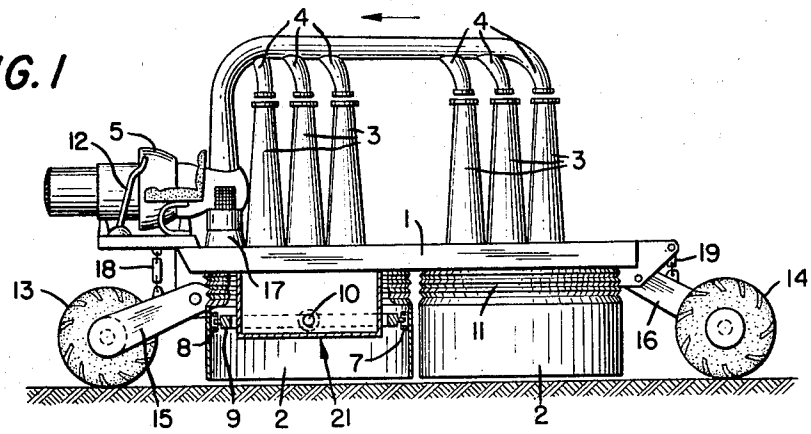
Aug. 2, 1966 J. H. BERTIN 3,263,764

GROUND-EFFECT HOVERING PLATFORMS WITH MULTIPLE AIR CUSHIONS AND STABILITY INCREASING MEANS THEREFOR

Filed Jan. 11, 1962

FIG. 1



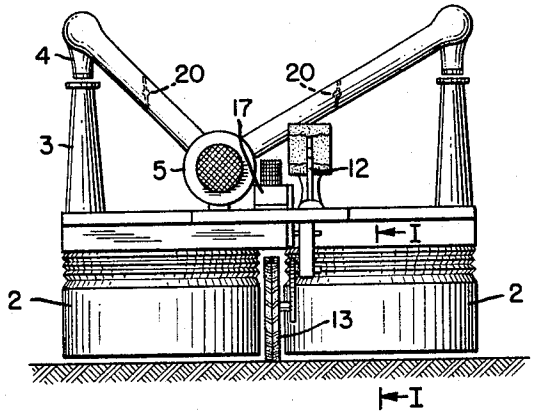
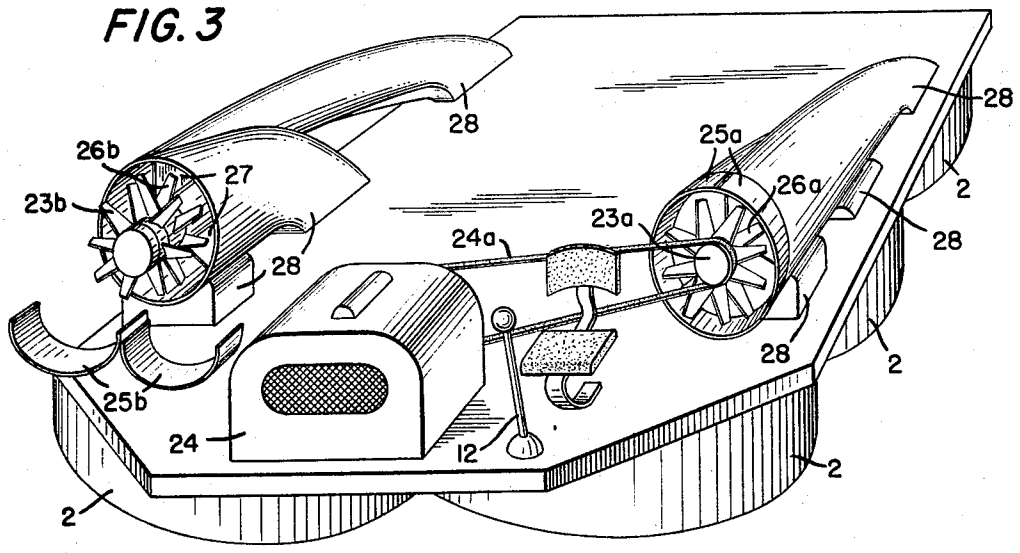


