

[54] RIDE QUALITY CONTROL FOR SURFACE EFFECTS CRAFT

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[58] Field of Search **180/116, 117, 118, 124, 180/120**

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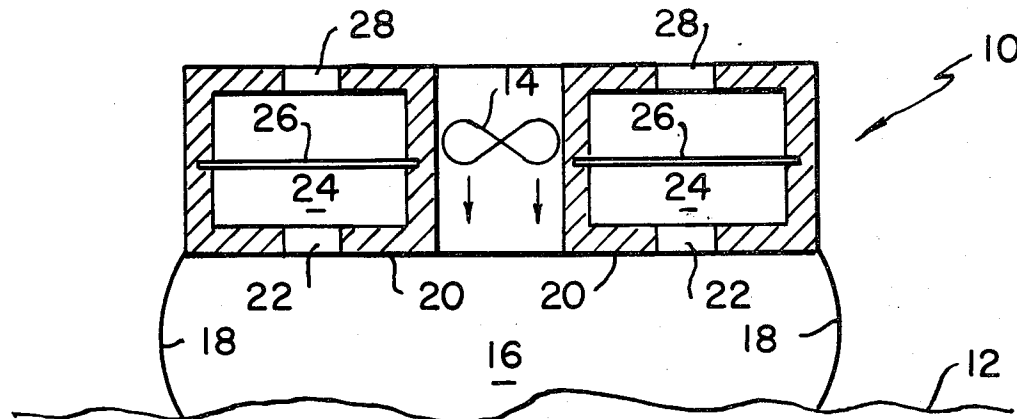
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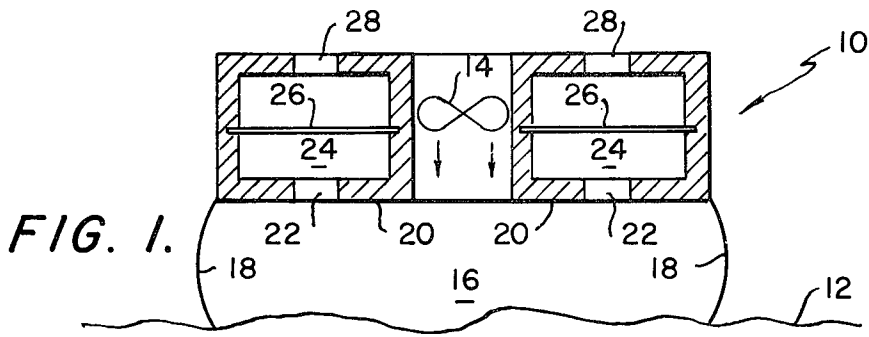
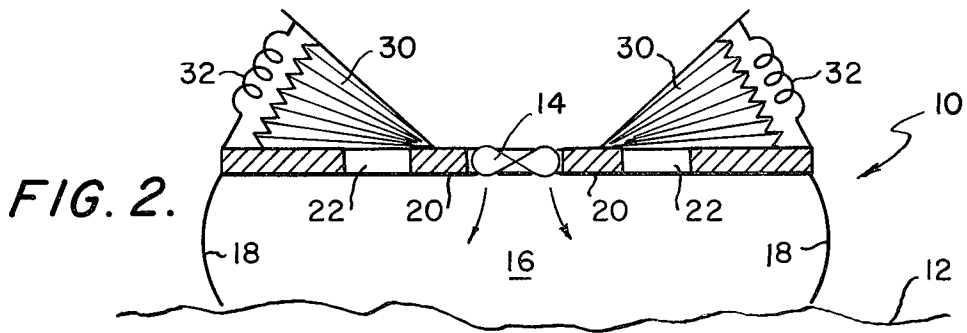
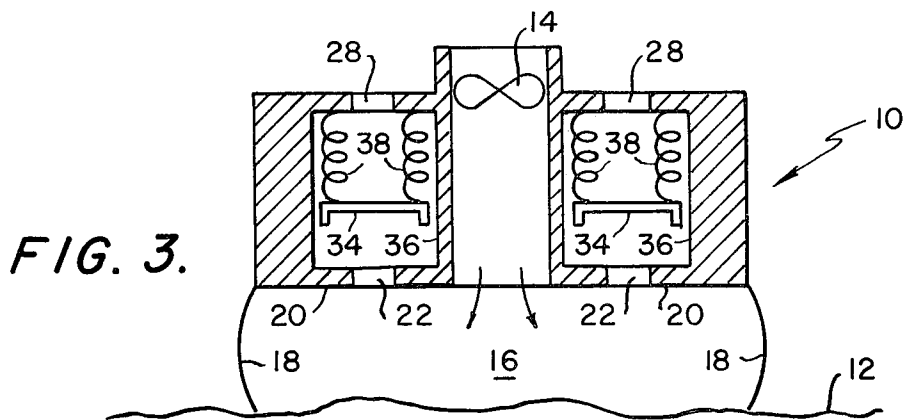
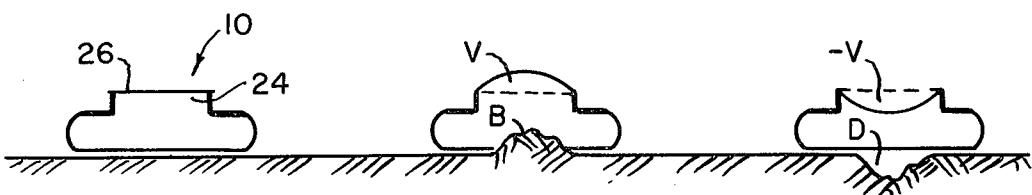
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[57] **ABSTRACT**

