

1 AIRSHIP/SPACECRAFT

Technical Field

5 The present invention is a combination airship and spacecraft that uses its lifting gas as fuel for thrusters to achieve space flight. The airship aspect operates to provide lift with lifting gas in one or more gas retaining structures that may change in volume. The spacecraft aspect provides control, power, services, and interior space for missions of the airship/spacecraft. An airship/spacecraft may be connected in arrays with others of its kind to form larger space structures and spacecraft.

A reaction thrusting power plant which may use lifting gas as fuel is included in the present invention. Such thrusters are capable of accelerating the airship/ spacecraft to sub-orbital and orbital speeds and altitudes, and may be used on any aircraft
10 or spacecraft having a large reservoir of gaseous fuel combustible by oxidation or in some other exothermic reaction. The preferred gaseous fuel for the thruster is a gaseous fuel that contains hydrogen gas.

The reservoir containing such gaseous fuel may be a gas retaining structure of an airship, such as a gas bag, wherein the gaseous fuel also serves as a lifting gas. Such reservoirs may also be pressure vessels which will efficiently hold internal and external overpressures, such pressure vessels also being included in the present invention. The separation of a gas retaining
15 structure into separate gas tight compartments with the use of a flexible folding diaphragm membrane is also included in the invention.

The invention also includes a method for the attainment of orbit by the airship/spacecraft with the use of the inventions disclosed herein as optional components of the airship/spacecraft.

The present invention has elements that are covered generally by class 244, aeronautics, and may be considered under
20 the following subclasses: 3, compound aeronautical machines; 12.2, circular; 12.3, dual propulsion; 12.4, thrust tilting; 24 miscellaneous aircraft; 29, propelled aeronautical machines; 61, aircraft power plants adapted to use the sustaining gas of an airship as fuel; 97, devices for changing buoyancy of lighter-than-air craft; 125, construction of hull and internal structure of lighter-than-air craft; 114, ships, particularly subclass 342; 126, construction of outer surface of lighter-than-air craft; 158, machine or structure designed for travel in the upper reaches of and/or beyond the atmosphere of a celestial body; and, 60, power plants, particularly
25 subclass 246. Although folding diaphragms and folding membranes exist in prior art, such as in United States Patent Nos. 4,056,697 and 3,979,295, a special class/subclass for the diaphragm membrane disclosed herein could not be found.

Background Art

30 There is presently a quest for a means to achieve economical heavy lifting into space. Construction of the limited space-station using multiple rocket launches, with assembly by crews manning the U.S. Space Shuttle orbiter, has proven to be expensive and uncertain by reason of the cost and risk. Current space technology, most notably in the United States of America, continues to rely upon conventional rocket configurations to achieve a substantial presence in space. The principal prospect of departure from such reliance exists in the space-plane project currently in the development phase. All such technologies require structures and materials that will withstand high g-forces and temperatures, because all such technologies involve high speed operation with
35 significant atmospheric friction and rapid acceleration and deceleration.

Recent entries in the field are known from United States Patent Nos. 5,730,390 and 5,842,665 in which prior art in space launch technology alternate to conventional rocket powered orbital insertion is discussed. Both of these inventions are for single stage, thruster-driven-rotor, rotor-driven, vertical-take-off spacecraft, and therefore rely upon aerodynamic effects to achieve altitude. The first of these, titled "Reusable Spacecraft", also relies upon the shape of the spacecraft to act as an aerodynamic lifting
40 body to gain altitude under power. That patent claims "a disk-shaped casing configured to generate buoyancy in horizontal travel through a gas atmosphere". Although the term "buoyancy" is used there, it is clear that the concept of aerodynamic lift was intended, because only aerodynamic lift is generated as a result of "horizontal travel through a gas atmosphere". Moreover, the patent does not include as an element of the invention the use of a lifting gas to create "buoyancy", as in the operation of a lighter-than-air-craft. "Buoyancy" as used in the present application means the effect of an object rising in a fluid as a result of the relative
45 lightness of the object with respect to the weight of the volume of the fluid the object displaces. Both of the above-referenced

1 inventions require the consumption of fuel to take-off and climb through the atmosphere, with power supplied by thrusters which
burn such fuel. Neither of these inventions involve the use of a lighter-than-air system for lifting the spacecraft through the
atmosphere, or involve the use of lifting gas as fuel for thrusters or other power generation.