FIG. 2

FIG. 3



United States Patent Office 3,263,764 Patented August 2, 1966

3,263,764

GROUND-EFFECT HOVERING PLATFORMS WITH MULTIPLE AIR CUSHIONS AND STABILITY INCREASING MEANS THEREFOR

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5 Claims. (Cl. 180—7)

This invention relates to hovering platforms or ground effect vehicles for which lift is provided, at a small height above the ground, by compressed air cushions, and is more particularly concerned with the stability of such vehicles. Indeed, initial flight testing has shown that such platforms are usually unstable and that they tend to oscillate in a combined pitching and rolling motion when travelling over rough ground. It has additionally been found that even directional stability cannot be ensured in absolutely satisfactory fashion by the use of fins, as ground irregularities will in certain cases set up instantaneous transverse components in the lifting force.

The first object of the invention is to improve the natural stability of ground effect hovering vehicles sustained mainly on gaseous cushions, without, however, increasing the rate of the gas flow necessary for sustention. This is attained, according to the invention, by the use of a plurality of separate gaseous cushions confined by distinct bounding means, and, in combination with said separate gaseous cushions compressor means for supplying separately each of said cushions with atmospheric air under pressure.

Another object of the invention is to provide a natural stability to the vehicle by means of circular elemental skirts bounding a plurality of plenum chambers separately supplied by compressor means with atmospheric air. The flexible skirts, which naturally remain circular due to the gas pressure within the plenum chambers defined by said skirts and the terrestrial surface over which the vehicle is flying, are mounted under a platform and provide simultaneously stability, economy, and also an improved ground clearance under said platform. These skirts are preferably mounted on a gimbal orientable circular frame, thereby developing, if necessary, a horizontal component of their elemental thrust. An elemental cushion can be provided with a skirt comprising a plurality of coaxial layers or skirts and an outermost curtain can surround several clustered elemental skirts, and embody at least one circular lobe.

In a preferred form of construction, a platform is supported on four circular elemental cushions, the minimum number of cushions to be used for providing a natural pitch and roll stability being three. The sustention powerplant comprises a turbojet engine operating as a compressed gas generator. The turbojet engine is provided with a discharge duct which branches out into a plurality of individual inducer nozzles which respective prime elemental injectors or eductors separately supplying said four cushions with a compressed gaseous mixture of inducer hot gas and atmospheric air. Operation of each elemental injector remains virtually unaffected by variations in the height above the ground of the skirts associated with other injectors and in the corresponding counterpressure in the diffuser ducts constituting the other injectors. The platform is preferably equipped with a front and a rear wheel supporting a minor fraction of the vehicle weight and only providing a positive guidance and propulsion, in a manner known per se.

In an alternative embodiment comprising for instance six elemental skirts, the sustention powerplant consists of an engine driving two axial blowers or fans. Each of the

fans is provided with several, for example, three distinct discharge ducts respectively supplying a corresponding number of elemental air cushions. The fans are for instance axial compressors having a shroud divided downstream by radial partitions to form the three discharge ducts and provided with stationary blades which are orientable in a manner known per se. Centrifugal compressors may be used in place of the axial compressors, each of them feeding at least one elemental cushion.

Other advantages and objects of the invention will appear in the following description with reference to the accompanying drawing, given by way of example and in which:

FIG. 1, is a diagrammatic elevation view of a vehicle according to the invention;

FIG. 2, is a corresponding front elevation view of the vehicle in FIG. 1; and

FIG. 3, is a perspective view of an alternative embodiment of a vehicle according to the invention and illustrates a vehicle in which the air cushions are supplied by shrouded fans equipped with radial partitions.

