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CONTROL SYSTEM FOR FLUID-CUSHION DEVICES

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Fig. 2

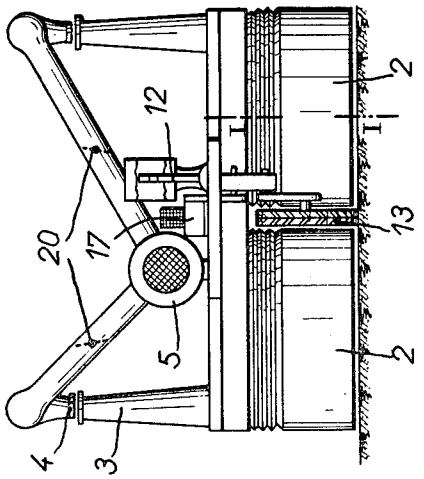
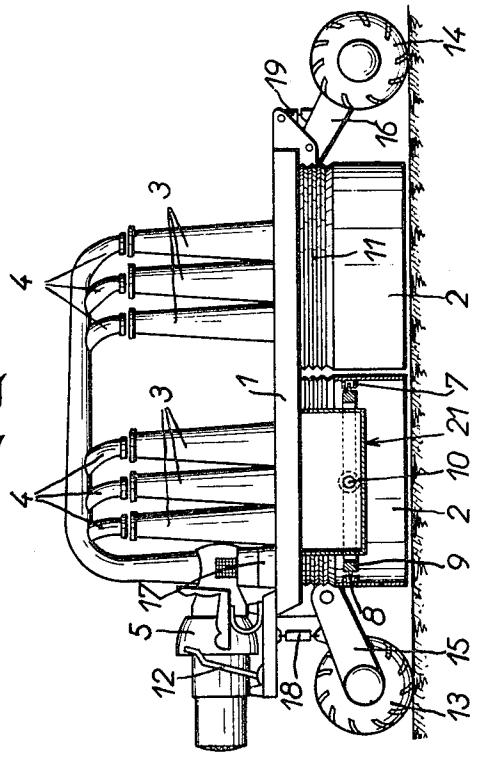


