding large sheer forces and bending moments. It is also forms an inherently stiff, torque tubelike structure. With reference to FIG. 4, payload can be moved from one part of the annular structure to another, as indicated by the arrows 37.

Access to and exit from the interior of the annular structure is by way of doorways 39 (FIG. 4) in the stern portion 24 and doorways 40 (FIG. 4) in the roofs of the body structures 22.

With reference now to FIG. 8, the gas-cushion vehicle 44 shown therein comprises a laterally-spaced pair of body structures 45 of hollow, elongated form extending longitudinally in substantially parallel array and adapted to carry the payload of the vehicle, and structural means in the form of bow and stern body members 46, 47 extending laterally between the fore-and-aft ends respectively of the body structures 45 so as to interconnect the latter. The body structures 45 and body member 46, 47 thus unite to form a hollow annular structure of rigid construction and of similar form to the annular structures of the vehicle 20 of FIGS. 4 to 6. A flexible sheet 48 of concave form is sealingly attached to the upper surface of the annular structure so as to cover the space between the body structures 45 thereof and so as to form a membraneous barrier between this space and the atmosphere above which is subjected to pure tension. Fan means 49, 50 housed in the body members 46, 47 supply pressurized air to the space between the structures 45 so as to form a vehicle-supporting cushion 51 within the space. The center of gravity *c.g.* of the vehicle 44 is disposed within the cushion space.

The cushion 51 is contained by a flexible skirt 52 which is attached to and depends from the periphery of the annular structure. The skirt 52 is of the same form as the skirt 29 of FIG. 5. Alternatively, the sides of the cushion 51 may be contained by a pair of rigid "sidewall" structures (of the same form as the sidewalls 28 of FIG. 5) and the ends of the cushion by portions of flexible skirt 52.

The vehicle is propelled by a rear-mounted airscrew unit 53. Access to and exit from the body structure 44 (and also the body members 46, 47) is by way of doorways 54 in the outer side surfaces of the body structures 44. The vehicle is provided with a forwardly-mounted control cabin 59.

The vehicle 44 is shown hovering over a land surface 55 and the vehicle is provided with a platform 56 for carrying additional payload disposed within the cushion space. The platform 56 is suspended from the body members 46, 47 of the annular structure by telescopic jacks 57 arranged in pairs adjacent to the corners of the platform 56 or otherwise spaced to provide clearance to enable wheeled cargo 58 to be driven on to the platform form either end.

In operation, the vehicle 44 may be driven into its unloading position or alongside a bay provided for this purpose, remaining "on cushion" until the platform 56 has been lowered. Depending on operating conditions, the vehicle may remain "on cushion" or if provided with "sidewalls," lowered to a position where the sidewalls engage the ground 55 while cargo is on or off-loaded as the case may be. Whether the vehicle remains on cushion or not, cargo is driven through front or rear portions of the skirt 52, the skirt deflecting to allow such passage. When the platform 56 has been loaded it can be raised vertically with the vehicle "on cushion" by means of the jacks 57, there being sufficient clearance between adjacent parts of the annular structure and the platform 56 to allow free circulation of cushion air. The vehicle can now proceed on its journey.

Referring now to FIGS. 9 to 13, a gas-cushion vehicle 65 comprises a laterally-spaced pair of buoyant body structures 66 of hollow, elongated form and of rigid construction, extending longitudinally in substantially parallel array and adapted to carry payload, and structural means in the form of four tubular struts 67 extending laterally between the body structures 66 so as to interconnect the latter. The interiors of the struts 67, 68 provide passageways for connection between the body structures 66 and the foremost pair of the struts 67 also provide access to a centrally-mounted control cabin 68 (FIGS. 12 and 13 only). The body structures 66 and struts 67 unite to form a hollow, framelike structure of rigid construction.

A flexible sheet 69 is sealingly attached to the framelike structure so as to cover the space between the body structure and so as to form a membraneous barrier between this space and the atmosphere above, the sheet being subjected to pure tension. Fan means 70 (FIG. 13) disposed between the foremost pair of struts 70 supply pressurized air to the space between the body structures 66 so as to form a vehicle-supporting cushion within the space. The fans 70 have atmospheric air intakes 71 and outlets 72 and are driven individually by small gas turbines (not shown).

