March 5, 1968 J. H. BERTIN 3,371,738

SURFACE EFFECT DEVICES WITH SKIRT HEIGHT ADJUSTING MEANS

Original Filed Jan. 11, 1962 2 Sheets-Sheet 1

Fig. 2

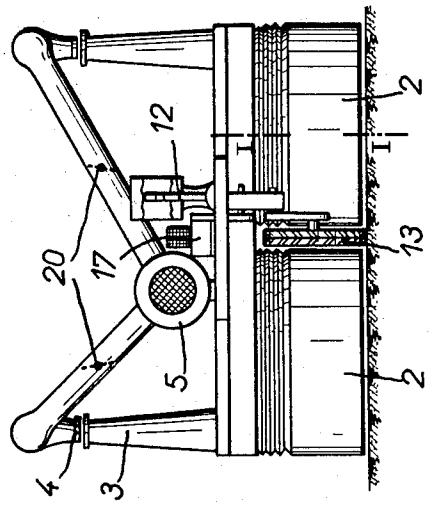
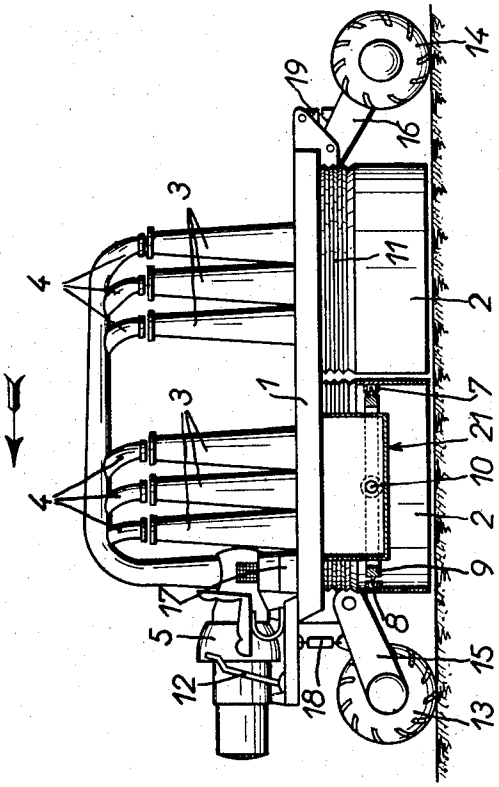


Fig. 1



Inventor
Jean H. Bertin
Stevens, Davis, Miller & Mosher
Attorneys

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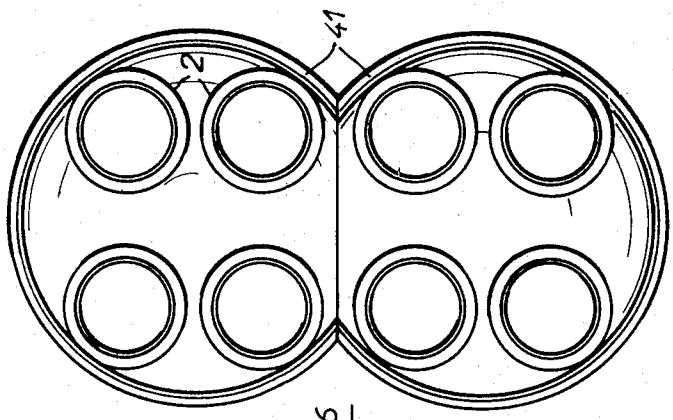