Fig. 1



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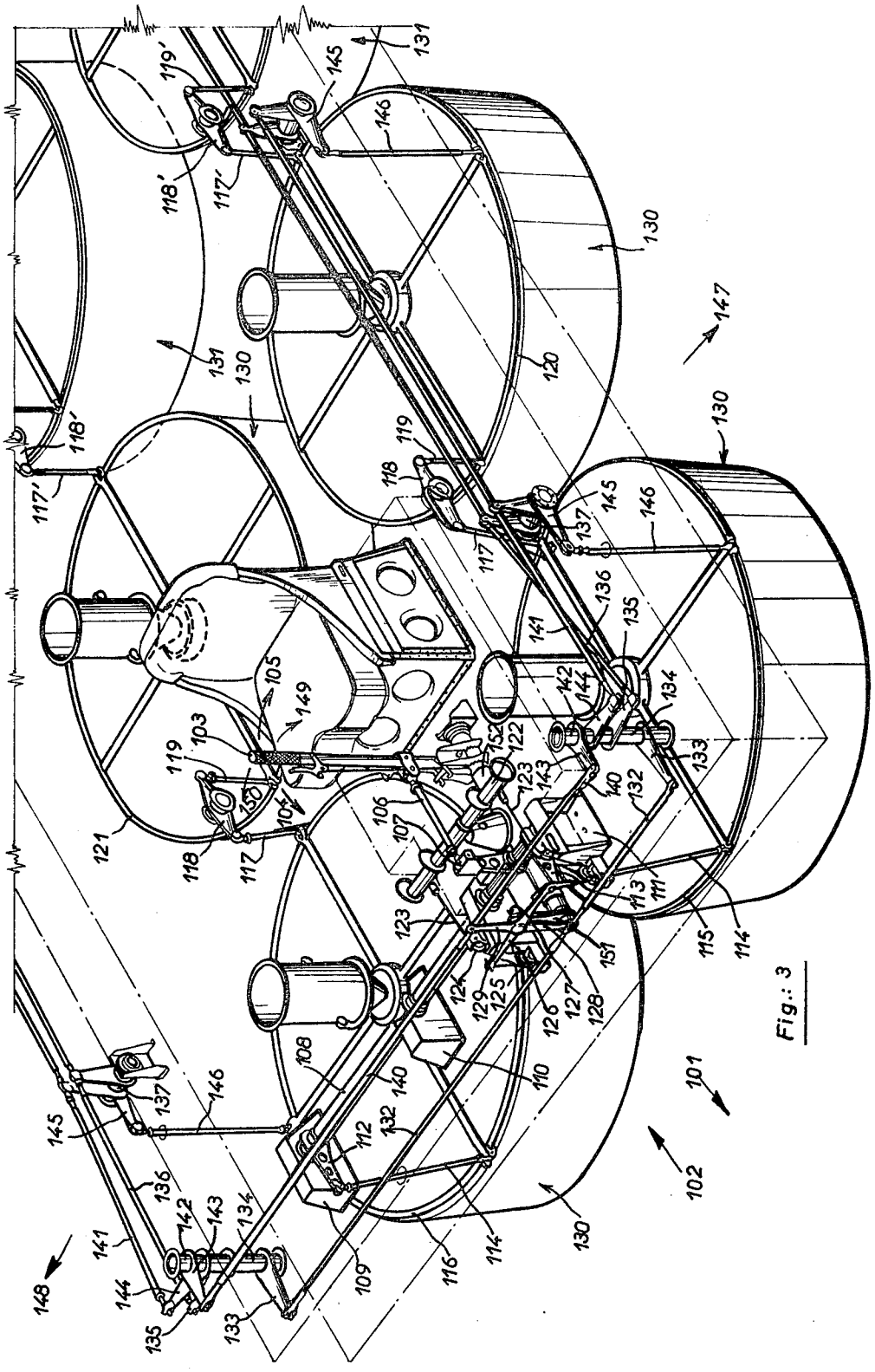


Fig.: 3

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CONTROL SYSTEM FOR FLUID-CUSHION DEVICES

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Continuation-in-part of application Ser. No. 165,634, Jan. 11, 1962. This application Oct. 23, 1965, Ser. No. 502,934
Claims priority, application France, Jan. 17, 1961, 849,877, Patent 1,310,483
Int. Cl. B60v 1/16
U.S. Cl. 180—121 11 Claims

This is a continuation-in-part of my co-pending application Ser. No. 165,634 filed Jan. 11, 1962, now Patent No. 3,263,764.

The present invention relates to fluid-cushion systems designed to sustain a movable body, for example a vehicle, at a small distance from a bearing surface such as the ground or the sea.

One of the objects of the present invention is to provide such fluid-cushion systems with controllable means for orienting the issuing fluid flow in order to produce by action or reaction forces which may be used for propulsion or for steering.

Another object of this invention, as applicable preferably to ground effect vehicles, is to provide orientable fluid-cushion systems which will permit the vehicle to negotiate obstacles without damage and without unduly increasing its height above the ground.

A further object of this invention is to provide such orientable fluid-cushion systems with a wall element offering a good resistance to wear and tear, and yet light and cheap.

In accordance with the present invention, fluid-cushion systems are combined with means for selectively varying the orientation of the outlet section thereof.

In a preferred embodiment of the present invention, the fluid-cushion systems comprise a gimballed wall element which laterally bounds the fluid cushion.

Other objects and advantages of the present invention will appear in the following description with reference to the accompanying drawings in which :

FIGURE 1 is a diagrammatic elevation view, partly in section, of a ground effect vehicle.

FIGURE 2 is a corresponding front elevation view.

FIGURE 3 is a fragmentary perspective view showing control linkages for the orientation of the fluid-cushion systems.