FIGS. 1 and 2 show a ground effect vehicle having a platform **1** on the undersurface of which are formed four separate and distinct gaseous cushions, each of which is fed gas under pressure discharged by three injectors comprising each of a diffuser duct **3** cooperating with an injector nozzle **4**. The diffuser ducts **3** corresponding to different gaseous cushions constitute double-ended discrete feed passages having an inlet or suction end and an outlet or discharge end. The injector nozzles **4** are supplied with motive gas tapped from the discharge pipe of a compressed gas generator **5** which is preferably a gas-turbine engine.

Each of said gaseous cushions is of the plenum chamber type and confined within a cylindrical skirt **2** made of flexible material, the cylindrical shape ensuring that internal pressure variations do not affect the cushion height. The skirt **2** is mounted on a supporting frame **7**. The frame **7** is gimballed by means of two horizontally opposed pivots **8** of a ring **9** supporting the pivots **8** and supported by two horizontally opposed pivots **10** solid with the platform 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 inside each cushion.

The upper portion of each skirt **2** provides an oscillation joint, an example being the bellows joint **11** (see FIGS. 1 and 2), whereby the skirt is able to move freely in all directions and full tightness within minimum friction is ensured.

Through the instrumentality of actuating means well known per se, such as the cable and pulley assembly shown in FIG. 8 of United States Patent No. 2,953,320, a flight control lever **12** controls the pivotal motion of the skirts above the two perpendicular axes containing respectively the pivots **8** and the pivots **10**. Thus it is possible to simultaneously orientate all the cushions in the same direction, thereby creating a horizontal force in that direction.

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 per se in the motorcycle art. The wheels are linked to the platform by arms **15, 16** provided with suspension elements **18, 19** designed to support only 10 to 20% of the total weight of the vehicle. The major part of the weight is supported by the gaseous cushions. The suspension elements may be adapted to permit stiffness adjustment, as shown for instance in U.S. Patent 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 lift 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 accelerations will therefore be suited to translational motion and to low speed manoeuvering.

As a part of the weight of the vehicle is supported by the wheels **13, 14** thus 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 heretofore mentioned. 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 FIG. 3, there is illustrated therein an alternative embodiment utilizing six air cushions supplied by fans in lieu of injectors.

Two fans **23***a* and **23***b* of the axial-flow type are mechanically driven by a motor **24**, through the medium of a belt, for example. They are provided with shrouds **25***a* and **25***b*, and with series of tiltable stationary deflecting blades or diffuser **26***a* and **26***b* which allow the air pressure downstream of said fans to be adjusted. Such tiltable blades are described for instance in U.S. Patent 2,305,311 The fairing **25***b* is shown open and the fan **23***b*. with its driving belt **24***a* removed.

Radial partitions **27**, numbering three per fan, bound the discrete feed passages **28** which supply the corresponding elemental air cushions.

The tiltable blades **26** are grouped into sectors which correspond with the feed passages **28** bounded by the partitions **27**. A collective inclination of the vanes associated with either fan will thus enable the air mass flow of either fan to be varied with respect to that of the other and the platform to be thereby tilted about the roll axis, whereas a partial inclination of the vanes of one sector only, while not appreciably affecting the flow through the other sectors, will enable the platform to be tilted about the pitch axis. The means for actuating the several series of tiltable stationary blades **26** may be similar to the means commonly used in helicopters for varying the incidence of rotor blades, which provide both general and individual variations and necessitate no further description. Means for actuating the blades may be analogous to those described in United States Patent No. 2,305,311. The orientable diffusers or blades in this embodiment consequently fulfill a function similar to that of the valves **20** in FIGS. 1 and 2.

A platform of this type may be equipped with the gimballed skirts and the wheels described with reference to FIGS. 1 and 2.

By thus providing the vehicle with three or more discrete plenum chambers and supplying compressed air separately to the several chambers by discrete feed passages, the flow of pressure fluid from one plenum chamber is avoided. Hence, any casual pressure variation in any of the plenum chambers, such for example as a loss of pressure occurring when a plenum chamber passes over a ditch, leaves the pressure obtaining in the other plenum chambers unaffected. The stability and load-carrying capacity of the vehicle is thereby markedly increased. In referring to the plenum chambers and feed passages being "discrete," it is meant that the chambers and feed passages are so isolated from one another that casual pressure variation in one plenum chamber will not be transferred or reflected through the feed system to other plenum chambers.