A system for improving ride quality of surface effect craft by using air cushion variable volumetric control. The air cushion volume is made resiliently variable by connecting a plenum, having a pressure yieldable member such as a diaphragm, bellows or piston, to the air cushion chamber. When the surface effect craft encounters an irregularity which changes the volume of the air cushion, such as rocks or waves, the resilient membrane, bellows, or piston responds to maintain a substantially constant total air volume thus tending to keep the vehicle at a constant height off the surface and thus reducing accelerations improving the quality of the ride.

4 Claims, 4 Drawing Figures





RIDE QUALITY CONTROL FOR SURFACE EFFECTS CRAFT

BACKGROUND OF THE INVENTION

The instant invention relates generally to surface effects craft such as captured air bubble, hovercraft, and other air cushion vehicles, and more particularly to a system for improving ride quality on such ships.

Surface effect craft are often subjected to large vertical accelerations when traveling over irregular terrain or heavy seas. As the craft moves irregularities encountered in the surface over which it travels cause rapid changes in the air cushion volume. Concomitant pressure changes, in turn, cause sharp vertical accelerations adversely affecting ride quality, to an extent so pronounced as to make the craft uninhabitable by the crew except for very brief exposures.

Surface effects craft are supported primarily by the lifting force resulting from a small pressure, usually less than 3 psi above atmospheric, in the vehicle's cushion acting upward against the vehicle. For these low pressures, the contained air roughly obeys the perfect gas law, where $PV=nRT$. If volume (V), temperature (T), and quantity (n) of air contained in the cushion volume remained constant, then total pressure would remain constant and the vehicle would remain at a constant equilibrium height. However, both volume and quantity do change; volume changing due to relative movement between the vehicle and the surface and quantity changing due to differences between inflow and leakage rates. The craft's force on the water is shown by the equation $F=PS=Ma$, where M is the mass of the craft, a is the vertical acceleration, P is the supporting cushion pressure, and S is the supporting cushion area. If pressure, in $P=nRT/v$, varies with respect to time, ie dp/dt , the vehicle will be accelerated by an amount equal to $S/M dp/dt$. From Newton's law and acceleration and force calculations ($F=PS=Ma$), it can be found that a 50 percent increase in cushion air pressure yields an increase in vertical accelerations of 0.5g's.

By direct control of the cushion volume it is possible to minimize the variations in cushion pressure and thus attenuate the vertical accelerations to bring about a significant improvement in the ride quality of the craft.

Previous attempts to solve this problem have been directed toward controlled modulation of the air leakage out of the cushion volume, but this technique has disadvantages. It operates by opening a valve which allows cushion air to escape upon pressure increase as when a positive volume irregularity (rock or wave crest) is in the air cushion volume. While pressure peaks are reduced, pressure fluctuations below nominal, as when a negative volume irregularity (hole or wave trough) is encountered, are not affected. Also the technique presumes continuous air loss by venting and thus wasted lift power or a requirement for additional lift power. If the vent is to be opened and closed it probably will be frequency limited and thus not compensate for high frequency undulations.

Another technique for improving ride quality is to modulate the lift air supply rate in response to pressure fluctuation in the cushion air, due to encountering irregularities in the surface. The disadvantages of this technique are the difficulty of keeping the supply rate changes in phase with the pressure fluctuations and the inherent frequency limitations.

Both of these systems entail complex and costly control systems because the pressure changes must first be sensed before the system can act, and then only after some lag. Furthermore, neither system has been demonstrated successfully to date, and analysis indicates that only modest reduction in vertical motion is achievable.

SUMMARY OF THE INVENTION

Accordingly, an object of the instant invention is to provide a new and improved system for the improvement of ride quality in surface effect craft.

Another object of the present invention is to provide a system for maintaining a constant volume of cushion air supporting a surface effect craft.

Still another object of the instant invention is to provide a ride control system for surface effect craft which reduces vertical accelerations tending to maintain the craft at a constant height above the mean surface level.

A further object of the instant invention is to provide a comfortable level of ride quality for a crew of a surface effect craft.