Referring to FIGURES 1 and 2, there is shown thereon a platform **1** with a plurality of gaseous cushions, each supplied by three ejectors **3**, the inductive nozzles **4** of which branch off the discharge duct of a compressed gas generator **5**, for instance a gas-turbine engine.

Each of said gaseous cushions is of the plenum chamber type and confined within a skirt **2** made of supple material and mounted on a supporting frame **7** gimballed by means of two horizontally opposed pivots **8** to a further gimbal **9** which is supported by two horizontally opposed pivots **10** solid with the platform **1** and set at right angles to the axis of the pivots **8**. The pivots **10** are preferably fixed to the walls of a flotation tank **21** disposed inposed inside each cushion.

The upper portion of each skirt **2** provides an oscillation joint, an example being bellows joint **11**, whereby the skirt is able to move freely in all directions and full tightness with minimum friction is ensured.

Through actuating means such as a joystick or control lever **12**, pivotal motion of the skirts is controlled about the two perpendicular axes containing respectively the pivots **8** and the pivots **10**. Thus it is possible to simultaneously orientate all the skirts in the same direction, thereby creating a horizontal force in that direction. Alternatively, the skirts could be orientated differentially in order to produce a steering couple.

The platform is further equipped with a front orientable wheel **13** and a rear wheel **14** driven by an engine **17**, for providing positive (friction) guidance and propulsion in a manner well known in the motorcycle art. The wheels are linked to the platform **1** by arms **15**, **16** provided with suspension elements **18** and **19** designed to support only 10 to 20% of the total weight of the vehicle, the major part of the weight being supported by the gaseous cushions. The suspension elements may be adapted to permit stiffness adjustment, as shown for instance in Brueder 2,757,376.

Valves **20** enable the compressed gas supplied by the gas generating engine **5** to be distributed as desired to the various cushions.

After the engine **5** has been started up, the platform **1** rises on its air cushions and may be piloted by movement of the control lever **12** which orientates the skirts **2**. Accelerations obtained thereby, however, must be kept to a low value in order to avoid diminishing the lifting efficiency, and such acceleration will therefore be suited to translational motion and to low speed maneuvering.

As a part of the weight of the vehicle is supported by the wheels **13**, **14**, the propulsion of said vehicle may be effected by means of the rear wheel and the accelerations and decelerations exceed those attained by aerodynamic means, with yet a good propulsive efficiency. The tandem wheels will in fact ensure good stability when travelling on the ground, even at cruising speeds, if they support 10 to 20% of the weight and if the front wheel **13** is steerable as said hereinbefore. The wheels may be fitted with tires having treads adapted to ensure good traction with the ground.

The effects of the sideway forces due to the wind are thus reduced, and the corresponding tipping couple may be further counterbalanced by suitably operating the valves **20** in a differential manner.

Referring now to FIGURE 3, it will be seen that motion of the platform in the direction of arrows **101** or **102** is determined by swinging a control lever **103** in the direction of arrows **104** or **105**. This lever **103** actuates through a rod **106** a crank lever **107** fast with a rod **108** journalled in bearings **109**, **110**, **111**. The rod **108** carries two crank levers **112**, **113** operating each a rod **114** secured to the front of skirt support rings **115**, **116**. These rings are associated, at the rear, with transmission rods **117** which, through rockers **118** and rods **119**, actuate in their turn support rings **120**, **121** of the next following skirts, and so on by means of a succession in cascade of control linkages comprising transmission rods **117'**, . . . rockers **118'**, . . . and rods **119'**, ...

It is thus possible to obtain a simultaneous and general inclination of the skirts, thereby generating by reaction a horizontal component force which propels the platform either forwardly in the direction of arrow **101** if the control lever **103** is pushed along arrow **104**, or rearwardly in the direction of arrow **102** if the control lever **103** is pulled along arrow **105**.

