United States Patent

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[33] France
[31] 118,640

[54] **FLUID CUSHION CONFINING DEVICE**
10 Claims, 14 Drawing Figs.

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[51] **Int. Cl.** **B60n 1/04**
[50] **Field of Search** 180/117, 120, 121, 126, 127, 116, 125, 118

[56] **References Cited**

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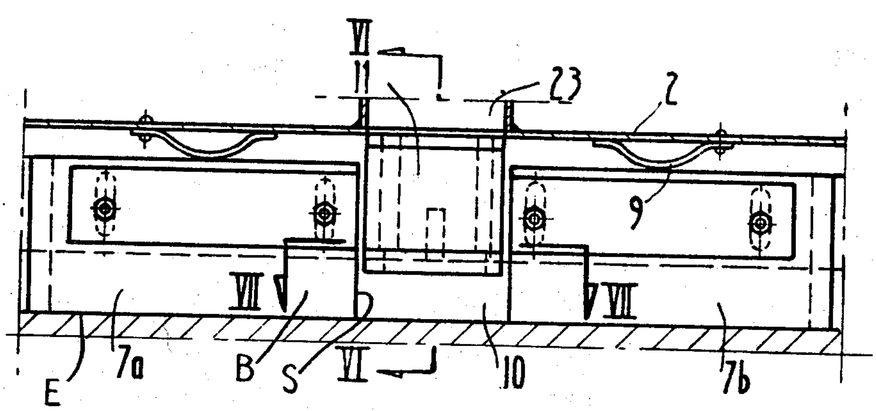
ABSTRACT: A device, applied to a ground effect vehicle, for confining a fluid cushion, the device comprising a sidewall for bounding the cushion round its periphery, the free end of the sidewall bearing in a substantially sealingtight manner on a bearing surface such as the ground, outlet means of adjustable cross section being provided for the fluid from the cushion.