The center of gravity of the vehicle 65 is disposed within the cushion space on a centrally-disposed fore-and-aft axis 73 (FIG. 12).

The vehicle 65 is designed for use over water and the body structures 66 are downwardly tapered (See FIG. 12) SO AS to serve as "sidewalls" in containing the vehicle-supporting cushion by dipping into the water. The ends of the cushion are contained by flexible skirts 74 of the same form as the skirt 29 of FIG. 5. If desired, the front skirt 74 can be shortened and the fans 70 used to cause air to flow down the back of the skirt so as to form an air-curtain therebeneath.

In order to ensure simplicity in skirt design, the parts of the body structures 66 in the vicinity of the skirt 74, i.e. the bow and stern ends of the body structures, may be straight as indicated at 75 (FIG. 12). Otherwise the upper part of each body structure is substantially tubular in cross section, the lower part thereof tapering downwardly towards the waterline.

Entrance to each body structure is by a doorway normally closed by means of a semidetachable stern piece 76 which is pivotally secured to the remainder of the structure by hinges (not shown). When each piece 76 is in its open position, wheeled cargo, indicated at 77 (FIG. 10), or cargo-carrying trucks, can be driven directly onto a given deck level within the associated body structure 66. In place of the "solid" bow design shown in FIG. 9, bow pieces similar to stern pieces 77 may be fitted so as to provide bow doorways.

The vehicle is propelled by water-jet propellers 78 disposed in ducts 79 formed in the rear end of each body structure 66. The proper propellers 78 are driven by engines 80.

Shutter-controlled cushion-air vents 85 are provided at the front and rear ends of the hull structures 66, the vents being connected through lateral ducts passing through the structures to the cushion space so as to provide controlled discharge of cushion-air in order to apply sideways-acting forces to the vehicle. When adjusted to provide oppositely-acting thrusts at the ends of the vehicle, turning forces can be applied thereto. Power driven water pump thrusters 86 are provided in transverse ducts 87 formed in the front of each hull structure 66 so as to provide a similar facility, particularly when the vehicle is "off cushion."

The vehicle 65 is provided with hollow fenders 88 disposed along the outer sides of the body structures 66 and which may be pressurized with air from the cushion and/or from an auxiliary air supply. Similar fenders may be provided at the front and rear if desired. The left-hand side of FIG. 12 shows how a fender 88 may be inflated direct from the cushion by means of a duct 89 provided with a control valve 89.

It will be understood that the cushion-containing flexible sheets **13**, **25**, **48** and **69** may be attached to a frame structure itself attachable to the associated body structures.

The sheeting means provide an operculum or canopy which may be of any suitable flexible material, for example, neoprene-coated nylon fabric sheet or polyurethane sheet. Alternatively, the sheeting means may be of a rigid material, for example, thin-gauge aluminum alloy. When the sheets are of rigid material they may be connected to remaining parts of the vehicle by flexible material.

The sheeting means need not be of single thickness. For example, double thickness contiguous sheeting means may be used so that the double thickness is effectively a single thickness.

The sheeting means may be of elastic material. For example, with reference to FIGS. **7** and **8**, if the concave sheeting means **25**, **48** were made of elastic rubber material the sheeting means would expand and contract to maintain the volumes of the cushions **27**, **51** substantially constant when the vehicles **20**, **44** travel over large waves. This "panting" would tend to reduce the unpleasant "ride" effects caused by vertically-acting forces resulting from "wave pumping" of the cushion spaces.

I claim:

1. A gas-cushion vehicle comprising a pair of hollow laterally-spaced body structures adapted to carry payload inside of said body structures, structural means extending between the body structures so as to interconnect said body structures, a membraneous barrier comprising flexible sheeting means covering the space between the body structures and being sealed to said body structures so as to separate said space from the atmosphere above, and means for forming a vehicle-supporting cushion of pressurized gas within said space.

2. A vehicle as claimed in claim **1** wherein said sheeting means comprise metal sheeting means.

3. A vehicle as claimed in claim **1** wherein said sheeting means comprise elastic flexible sheet means.

4. A vehicle as claimed in claim **1** wherein said sheeting means are of concave form with the concavity facing said space between the body structures.