Sideways displacement of the platform along arrows **147** or **148** is determined by actuating the control lever **103** in the direction of arrows **149** or **150**. This operation modifies the position of a cross-piece **126** journalled at **127** on a crank lever **151** fast with a rod **152** transmitting movements from lever **103**. Such a displacement of the axis of the cross-piece **126** causes a like displacement in translation of the latter and a corresponding displacement in the same direction, to the left or to the right, of horizontal rods **132** and **140** linked respectively to the lower and upper arms **128** and **129** of the cross **126**.

Through linkages to be described hereafter, the skirts are oriented too in a same lateral direction and a corresponding horizontal component force is created.

In addition to the above translational movements of the platform in the longitudinal direction (arrows **101** and **102**) and in the transverse direction (arrows **147** and **148**), the platform may also be imparted with a yaw movement or rotation about a vertical axis for steering purposes.

For this purpose, the platfrom is equipped with a swing-bar **122** operable by the operator's feet and controlling, by means of cables **123** and pulleys **124** and **125**, the cross-piece **126** to give to the branches **128**, **129** of the latter opposite displacements. In order to obtain a differential orientation of a front group of say four skirts **130** and a rear group of also four skirts **131** (in the case of an eight-skirt vehicle), the skirts of each group are connected with respective branches **128**, **129** of the cross-piece **126**. Thus, to branch **128** are linked rods **132** and crank levers **133** fast with sleeves **134** to which are secured crank levers **135** which actuate linkages **136**. It is to be noted that these latter linkages do not affect the group of skirts **130** as they are freely mounted on axles **137**; they actuate the group of skirts **131** by means of crank levers and rods (not shown on the drawing but similar to crank levers **145** and rods **146** described hereafter).

Control of the group of skirts **130** is effected by means of rods **140** connected to branch **129** of cross-piece **126**. These rods **140** actuate linkages **141** through sleeves **142** fast with crank levers **143**, **144** and eventually crank levers **145** and rods **146** which control the skirts **130**.

It will now be easily seen that, if, instead of imparting opposite displacements to rods **132** and **140** by rotating the cross **126** upon actuation of the swing-bar **122**, the rods **132** and **140** are displaced in the same direction by bodily translating the cross **126** to the left or to the right upon actuation of the control lever **103** along arrows **149** or **150**, all the skirts **130** and **131** of both groups will be oriented in the same lateral direction **147** or **148** and this will result in a horizontal thrust component in the opposite direction **148** or **147**, as specified above.

An improvement which is applicable to platforms with multiple skirts consists in imparting different elasticity characteristics to the elemental skirts supporting such platforms. As will be readily understood, the geometrical size of each skirt, namely its height and diameter, and its volume in particular, together with its stiffness and the dimensions of its associated supply duct, all affect the instantaneous rate of leakage and determine a natural period of vertical oscillations of the corresponding air cushion. If all the skirts were identical, such vertical oscillations might give rise to resonance phenomena which may detrimentally affect overall platform sustention. On the other hand, if the elemental skirts be given different sizes, then the natural oscillation periods of the various air cushions will be different and the sustention will tend to be aperiodic.

Thus, in vehicles of this type, the lift and guidance functions may be fulfilled, either independently or jointly, by several different elements, such as wheels and air cushions. Such vehicles should extend both the field of application and the capabilities of the wheeled vehicles used heretofore, in particular over widely varying ground surfaces where deep mud, snow or sand may be encountered.

Obviously, the number of air cushions, compressed gas generators, ejectors and so on may be modified as required, and it will be well understood by those skilled in the art that various further changes and modifications may be made in the presently preferred embodiments of the ground effect platform hereinbefore disclosed, within the spirit and scope of the invention as set forth in the appended claims.

What is claimed is:

1. A ground effect machine movable along a bearing surface in narrow spaced relation therewith, of the kind comprising a platform and support frame and at least one plenum chamber carried by said support frame and cooperating with said surface to form thereagainst a fluid cushion sustaining said machine, said plenum chamber being laterally bounded by a side wall exposed inwardly to said cushion and outwardly to surrounding medium and having a lower free end designed, in operation, to move above but adjacent to said surface and an upper portion attached to said support frame and substantially fluid-tightly connected to said platform, wherein the improvement comprises means mounting said support frame and attached portion of said plenum chamber side wall for bodily tilting the latter with respect to said platform, and controllable means operable from said platform for selectively tilting said plenum chamber side wall bodily, thereby selectively inclining said free end thereof with respect to said surface.