Fig.: 6

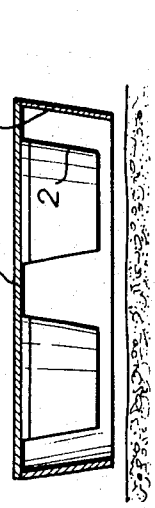

Fig.: 5

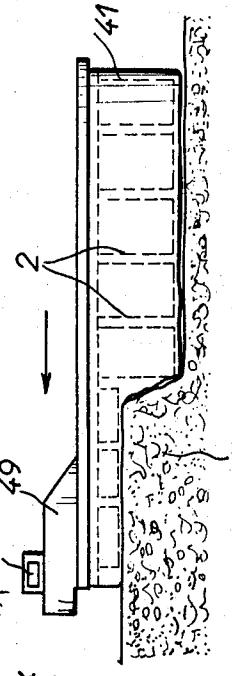

Fig.: 7

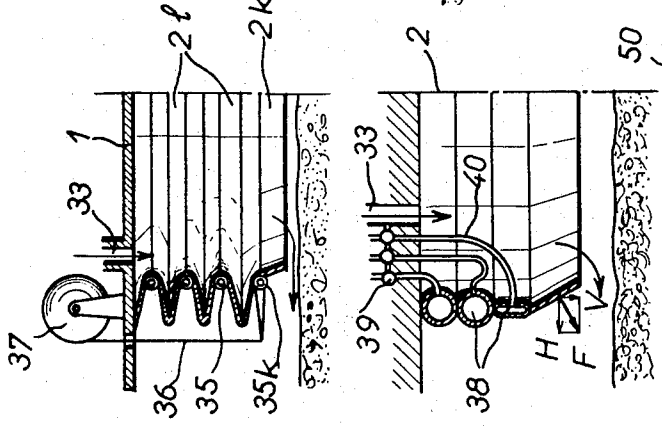

Fig.: 4

Fig.: 3

Inventor
Jean H. Bertin
Stevens, Davis, Miller & Mosher
Attorneys

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SURFACE EFFECT DEVICES WITH SKIRT HEIGHT ADJUSTING MEANS

Jean H. Bertin, Neuilly-sur-Seine, France, assignor to Societe Bertin & Cie, Paris, France, a company of France

Original application Jan. 11, 1962, Ser. No. 165,634, now Patent No. 3,263,764, dated Aug. 8, 1966. Divided and this application Oct. 20, 1965, Ser. No. 498,315

Claims priority, application France, June 30, 1961, 80,047

5 Claims. (Cl. 180—127)

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

The present invention relates to ground effect vehicles or like movable bodies sustained at a small distance from a ground, sea or other surface by means of compressed fluid cushions, in a known manner.

One of the objects of the present invention is to reduce to a minimum the unavoidable leakage of fluid from said cushions and the compressed fluid consumption.

Another object of this invention is to provide fluid-cushion devices 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 fluid-cushion devices offering a good resistance to wear and tear, and yet light and cheap.

In accordance with the present invention, the vehicle is equipped with one or preferably several retractable, fluid-cushion bounding skirts operable to be downwardly extended or upwardly retracted. In a preferred embodiment of the invention, each skirt is made of supple, fluid-tight, wear and tear resisting material, whereby said skirt is stretchable downwardly upon exertion of internal pressure or collapsible upwardly upon retraction.

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.

FIGURES 3 and 4 show two alternative embodiments of skirts in accordance with the invention, FIGURE 4 being preferred.

FIGURES 5 and 6 are respectively a side elevation and a plan view of a multi-skirt arrangement.

FIGURE 7 illustrates a vehicle passing over an obstacle.

Referring now to FIGURES 1 and 2, there is shown thereon a platform **1** with four 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** and 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 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.

A control system shown diagrammatically in the form of a lever **12** controls the pivotal motion of the skirts about the two perpendicular axes containing respectively the pivots **8** and the pivots **10**. An effective control mechanism is not illustrated as it does not appear useful for a clear understanding of the invention as defined in the appended claims. However, such a mechanism is described and illustrated in my copending application, Ser. No. 502,934, filed Oct. 23, 1965. With such a mechanism it is possible to simultaneously orientate all the skirts in the same direction, thereby creating a horizontal force in that direction. Alternatively, the skirts may 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 manoeuvering.

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.

FIGURE 4 illustrates, in vertical half-section, a conical skirt portion **2***h*. The wall of the cushion is in this case inclined, and its open lower end is of smaller area than its upper end, so that the force of the pressure F, exerted normal to the wall, produces a vertical component V tending to stretch the skirt, in addition to the horizontal component H which maintains the circular planform.

In accordance with a feature of the present invention, it is possible to raise a skirt, or even to raise one of its edges only. FIGURE 3 shows a raisable skirt together with its associated raising device.

This skirt, provided with a conical lower portion **2***k*, comprises an upper bellows-type portion **2***l*. Rigid hoops **35** prevent any increase in diameter of the bellows. The bottom hoop **35***k* is connected by cables **36**, symmetrically disposed in plan view, to hoist gears such as **37** for adjusting the height of the skirt.

Thus the raising of a skirt may be under the control of a detected obstacle ahead of it, in which case a mechanical or electro-optical feeler or sensing system is provided to operate the hoist gear, but of course it will be understood that such control may be entrusted to the pilot if desired. The cables **36** may be connected to a single hoist gear **37** in order to obtain an even raising of the skirt. It is also manifest that the hoist gears **37** may be control differentially if required. The orientation of

the resulting efflux provides a means of controlling yawing motion in the platform, and this method of control is equivalent to that used with the gimballed cylindrical skirts described hereabove.

FIGURE 4 illustrates another method of adjusting the length of the skirt. The sides of the skirt are formed in part at least by superposed annular air chambers or tubes **38**, the extension of which varies according as the tubes are inflated or not. A simple inflating device is provided in the form of a three-way cock **39**, whereby each air tube **38** may be connected through a flexible tube **40** to a pipe supplying gas under pressure, for example to the compressed air pipe **33** upstream of the skirt **2**, or to exhaust.