Briefly, these and other objects of the instant invention are attained by the use of a plenum chamber and pressure yieldable resilient member, constituting a controllable volume, which is added to the main lift cushion volume. The resilient member responds to maintain a constant volume of air in the cushion when the craft encounters a surface irregularity above or below the mean surface level. The resilient member may be a membrane, or spring biased bellows or piston.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the invention and many of the attendant advantages thereof will be readily appreciated as the same become better understood by reference to the following detailed description when considered in connection with the accompanying drawing wherein:

FIG. 1 is an elevation cross-sectional view of a surface effect craft utilizing a resilient diaphragm according to the invention;

FIG. 2 is an elevation cross-section of a surface effect craft utilizing a bellows and spring arrangement;

FIG. 3 is an elevation cross-section of a surface effect craft utilizing a piston and spring arrangement; and

FIG. 4a, 4b, and 4c are elevations of a surface effect craft showing the effect on a membrane when surface irregularities are encountered.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, wherein like reference numerals designate corresponding parts throughout the several views, there is shown generally in FIG. 1, a surface effect craft 10 supported "on-cushion" over a surface 12, which may be land or water. A lift fan 14 is shown in a central duct and supplies air to an air cushion volume 16 which is confined by flexible skirts 18. The skirts 18 are attached around the periphery of the craft 10 and may have various configurations other than shown, particularly forward and aft. Also confining the air cushion is the "wet-deck" or hull 20 of the craft 10 upon which the air in the cushion acts to produce lift.

A plurality of vent holes 22 are formed through the wet deck 20 to communicate with plenum chambers 24

and act to restrict or modulate the airflow there through. A resilient membrane 26 is stretched across the plenum and seals air cushion volume from escaping into the atmosphere. Atmospheric vent holes 28 may also be formed in the plenum chambers 24 above the resilient membranes 26 to restrict airflow when the membrane responds. Restricting or modulating the airflow through the airflow restricting vent holes 22 and 28 obviously changes the rate of flow compared to a non-restricting vent hole, and therefore acts as a high frequency filter. Since high frequency pressure changes are generally of high amplitude, the airflow modulating vent holes limit the excursions of the diaphragm to reasonable dimensions. Also, the smallness of vent holes 22 communicating with the air cushion, tend to protect the membrane from the impingement of water. The vent holes 28 communicating with the atmosphere also limit the wholesale leakage of the air cushion should the membrane 26 rupture.

Referring now to FIG. 2 another embodiment of the ride quality improvement system for the surface effect craft is shown. Here the resilient membranes are replaced by a plurality of bellows 30 that communicate with the air cushion volume 16 through vent holes 22 in the wet deck 20. Because the bellows are not resilient, springs 32 are connected across the stationary and movable portion of the bellows and exert a compressive force on the air contained therein.

Referring now to FIG. 3, another embodiment of the ride quality improvement system is shown. Here a plurality of pistons 34 are in sealed and sliding relationship within cylinders 36. The cylinders communicate with the air cushion volume 16 through vent holes 22 in the wet deck 20. A plurality of springs 38 bias the pistons 34 downwardly and exert a compressive force on the air in the cylinders 36 below and in the air cushion volume 16.

As should be obvious from the discussion herein before, each of the embodiments, whether the resilient membrane, the spring biased bellows, or the spring biased piston operate by adding a resiliently variable and controllable volume to the air cushion volume 16, which will automatically vary when the surface effect craft 10 encounters an irregularity in the surface. The system operates about an equilibrium point, that is, it responds to pressure increases and decreases, caused by bumps or depression, by increasing or decreasing the overall air cushion volume. Referring now to FIG. 4 there is shown three views of a simplified version of a surface effect craft 10 using the membrane system of FIG. 1 for convenience of explanation. FIG. 4a shows the surface effect craft "on-cushion" on level and smooth ground or water. The membrane 26 is stretched across the plenum 24, but obviously bellowed by slightly due to air-cushion volume 16 pressure. As the craft moves and encounters a bump or positive irregu-

larity "B", the membrane 26 responds upwardly due to increased pressure to increase the over-all air cushion volume the same amount as occupied by the bump. In the case when the craft encounters a depression or negative irregularity "D", the membrane responds downwardly, due to decreased pressure, to reduce the over-all air cushion volume by the same amount that the depression has increased the volume.

Obviously many modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A system for improving ride quality of surface effect craft having an air cushion volume comprising: means for automatically varying the volume of the air cushion volume to minimize cushion pressure fluctuations and attenuate vertical accelerations when surface irregularities are encountered; and air flow modulating vent holes coacting with said means for automatically varying the volume of the air cushion volume.
2. A system for improving ride quality of surface effect craft having an air cushion volume comprising: an elongated plenum having an end communicating with the air cushion volume, and another end communicating with the atmosphere; a resilient membrane stretched across said elongated plenum in sealing relationship between said ends; and air flow modulating vent holes at the ends of said plenum.
3. A system for improving ride quality of surface effect craft having an air cushion volume comprising: a bellows, the inside of which communicates with the air cushion volume, and the outside of which communicates with the atmosphere; a spring biasing said bellows to exert a compressive force on the air contained therein; and an air flow modulating vent hole separating the inside of said bellows and the air cushion volume.
4. A system for improving ride quality of surface effect craft having an air cushion volume comprising: a cylinder having one end communicating with the air cushion volume and another end communicating with the atmosphere; a piston in sliding and sealing relationship within said cylinder; a spring biasing said piston to exert a compressive force on the air contained in said cylinder portion communicating with the air cushion volume; and an air flow modulating vent hole separating said cylinder from the air cushion volume.

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