

CLAIMS:

1. A suspension system for a vessel, the vessel having at least one left hull, at least one right hull and a chassis portion,

the suspension system including locating arrangements for constraining motion of the left and right hulls in at least a longitudinal and a lateral direction relative to the chassis portion, supports for at least partially supporting the chassis portion relative to the at least one left hull and at least one right hull, and at least a front left and back left damping ram connected between the chassis portion and longitudinally spaced points on the at least one left hull, at least a front right and back right damping ram connected between the chassis portion and longitudinally spaced points on the at least one right hull,

wherein the suspension system further includes a deck attitude control system comprising a controller, and at least one respective force, pressure, acceleration, orientation or position sensor, and a respective actuator arrangement for each of at least two orthogonally spaced damper rams of the front left, front right, back left and back right damper rams,

the controller, in use, controlling the actuators in dependence on signals from the at least one force, pressure, acceleration, orientation or position sensor to control a position of at least one point on the chassis relative to at least one reference.

2. A suspension system as claimed in claim 1 wherein the at least one respective force, pressure, acceleration, orientation or position sensor provides at least one respective output signal from which a force in the damper ram is calculated.

3. A suspension system as claimed in claim 1 wherein the at least one respective force, pressure, acceleration, orientation or position sensor provides at least one respective output signal indicative of a displacement of the respective damper ram.

4. A suspension system as claimed in claim 1 wherein the at least one reference is a point on an object, or an absolute point in space, or an absolute orientation.
5. A suspension system as claimed in claim 1 wherein each damper ram is an electro-mechanical ram.
6. A suspension system as claimed in claim 1 or 5 wherein each respective actuator arrangement includes a respective motor.
7. A suspension system as claimed in claim 6 wherein the motor is a linear motor or electro-magnetic actuator formed at least in part within and/or around the damper ram.
8. A suspension system as claimed in claim 1 wherein each respective damping ram is a fluid ram including a respective compression chamber and a respective rebound chamber,
the actuator adjusting the pressures in the respective compression and rebound chamber of the at least two orthogonally spaced damper rams.
9. A suspension system as claimed in claim 8 wherein each actuator arrangement for the respective one of the at least two orthogonally spaced damper rams includes at least one respective valve.
10. A suspension system as claimed in claim 8 or claim 9 wherein each respective actuator arrangement includes a respective pump.
11. A suspension system as claimed in claim 9 wherein the at least one respective valve includes:
a respective damper compression chamber control valve in fluid communication with the respective damper compression chamber;
a respective damper rebound chamber control valve in fluid communication with the respective damper rebound chamber.

12. A suspension system as claimed in claim 11 wherein the respective damper chamber control valve adjusts the pressure in the respective damper chamber.
13. A suspension system as claimed in claim 11 wherein the respective damper chamber control valve selectively communicates the respective damper chamber with a pressure source.
14. A suspension system as claimed in claim 13 wherein the respective damper chamber control valve selectively communicates the respective damper chamber with a fluid reservoir.
15. A suspension system as claimed in claim 13 wherein the damper ram includes a minimum pressure arrangement including non-return valves and a fluid pressure accumulator, the maximum pressure in the fluid accumulator being regulated by a pressure relief valve which relieves excess pressure to a reservoir or tank,
the respective damper chamber control valve selectively communicates the respective damper chamber with the fluid accumulator.
16. A suspension system as claimed in claim 9 wherein the at least one respective valve includes a variable damper valve providing a controllable variable restriction between at least the compression chamber or rebound chamber and an accumulator.
17. A suspension system as claimed in claim 16 wherein the variable damper valve is varied by the controller to provide a force in the damper ram that corresponds to a force required by the controller while pressures and flows in the damper ram and actuator arrangement are sufficient to provide the required force, after which the damper valve is restricted or closed and the fluid pressure or volume in the compression and rebound chambers is controlled using a pump and/or valves, a pressure source and a reservoir.

18. A suspension system as claimed in claim 1 wherein each respective damping ram is controlled by the controller to provide a damping force that corresponds to a force required by the controller up to an instantaneous limit damping force determined in part by a velocity or rate of displacement of the damper ram, beyond which power is supplied to the damping ram by the actuator arrangement to provide a motive force that corresponds to a force required by the controller.

19. A suspension system as claimed in claim 1 wherein the supports vary in pressure by less than 25% through a range of at least 50% of a travel of the support.

20. A suspension system as claimed in claims 1 or 19 wherein the supports are independent.

21. A suspension system as claimed in claims 1 or 19 wherein the supports are at least partially interconnected.

22. A suspension system as claimed in claims 1 or 19 wherein the supports are selectively interconnected.

23. A suspension system as claimed in claim 1 wherein the supports include a front left support ram, a front right support ram, a back left support ram and a back right support ram, each respective support ram having at least a respective support compression chamber, the respective support compression chamber forming at least part of a respective support compression volume.

24. A suspension system as claimed in claim 23 wherein the front left and front right support rams are respectively interconnected by lateral cross connections, each respective lateral cross-connection being between the respective compression chamber of a front support ram on one side of the vessel and a support rebound chamber of a laterally spaced front support ram on an opposite side of the vessel;

the back left and back right support rams are respectively interconnected by lateral cross connections, each respective lateral cross-connection being between the respective compression chamber of a back support ram on one side of the vessel and a back rebound chamber of a laterally spaced back support ram on an opposite side of the vessel.

25. A suspension system as claimed in claim 23 wherein the front left, front right, back left and support rams are respectively interconnected by respective lateral cross connections,

the front left support compression chamber of the front left support ram being connected to a front right support rebound chamber of the front right support ram by a front left compression conduit forming the front left support compression volume,

the front right support compression chamber of the front right support ram being connected to a front left support rebound chamber of the front left support ram by a front right compression conduit forming the front right support compression volume,

the back left support compression chamber of the back left support ram being connected to a back right support rebound chamber of the back right support ram by a back left compression conduit forming the back left support compression volume, and

the back right support compression chamber of the back right support ram being connected to a back left support rebound chamber of the back left support ram by a back right compression conduit forming the back right support compression volume.

26. A suspension system as claimed in any of claims 23 to 25 wherein the front left and back right support compression volumes are selectively interconnected by a first diagonal support interconnection valve, and

the front right and back left support compression volumes are selectively interconnected by a second diagonal support interconnection valve.

27. A suspension system as claimed in any of claims 23 to 26 wherein at least two of said front left, front right, back left or back right support compression volumes are selectively interconnected.

28. A suspension system as claimed in claims 26 or 27 wherein said selective interconnection is open during a deck attitude control system operation and closed when the deck attitude control system is not in use.