5 That rockets have been carried aloft by balloons and launched from altitude is well known: the balloon was an
expandable flexible gas envelope that was discarded upon launch. without a framework structure and without any role in the
enhancement of the lifting capacity of the lifting gas except to expand as the pressure of the ambient atmosphere decreased with
altitude. The present invention is clearly distinct from such a system. The present invention is an airship and a spacecraft. The
present invention may include dynamic gas retaining structures with expandable frameworks which are used to maximize the
10 altitude to which the lifting gas will be effective to lift the airship. Such gas retaining structures may also be components of a
pressure vessel which will efficiently hold internal and external overpressures. Such a pressure vessel would function by reducing
the pressure strain on any one gas retaining structure in a group of nested gas retaining structures, i.e. a series of gas retaining
structures each of which encloses gas retaining structures of lesser volume, to a fractional value of the overall pressure differential
existing between the interior of the innermost gas retaining structure and the exterior of the outermost gas retaining structure. A
similar pressure vessel is disclosed in United States Patent No. 4,228,759. However, the "pressure-sustaining vessel" disclosed
15 in that patent is limited to construction with "concentrically nested shells" and by the inclusion of other limiting elements.

The lifting capacity of the airship/spacecraft may be controlled by the partitioning of one or more of the gas retaining
structures with a flexible gas impermeable membrane within each gas retaining structure. Such a membrane would separate a gas
retaining structure into gas tight compartments that may each have the same potential volume as the volume of the gas retaining
structure. A membrane within a gas retaining structure functions as a pump by which gas introduced into the gas retaining structure
20 on one side of the membrane causes the gas on the opposite side of the membrane to exhaust from a port in the gas retaining
structure. Such a flexible membrane may be a folded diaphragm. The separation of a gas retaining structure into separate gas tight
compartments with the use of a flexible folding diaphragm membrane is also included in the invention. For ascent of the
airship/spacecraft the partitioning of the gas retaining structure is utilized to gradually introduce lifting gas into one or more of the
gas retaining structures while exhausting the atmospheric or other gases to be displaced by the lifting gas; thereby controlling the
lifting capacity of the airship/spacecraft. Although the partitioning of gas tight envelopes is known from United States Patent No.
25 4,032,085, Dirigible, Especially Non-Rigid Dirigible, in which the gas containing partitions are "adapted to receive pressure without
any substantial deformation"; United States Patent No. 4,773,617, Lighter-Than-Air Craft, in which "gas tight bulkheads" that
"divide" a "gas tight pocket into a plurality of separate longitudinal compartments"; and United States Patent No. 5,005,783,
Variable Geometry Airship, with "a flexible gas envelope which is fixed" to an airship frame, the shape of such envelope being
changeable with "adjusting lines"; there does not appear to be any prior art concerning the division of a gas retaining structure by
30 a flexible membrane which can separate the gas retaining structure into two compartments that may each have the same potential
volume as the volume of the entire gas retaining structure to be thus divided. Also, there does not appear to be any prior art
concerning the use of the flexible folded diaphragm membrane component for such compartmentalization of gas retaining
structures, or concerning the component itself.

35 The present invention uses the lifting gas as fuel for thrusters which then power on the flight of the entire
airship/spacecraft. The present invention provides a single-stage launch vehicle which can use the airship structures as components
of space-frames and larger spacecraft.

The types of propulsion systems which create a propulsion force known as thrust to propel vehicles at high altitudes are
the rocket motor and the jet engine. The propulsion force is the reaction force arising from increasing the backward momentum
40 of a mass by the action of the propulsion system. In the case of the rocket motor, the rearward ejected mass comes from the
propellant chemicals carried with the vehicle, and the backward momentum from the reaction between those propellant chemicals.
In the case of the jet engine, addition of heat energy to a controlled flow of air passing through the jet engine increases the backward
momentum of the airflow.

45 Some of the features of the present invention disclosed here as the "turbo-rocket thruster" relate to features of both jet

1 engines and rocket motors. The use of the hyphenated description "turbo" in the present invention relates to the inclusion in the present invention of a turbine compressor driven by a gas turbine, as in a jet engine. The noun "rocket" relates to the fact that the present invention involves the rearward ejection of mass which may come from the chemical reaction of propellant chemicals which are carried with the vehicle, in this case a reservoir of fuel in a gaseous state and a reservoir of oxidizer. Unlike conventional jet
5 engines which compress intaken air, the turbine compressor of the turbo-rocket thruster is used to compress intaken gaseous fuel, which may not otherwise have sufficient density for efficient combustion, to a state of greater density. Also, unlike conventional jet engines, the combustion of the gaseous fuel compressed by the turbine compressors takes place with a stored oxidizer which is injected into the compressed gaseous fuel stream.