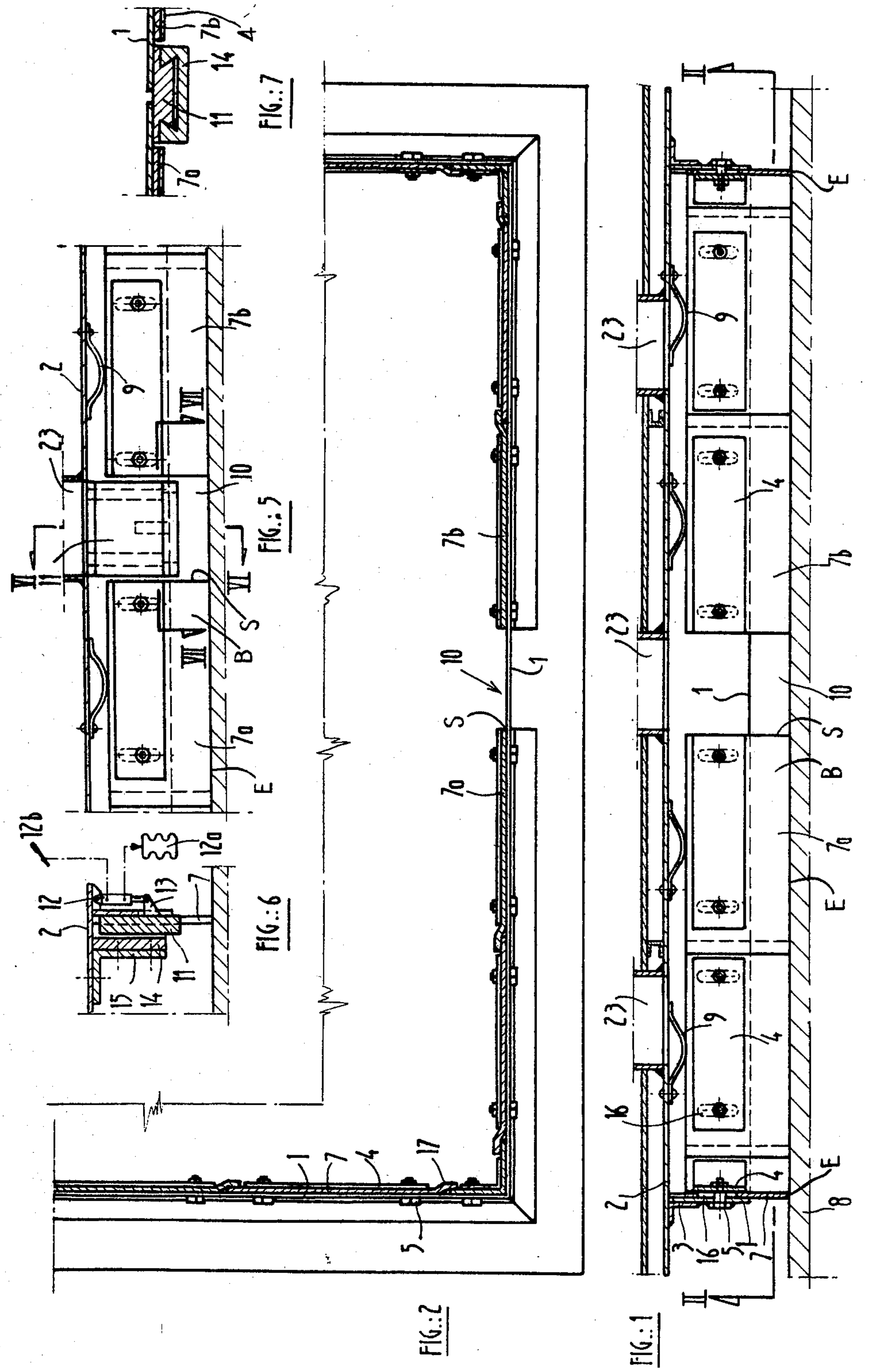
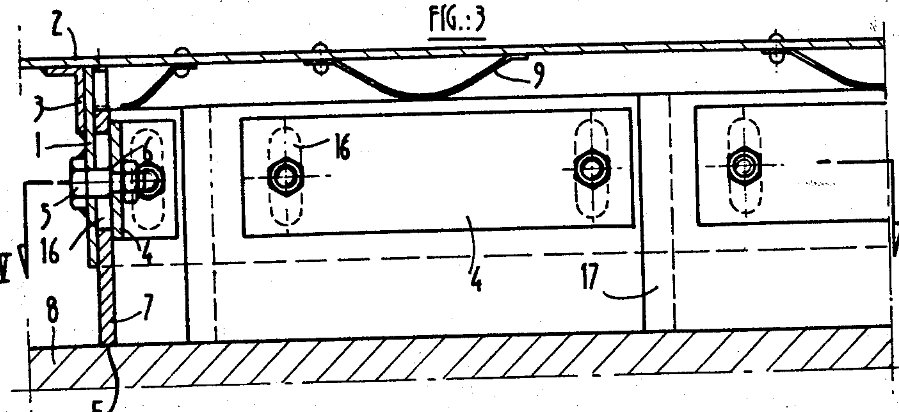