2. Machine as claimed in claim **1**, wherein said plenum chamber side wall comprises a fluid-pressurizable skirt made of flaccid, fluid-tight material and extending from said support frame toward said bearing surface.

3. Machine as claimed in claim **2**, wherein said mounting means comprises a mechanical support attached to said platform and gimballed to said frame.

4. Machine as claimed in claim **2**, comprising a plurality of separate and distinct skirts of flaccid material extending each from a respective support frame toward said bearing surface, and means mounting at least some of said skirts for tiltable movement with respect to said platform, wherein said controllable means comprise means for simultaneously tilting said tiltable skirts in generally opposite directions.

5. Machine as claimed in claim **1**, comprising a plurality of separate and distinct skirts of flaccid material extending each from a respective support frame toward said bearing surface, and means mounting at least some of said skirts for tiltable movement with respect to said platform, wherin said controllable means comprises means for simultaneously tilting said tiltable skirts in a same general direction.

6. An air cushion vehicle comprising a frame, a plurality of plenum chambers under which the air cushion is formed and from which air is exhausted, said chambers functioning as the vehicle lifting medium and being attached in tiltable relationship to said frame, steering control means for tilting at least one of said plenum chambers with respect to said frame and with respect to the ground over which the vehicle travels to vary the relative proportion in a selected direction of air exhausted from the bottom of said chambers to maneuver said vehicle, and an air generating source to supply air for said chambers to elevate said vehicle sufficiently to allow said plenum chambers to tilt.

7. An air cushion vehicle according to claim **6**, consisting of two plenum chambers.

8. An air cushion vehicle according to claim **6**, consisting of three plenum chambers.

9. An air cushion vehicle comprising a frame, a plurality of plenum chambers under which the air cushion is formed and from which air is exhausted, said chambers functioning as the vehicle lifting medium and being attached in tiltable relationship to said frame, steering control means for tilting said plenum chambers with respect to said frame and with respect to the ground over which the vehicle travels to vary the relative proportion in a selected direction of air exhausted from the bottom of said chambers to maneuver said vehicle and an air source introducing air into said plenum chambers to elevate said vehicle sufficiently to allow said plenum chambers to tilt.

10. An air cushion vehicle comprising a frame, a

plurality of plenum chambers under which the air cushion is formed, said chambers functioning as the vehicle lifting medium and being attached in tiltable relationship to said frame, steering control means for tilting at least one of said plenum chambers with respect to said frame and with respect to the ground over which the vehicle travels to vary the relative proportion in a selected direction of air exhausted from the bottom of said chambers to maneuver said vehicle, an air generating source comprising means to pump air into said chambers to elevate said vehicle sufficiently to allow said plenum chambers to tilt.

11. An air cushion vehicle comprising a frame, a plurality of plenum chambers under which the air cushion is formed, said chambers functioning as the vehicle lifting medium and being attached in tiltable relationship to said frame, steering control means for tilting said plenum chambers with respect to said frame and with respect to the ground over which the vehicle travels to vary the relative proportion in a selected direction of air exhausted from the bottom of said chambers to maneuver said vehicle, an air generating source comprising means to pump air into said chambers to elevate said vehicle sufficiently to allow said plenum chambers to tilt.

References Cited

UNITED STATES PATENTS

2,953,320	9/1960	Parry.	
3,170,530	2/1965	Black	180—7
3,209,848	10/1965	Holloway	180—7
2,981,501	4/1961	Schaefer.	
3,150,731	9/1964	Franklin et al.	180—7

FOREIGN PATENTS

1,310,483	10/1962	France.

A. HARRY LEVY, Primary Examiner

U.S. Cl. X.R.

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