5. A vehicle as claimed in claim **1** wherein the structural means extending between the body structures are formed to serve as passageways between said body side structures.

6. A vehicle as claimed in claim **1** wherein at least one extremity of a body structure is provided with means allowing access to the interior thereof.

7. A vehicle as claimed in claim **6** wherein said means allowing access to the body structure comprises an end portion movably connected to the remainder of the body structure.

8. A vehicle as claimed in claim **1** wherein means are provided for carrying additional payload within the space occupied by the vehicle-supporting cushion.

9. A vehicle as claimed in claim **8** wherein said means comprise platform means and means for lifting and lowering the platform means away from and on to a ground surface beneath the vehicle.

10. A vehicle as claimed in claim **1** wherein the lower portions of the body structures are of flexible construction.

11. A vehicle as claimed in claim **10** wherein said lower portions are of inflatable construction.

12. A vehicle as claimed in claim **1** wherein the ends of the vehicle-supporting cushion are contained by skirt means extending laterally between the ends of the body structures.

13. A vehicle as claimed in claim **12** wherein the skirt means are of inflatable construction.

14. A vehicle as claimed in claim **1** including thrust means for imparting a lateral thrust to the vehicle.

15. A vehicle as claimed in claim **14** for operation over water wherein said thrust means comprise water-pump thrust means carried by the body structures.

16. A vehicle as claimed in claim **14** wherein said thrust means comprise means for releasing cushion gas from the space between the body structures.

17. A vehicle as claimed in claim **1** for operation over water wherein the body structures are of elongated form and include a pair of wall structures extending lengthwise along and depending from the body structures so as to dip into the water and preserve a cushion-gas seal.

18. A vehicle according to claim **1** wherein said means for forming a vehicle-supporting cushion of pressurized gas within said space comprises means for forming said cushion independently of vehicle travel.

19. A gas-cushion vehicle comprising a pair of hollow laterally-spaced body structures adapted to carry payload inside of said body structures, spacer means of hollow form extending laterally between the ends of the body structures so that the body structures and spacer means together form an annular structure, a membraneous barrier comprising flexible sheeting means covering the space defined by the annular structure and being sealed thereto so as to separate said space from the atmosphere above, and means for forming a vehicle-supporting cushion of pressurized gas within said space.

20. A vehicle according to claim **19** wherein said means for forming a vehicle-supporting cushion of pressurized gas within said space comprises means for forming said cushion independently of vehicle travel.

21. A gas-cushion vehicle for operation over water and comprising a pair of hollow laterally-spaced body structures of buoyant construction and adapted to carry payload inside of said body structures, doorway means for providing access to the interiors of said body structures, structural means extending laterally between said body structures so as to interconnect said body structures, a membraneous barrier comprising flexible sheeting means covering the space between the body structures and being sealed to said body structures so as to separate said space from the atmosphere thereabove, and means for forming a vehicle-supporting cushion of pressurized gas within a said space, the center of gravity of said vehicle being within said space.

22. A vehicle according to claim **21** wherein said means for forming a vehicle-supporting cushion of pressurized gas within said space comprises means for forming said cushion independently of vehicle travel.

23. In a gas-cushion vehicle, the combination of a pair of laterally spaced hollow body side structures adapted to contain payload, said structures having opening means providing access to the insides of said structures for enabling loading and unloading of payload therein; means rigidly interconnecting said body side structures; cushion containing transverse skirt means at the stern and bow ends of said body structures, said body side structures and said skirt means peripherally bounding a gas cushion cavity; sheeting means sealed to said body structures so as to form a membraneous barrier between said cavity and the atmosphere above and to contain a gas cushion within said cavity; and means for generating a gas pressure within said cavity independently of vehicle travel so as to provide a vehicle supporting cushion.

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,559,608 Dated February 2, 1971

Inventor(s) Edward Gunston Tattersall

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the patent heading, the expression:

"Priority Mar. 14, 1966
Great Britain
11102/66"

should be changed to read:

"Priority Mar. 14, 1966
Great Britain
11102/66;
Feb. 10, 1967
Great Britain
6525/67;
cognate complete specification
filed Mar. 7, 1967."

Signed and sealed this 8th day of June 1971.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

WILLIAM E. SCHUYLER,
Commissioner of Patent