FIG.:7
FIG.:5
FIG.:6
FIG.:2
FIG.:1

FIG.: 3



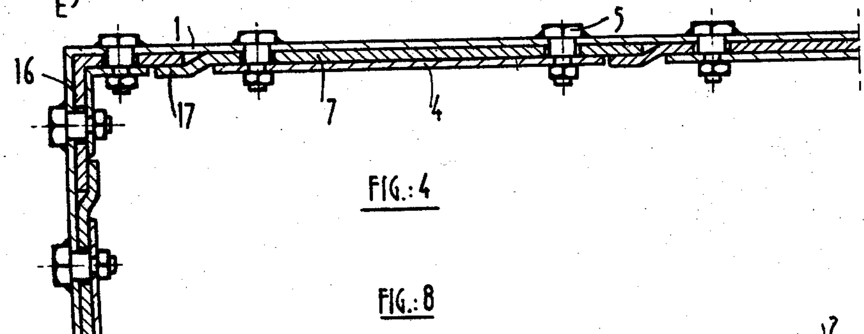


FIG.: 4

FIG.: 8

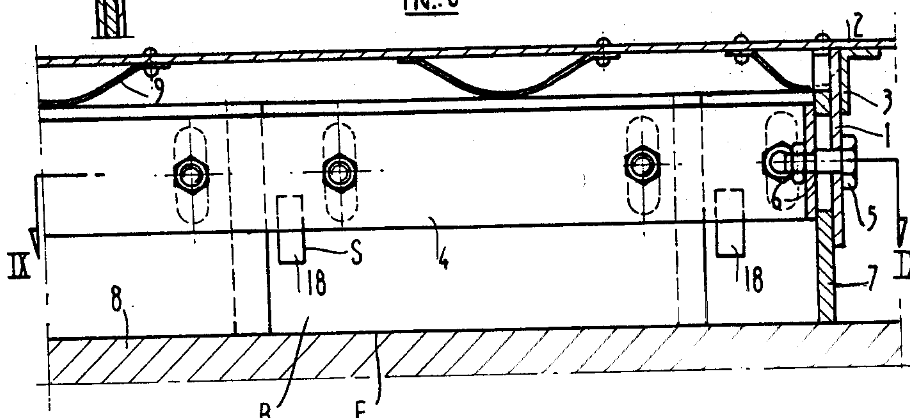
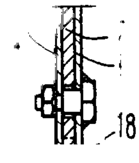


FIG: 9



FLUID CUSHION CONFINING DEVICE

The invention relates to "plenum chamber" means for confining at least one fluid cushion for ground effect machines. The devices, which confine the fluid between a frame integral with the machine and an opposite bearing surface such as the ground, comprise a wall, generally movable with respect to the frame, which bounds the cushion along at least part of its periphery, the wall having a free end in the direction of the bearing surface.

The invention applies both to freely moving and to guided vehicles; in the latter case it applies both to the lifting and the guiding cushions.

The following description will be limited to lifting cushions, but the information relating to this type of cushion can obviously be applied to guiding cushions, it the reference to vertical forces (the weight of the vehicle) is replaced by a reference to forces having a component perpendicular to the bearing surface and due e.g. to the wind or to centrifugal force when the vehicle follows a curved trajectory.

As is known, the sidewalls of the plenum chamber cooperate with the end of the chamber and the surface of the ground to from a space in which there is an excess pressure p with respect to the outside of the cushion (see FIG. **12**).

Under normal conditions, the bottom of the plenum chamber is separated from ground level by a height h called the flight or outlet height, the size of which depends on a compromise chosen between at least two requirements. The height of flight cannot be too low, since this affects the capacity of the vehicle for overcoming obstacles on its path. On the other hand, the height must not be too great, since the resulting escape rate Q would be very high and would require a prohibitively large source or sources of energy to supply the lift. It can easily be shown that the lifting power is proportional to the ratio Lh/S, which reduces to h/D for plenum chambers having a circular periphery. In these formulae, L is the perimeter of the free edge of the plenum chamber, S is the support area bounded by the perimeter, h is the space between the free edge and the bearing surface, and D is the diameter of a circular free edge (see FIGS. **12** to **14**). The cushion can be fed more economically in proportion as these ratios are smaller.

The result, however, is another disadvantage, an increase in the rigidity of the system. By analogy with the operation of a spring, the rigidity of the system can be defined as the ratio of the variation in the force bearing the cushion to the variation in the height of flight associated with it. If p_{max} is the maximum excess pressure in the cushion when the escape rate is zero (h tends towards zero), the expression for the rigidity R is:

$$R=\frac{S(p_{max}-p)}{h}=\frac{(p_{max}-p)}{\frac{h}{S}}$$

As can be seen, this rigidity (called the "aerodynamical" rigidity) approaches infinity when h/S, (h/D for plenum chambers with a free circular edge) approaches zero, unless ($p_{max}-p$) simultaneously approaches zero owing e.g. to the shape of the characteristic curve of the source of compressed fluid. In this way, economic operation appears to exclude operation at low rigidity or great elasticity, which means that the system cannot be comfortable.

The aim of the invention is to reconcile these two requirements by disassociating the effect of the outlet cross section from the effect of the lift area. According to the invention, the fluid does not escape around the perimeter L of the cushion, but at fixed points through outlet means cross section but having a shape such that the variation in ratio h/S or h/D is much more favorable to the flexibility of the system without increasing the expense.