The use of gaseous hydrogen as fuel for power plants which compress air with turbine compressors is known from United
10 States Patent No. 5,012,640, The Combined Air-Hydrogen Turbo-Rocket Power Plant. The power plant disclosed in that patent, however, uses evaporating liquid hydrogen to drive a turbine which powers a turbine compressor to compress air into which gaseous hydrogen is injected for combustion, and does not use the turbine compressor to compress the hydrogen. Also, that power plant does not use stored oxidizer to burn the hydrogen, but uses the air which has been compressed for such combustion.

15 Disclosure of Invention

The present invention is an airship/spacecraft that uses its lifting gas as fuel for thrusters to achieve transition from airship operation to space flight. Such thrusters may be of the turbo-type, which intake and may compress gaseous oxidizer and/or gaseous fuel; of the rocket type, which use stored oxidizer; and/or hybrids of those types. At least one of the thrusters must be capable of functioning without an atmospheric oxidizer, as in the case of a rocket thruster. Other thrusters may be employed to operate where
20 an atmospheric oxidizer is available, as in the case of an atmospheric turbojet engine. Propeller thrusters may also be used for low altitude stabilization and maneuver.

The lifting component of the airship is comprised of one or more gas retaining structures, which may be flexible, as in the case of balloons and blimps; semirigid, as in the case of a gas retaining structure that is partially or completely supported by a framework; or rigid, as in the case of dirigibles, in which a framework supports a hull, which itself may be a gas retaining
25 structure, to contain other gas retaining structures, such as flexible gas bags. A gas retaining structure may also be a combination of the types described above. Each gas retaining structure comprises one or more conduits for transporting gases into and out of the gas retaining structure.

The airship in the present invention may also have a gas retaining structure with an integrated framework to restrict expansion and contraction or allow for flexion, expansion, and contraction of the structure. An example of such a structure is shown
30 in the diagrammatic view of the airship/spacecraft shown in FIG. 1 in which the the framework of the gas retaining structure is constructed of toroidal elements. Such a framework may also be employed in a hull structure that contains gas bags, or be integrated with gas bags. Such a framework may also be dynamic, to effect controlled changes of size and shape of the framework and redistribution of framework stress.

A gas retaining structure may also be comprised of a plurality of other gas retaining structures of one or more of the types
35 described above, hereinafter referred to as a "compound gas retaining structure". Such a compound gas retaining structure is shown in FIGS. 5 and 6, but contained within a larger structure, which can also be a gas retaining structure. The component gas retaining structures of compound gas retaining structures may contain gases different from one another in chemical composition which are under pressures different from one another, from the environment within a larger containing structure, which may also be a gas retaining structure, and/or from the external environment.

Another kind of compound gas retaining structure is one in which gas retaining structures of various sizes are arranged
40 as nested shells, as shown in FIGS. 7 and 8, in which a plurality of gas retaining structures are constructed so that a gas retaining structure contains another gas retaining structure, and where the containing gas retaining structure itself is contained within another gas retaining structure, and so on. As with others of the compound type different shells of the nested structure may contain different gases. The pressure vessel is designed to sustain a pressure differential between its interior and its surroundings, by forming a hull
45 from a multiplicity of such nested shells, including an innermost shell and several outer shells separated by intervening fluid filled

1 clearances, with a means for transporting fluid into and out of each of the nested shells. The pressure vessel may also have a means
for adjusting and maintaining the individual pressure in each fluid filled clearance at a fractional value of the overall pressure
differential between the interior of the innermost shell and the outside, the sum of the individual pressures in said clearances
equaling said overall pressure differential. Such a pressure vessel will efficiently hold internal and external overpressures, and
5 would function by reducing the pressure strain on any one gas retaining structure in a group of nested gas retaining structures to
a fractional value of the overall pressure differential existing between the interior of the innermost gas retaining structure and the
exterior of the outermost gas retaining structure.

When a compound gas retaining structure functions as such a pressure vessel, the structural demand on each component
gas retaining structure is reduced by maintaining the differential in the pressure held between successively contained structures.
10 The pressure contained or withstood by each of the component structures would be reduced to the pressure differential between
the immediately successive component structures, thus permitting lighter construction of the component structures. A compound
gas retaining structure also allows for control of the center of mass of the entire structure by altering the density of the gases
contained in the component structures, either by pressure or composition. For example, the system shown in FIGS. 7 and 8 would
always maintain an upright orientation in an atmosphere if the density of the gas within the successively smaller nested structures
15 were less than the next larger one. The same would also apply to the system shown in FIGS. 5 and 6 if the density of the gas in
the component gas retaining structures is controlled so that the center of mass of the system is below its spatial center.