Those skilled in the art will understand that the invention makes provisions, in the embodiments thereof described, for effectively precluding transmission of pressure drops and fluid flows from one plenum chamber to another. Thus, each embodiment illustrated is provided with a barrier effective to carry out the desired mode of operation. In the embodiment illustrated in FIG. 1, an aerodynamic barrier developed as a pressure gradient created by the diffuser of each injector precludes transmission of pressure drops and fluid flows from the plenum chamber associated with the respective diffuser to any other of the plenum chambers. In the embodiment of FIG. 3, the barrier is a physical or mechanical barrier defined by the axial shrouding or radial partitions **27** and the blades **26**.

The pressure drops in a given plenum chamber may, of course, be caused, for example, by uneveness in the terrain over which the vehicle is travelling. The result of isolating the cushions as above described prevents an abrupt pressure drop in any one cushion from being transmitted throughout the other cushions. The result is that only a minor fraction of the total sustaining force will be lost at that particular moment. In practice, even this fractional loss in lift is minimized since any reduction in the sustaining force will automatically cause a lowering of the ground effect vehicle and a corresponding decrease in the leakage gap of the plenum chambers. This causes an increase in pressure in the cushions thereby increasing lift and the vehicle is thus automatically self-stabilized.

The number of air cushions, compressed air generators, ejectors or fans 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 hovering platform hereinbefore disclosed, within the spirit and scope of the invention as set forth in the appended claims.

What I claim and desire to secure by Letters Patient is:

1. A ground effect vehicle comprising, first means including platform means; second means secured to and depending from the underside of said platform means and defining at least three discrete plenum chambers which in operation provide individual gaseous cushions sustaining said vehicle; third means carried by said platform means to supply a gaseous fluid under pressure to said plenum chambers individually; said third means comprising a source of gaseous pressure fluid common to said three discrete plenum chambers, and means individual to each plenum chamber and disposed between said common source and its respective plenum chamber and effective to supply a flow of gaseous fluid to each of said plenum chambers individually; fourth means in the last mentioned means effective to isolate each said plenum chamber from each other when there is a drop in pressure in the associated plenum chamber so as to preclude transmission of pressure drops and fluid flows from any one of said plenum chambers to any other of said plenum chambers.

2. A ground effect vehicle according to claim **1**, in which said fourth means comprise a plurality of injectors for moving ambient atmospheric air under pressure into said plenum chambers independently of each other.

3. A ground effect vehicle according to claim **1**, in which said fourth means comprise a plurality of injectors each associated with a respective plenum chamber for moving ambient atmospheric air under pressure into said plenum chambers independently of each other; each injector comprising a diffuser duct having an inlet open to the atmosphere and an outlet open to its respective plenum chamber, and an injector nozzle supplied with gaseous fluid under pressure from said third means and disposed for discharging pressure fluid into said diffuser duct.

4. A ground effect vehicle according to claim **1**, in which said source of gaseous pressure fluid comprises turbojet engine means.

5. A ground effect vehicle according to claim 1, in which said source of gaseous pressure fluid comprises driven fan means.

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A. HARRY LEVY, *Primary Examiner.*

Disclaimer

3,263,764.—*Jean Henri Bertin*, Neuilly-sur-Seine, France. GROUND-EFFECT HOVERING PLATFORMS WITH MULTIPLE AIR CUSHIONS AND STABILITY INCREASING MEANS THEREFOR. Patent dated Aug. 2, 1966. Disclaimer filed Aug. 2, 1966, by the assignee, *Societe Bertin & Cie.*

Hereby enters this disclaimer to claim 5 of said patent.

[*Official Gazette October 11, 1966.*]