To this end, a confining means according to the invention is characterized by a combination of means for keeping the free end of the peripheral confining wall in substantially leak-obstructing contact engagement with the bearing surface, and by at least one outlet means of variable and controllable cross section. As a result, at least most of the flow from the cushions escapes through the outlet means, whose nominal or maximum cross section, position and shape can be chosen in advance.

The walls can move with respect to the vehicle frame and can thus climb obstacles and/or follow the shape of the bearing surface while remaining in substantially sealingtight contact with it.

To this end, use can advantageously be made either of rigid walls made of sliding plates or the like and pushed towards the bearing surface by resilient means such as springs, or of walls which are deformable but have a rigidity greater than the compressive forces to which they are subjected.

In a first embodiment, the outlet means of controllable cross section comprises an unwalled part of the cushion periphery.

The maximum cross section is advantageously adjusted by a closure member of adjustable position, e.g. by a sliding closure member which can be adjusted in dependence on the internal pressure in the fluid cushion and/or by the pilot of the vehicle.

In another embodiment, which applies more particularly to the case where the walls confining the cushion comprise sliding plates or the like, the fluid escaping from the cushion is controlled by ducts in the plates or the like. The flow can advantageously be controlled by the ducts in cooperation with closure plates which are stationary with respect to the vehicle.

According to an advantageous embodiment, at least one of the controlled outlet means is disposed at the rear of the machine, so that at least part of the flow escaping from the cushion can be used to drive the vehicle.

The following nonlimitative exemplary description, which refers to the accompanying drawing, will show how the invention can be embodied.

FIG. **1** is a vertical section of a means for confining a fluid cushion, comprising an adjustable outlet means according to a first embodiment of the invention;

FIG. **2** is a cross section along II–II in FIG. **1**;

FIG. **3** is a larger-scale view of part of FIG. **1**;

FIG. **4** is a view along IV–IV in FIG. **3**;

FIG. **5** is a view of part of FIG. **1**, showing an elevation of a means for closing the adjustable outlet means;

FIGS. **6** and **7** are sections respectively along VI–VI and VII–VII of the closure system shown in FIG. **5**;

FIG. **8** is a cross section similar to FIG. **3**, showing an arrangement of the outlet means in a second embodiment of the invention;

FIG. **9** is a cross section along IX–IX of FIG. **8**;

FIG. **10** shows an elevation of a ground effect vehicle to which the invention can apply. The right part of the FIG. shows an advantageous arrangement of the outlet means;

FIG. **11** is a section along XI–XI of FIG. **10**; and

FIGS. **12** to **14** are diagrams of the different physical or geometrical quantities mentioned at the beginning of the description.

FIG. **12** is a side view of a confining "plenum chamber" means and FIGS. **13** and **14** show two views from beneath of the device shown in FIG. **12**, corresponding to two different forms of the device.

FIGS. **1** to **7** show a device for laterally bounding a fluid cushion supplied through orifices **23** and used for lifting a ground effect machine whose frame is denoted by reference **2**. Angle members **3** rigidly attach the frame to a peripheral plate **1**. These components are shown more clearly in FIGS. **3** and **4**.

Plates **4** disposed parallel to peripheral plate **1** are kept at a fixed distance from plate **1** towards the inside of the cushion, by means of bolts **5** having a shoulder **6** for the purpose. Rigid or semirigid plates or the like **7** formed with oblong apertures **16** round bolts **5** can slide vertically between plates **1** and **4**. The plates at their free end E are in contact with a bearing surface. The surface used as an example in the drawings is a prepared track **8**.

The sliding plates **7** are kept with their free ends E in constant contact with the bearing surface, due to the action of leaf springs **9** or any equivalent resilient device.

Neighboring sliding plates overlap in twos, forming substantially sealingtight coverings **17**.

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[54] **AIR CUSHION VEHICLES HAVING INCREASED ROLL STIFFNESS**
10 Claims, 9 Drawing Figs.

[52] U.S. Cl. **180/118,** 180/121; 104/23
[51] Int. Cl. **B60v 1/02,** B60v 1/00
[50] Field of Search 180/118, 121, 124, 125; 104/23FS

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ABSTRACT: The invention relates to an air cushion vehicle in which the cushions on opposite sides of the vehicle are so interconnected that if the vehicle rolls to one side then the air cushion on the other side is automatically lifted up to produce a righting moment to correct the roll.