As may be seen from FIGURE 4, it is thus possible to provide a skirt which has a bottom conical portion and which is controlled pneumatically throughout. Alternatively, the air tubes **38** may be combined with mechanical hoist gears **37** should it be desired to utilize the full difference in depth that may be obtained by entirely deflating the air tubes when the skirt is raised.

Individual or elemental skirts such as described above are preferably provided in large number and clustered together to increase platform stability, but this in turn implies a large total efflux or leakage perimeter. Therefore, when it is desired to achieve high lift efficiency, an encompassing peripheral skirt may be used in conjunction with the clustered elemental skirts. Referring now to FIGURES 5 and 6, there is illustrated thereon a peripheral skirt **41** which is frusto-conical to some degree in side elevation and has a circular dual-lobe planform. Such a skirt may be supplied separately, at an adjustable pressure, rather than be only fed with the leakages from the inner elemental skirts **2**.

Adjustment of the relative heights of the skirts **2** and **41** allows selecting for the platform **1** either a high degree of stability (when the skirts **2** are relatively long with reference to the skirt **41**), or great lifting efficiency (when the skirt **41** is relatively long with reference to the skirts **2**).

If reference be now had to FIGURE 7, in which is illustrated a platform provided with a peripheral skirt **41** and a plurality of raisable elemental skirts **2**, it will be appreciated that such a platform is capable of negotiating very substantial differences in ground level, of the order, for example, of one-fifth of its overall length. The provision of a multiplicity of elemental skirts ensures that the raising of any single skirt results in only a slight sinking of the whole vehicle. Were the difference in ground level to be negotiated in the opposite direction to that shown in FIGURE 7, simultaneous raising of all the skirts would enable the platform to be lowered before the change in level **48** were encountered. The size of the powerplant **49** and the pilot's cabin **50** provide some indication of scale.

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 sustension. 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 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 fluid cushion skirting system for a movable body of the ground effect type having a support frame spaced from a bearing surface along which said body is designed to move, and a skirt free edge positioned in operation adjacent to but clear of said bearing surface to define therewith an operative leakage gap between an inner pressure fluid cushion and an outer lower pressure fluid medium and forming the periphery of an orifice opening extending in close proximity to said bearing surface, wherein the improvement comprises a supple fluidtight skirt body portion carried by said support frame and laterally bounding a cavity for confining said pressure fluid cushion and extending for substantially its full length outwardly from said support frame toward said bearing surface and terminating in said skirt free edge, said skirt body portion being at least partly contractible toward and expansible away from said support frame, and selectively operable, skirt body control means for selectively adjustably contracting or expanding at least a part of said skirt body portion whereby the operative length of said part is adapted to be varied to permit the position of said support frame relative to said bearing surface to be varied while keeping said skirt free edge in proximity to said bearing surface whereby leakage from said cushion to said outer fluid medium is minimized and whereby damage to the body structure is avoided.

2. Skirting system as claimed in claim **1**, wherein said skirt body control means comprise a hoisting gear carried by said support frame and a cable actuated by said hoisting gear and connected to said skirt body portion at a point thereof adjacent said free edge.

3. Skirting system as claimed in claim **1**, wherein said skirt body portion comprises at least partly superposed inflatable and deflatable tubes, and said skirt body control means comprise a source of pressure fluid and valve means for connecting each of said tubes selectively to said pressure fluid source and to exhaust, respectively, whereby a respective one of said tubes is alternatively inflated and deflated.

4. Skirting system as claimed in claim **1**, wherein said skirt body portion comprises at least a section in the form of bellows and spaced inextensible hoops engaging the folds of said bellows to prevent deformation thereof.

5. A fluid cushion skirting for a movable body of the ground effect type having a support frame spaced from a bearing surface along which said body is designed to move, and a plurality of separate and distinct skirt free edges each positioned in operation adjacent to but clear of said bearing surface to define therewith an operative leakage gap between an inner pressure fluid cushion and an outer lower pressure fluid medium and forming the periphery of an orifice opening extending in close proximity to said bearing surface, wherein the improvement comprises a plurality of separate and distinct supple fluidtight skirt body portions each carried by said support frame and laterally bounding a cavity confining a respective one of said fluid cushions and extending substantially its full length outwardly from said support frame toward

said bearing surface and terminating in said skirt free edge, each said skirt body portion being at least partly contractible toward and expansible away from said support frame, and individual, selectively operable, skirt body control means for adjustably contracting or expanding at least a part of each skirt body portion whereby the operative length of said part is adapted to be varied to permit the position of said support frame relative to said bearing surface to be varied while keeping said skirt free edge in proximity to said bearing surface whereby leakage from said cushion to said outer fluid medium is minimized and whereby damage to the body structure is avoided.

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A. HARRY LEVY, *Primary Examiner.*