The preferred embodiment places the thrusters on a structure which may include controls, machinery, tanks for fuel and/or
oxidizer, and interior space for crew, passengers, cargo, or equipment, or all of them, which shall be hereinafter referred to as the
spacecraft body. The spacecraft body may be separate from but connected to the gas retaining structure as shown in FIG. 1. An
20 example of a spacecraft body, which is shown diagrammatically in FIGS. 1 and 2, has thrusters which are shown as spherical
structures partially imbedded in the structure of the spacecraft body. Although the preferred embodiment separates the functions
of the spacecraft body from the gas retaining structure, one or more functions of the spacecraft body can be integrated with a gas
retaining structure. Indeed, the spacecraft body structure may even be a compartment of a gas retaining structure, as shown in FIGS.
9-11. The spacecraft body may include a fuel and oxidizer supply for thrusters, and may itself be a heavier-than-air lifting body,
25 as shown in FIG. 2, detachable from the airship component and capable of gliding or powered flight. Control surfaces for
aerodynamically controlling the spacecraft body in aerodynamic flight can be included for such operation.

One object of the invention is to provide an airship which has sufficient buoyancy to rise vertically to and beyond an
altitude of neutral buoyancy in the region of the stratosphere/ionosphere and higher. If the region of the atmosphere at which the
vehicle reaches neutral buoyancy has sufficient atmospheric oxidizer for the combustion of fuel in an atmospheric oxidizer
30 compressing thruster, thrust from one or more such thrusters may be used to further the ascent of the airship. Where the
atmospheric oxidizer compressing thrusters can not function because sufficient atmosphere cannot be compressed to provide
atmospheric oxidizer for the combustion of fuel, thrusters which utilize stored oxidizer for oxidation of the fuel are used to further
the ascent of the airship. During the application of thrust the flight path of the airship/spacecraft may be controlled by directing
the thrust.

35 Up to the point of the application of thrust, and by reason of operation in an atmosphere of sufficient density to provide
buoyancy, the airship/spacecraft is operated as an airship. However, when the effect of buoyancy is insignificant, the
airship/spacecraft must be operated purely as a thruster powered spacecraft. The point of transition from operation as an airship
depends in part on the altitude at which the airship reaches neutral buoyancy, which is the altitude at which the density of the lifting
gas will no longer provide a buoyant force to contribute to the ascent of the airship. The altitude of neutral buoyancy may be
40 controlled by the regulation of the density of the gas in gas retaining structures, either by venting to the atmosphere, rarefaction
by pumping gas out, or by increasing the volume of gas retaining structures, as shown in the structural expansion from FIG. 12
to FIG. 15, or a combination of thereof. The preferred method of increasing the altitude at which neutral buoyancy occurs is by
increasing the volume of gas retaining structures.

45 The gas retaining structure contemplated has the ability to withstand sustained internal and external overpressures. The
preferred gas retaining structure is one constructed using one or both of the structural systems which are the subjects of United

1 States Patent Application Nos. 09/276665 and 09/276666. Such gas retaining structures can also be constructed to have the
capability of changing volume and shape while maintaining structural strength. Moreover, gas retaining structures so constructed
have sufficient strength and size to include as components in the framework of permanent space platforms, space habitats, and
spacecraft for space voyages. Thus, the gas retaining structure may also be used as the framework for centrifugal artificial gravity
5 which can be generated by rotating circular arrays thereof, as shown in FIGS. 16-19.

The lifting capacity of the airship/spacecraft may also be controlled by the gradual introduction of lifting gas into the gas
retaining structures while exhausting ballast gases, which may be atmospheric gases, preferably nitrogen. This may be
accomplished without the mixing of the lifting gases with the ballast gases by partitioning one or more of the gas retaining
structures with a flexible gas impermeable membrane within each. Such a membrane would separate the lifting gases being
10 introduced into a gas retaining structure from the ballast gases being extracted by separating the gas retaining structure into two
compartments that may each have the same potential volume as the volume of the gas retaining structure. Such a membrane should
be roughly of the same shape as one of the halves of the gas retaining structure compartmentalized, and attached within the gas
retaining structure so that separate gas tight compartments may be formed by the walls of the gas retaining structure and the
membrane. Such a membrane should be attached within the gas retaining structure so that it can be expanded to the shape of either
15 half of the gas retaining structure. The membrane within the gas retaining structure also functions as a pump by which a first gas
introduced into the gas retaining structure on one side of the membrane, the first side, with a greater pressure than a second gas on
the opposite side of the membrane, the second side, will cause the second gas on the second side of the membrane to exhaust from
a port in the gas retaining structure on the second side of the membrane. For ascent of the airship/spacecraft the partitioning of the
gas retaining structure is utilized to gradually introduce lifting gas into one or more of the gas retaining structures while exhausting
20 the ballast or other gases to be displaced by the lifting gas; thereby controlling the lifting capacity of the airship/spacecraft. This
process is illustrated in the frames shown schematically in FIGS. 4a through 4i in which the hatched area 64 represents the
compartment of the gas retaining structure 61 filled with lifting gases, and the blank area 62 the compartment of the gas retaining
structure 61 filled with ballast gases. The compartments are separated by the membrane 63 within the gas retaining structure 61.
FIG. 4a shows the gas retaining structure 61 completely filled with ballast gases 62, with the membrane 63 laying against the
25 bottom of the gas retaining structure 61. FIG. 4i shows the gas retaining structure 61 completely filled with lifting gases 64, and
the membrane 63 pressed against the top of the gas retaining structure 61. The remaining intermediate FIGS. 4b through 4h
sequentially show the gas retaining structure 61 being increasingly occupied by the lifting gases 64 as the lower compartment 64
of the gas retaining structure 61 is filled with lifting gases 64 and the lessening volume of the gas retaining structure 61 being
occupied by the ballast gases 62 as they are pumped out of the upper compartment 62 of the gas retaining structure by the lifting
30 gases 64 as they force the membrane 63 upward. Initially the lifting gases should be stored as liquid gases in tanks, which may
be then evaporated and expanded in to a gaseous state for introduction into a gas retaining structure.

The flexible membrane by which a gas retaining structure is separated into two gas-tight compartments may be a sheet
material thin enough to conform roughly to the shape of the bottom half and likewise the top half of the gas retaining structure while
maintaining its structural integrity and separation of the lifting gases from the ballast gases. The material would roughly form a
35 flexible container which would approximate a part of a bag that would have roughly the same shape as the bottom half and likewise
the top half of the gas retaining structure. If the gas retaining structure is sufficiently symmetrical the membrane may be a folded
diaphragm, as shown in FIGS. 3a and 3b as 66, and which may be expanded by pressure above or below to conform roughly to the
shape of the top or bottom of a gas retaining structure as shown in FIGS. 3a as 65, the folds being shown as 66 therein and in FIG.
3b. A requirement for the material of the folded diaphragm membrane is that the material of the membrane itself be flexible enough
40 so as to allow the expansion to approximate an interior half of the gas retaining structure. The fold creases in the membrane may
be reinforced with a spring wire, which may be metal, polymer or other suitable material. The folds may also be permanently
formed with the membrane by other methods, such as molding or casting. Although the example shown in FIGS. 3a and 3b has
twenty (20) panels and nineteen (19) folds, larger and small numbers of panels are possible. The larger number of folds and panels,
the flatter the folded diaphragm membrane will be relative to the shape it has when expanded.

45 Ballast exhaust may also be used to provide thrust for the airship/spacecraft while moving through the atmosphere.

1 Ballast exhaust may be transported through conduits from gas retaining structures with buoyancy lifting capacity control systems to a ballast exhaust gas thruster, which has one or more directional thruster nozzles for ballast exhaust gases to direct the thrust of the exhaust. Such a ballast exhaust thruster may assist the lift and steering of the airship/spacecraft.

5 The preferred lifting gas for the airship phase is diatomic hydrogen, which provides the greatest lift and is a commonly used rocket fuel. The lifting force of diatomic hydrogen in air at sea level, both being at standard temperature and pressure, is approximately 65 pounds per 1,000 cubic feet of hydrogen.

10 Depending on the lifting gases used and the rapidity of the introduction of such lifting gases into the gas retaining structures, a fully loaded airship/spacecraft may reach a vertical velocity of 300 meters/second by the time it reaches neutral buoyancy without the necessity to consume any fuel for thrusting. With the advantage of the momentum provided by the acceleration due to buoyancy, the continued ascent of the airship into space as a spacecraft is then a result of the application of thruster power. With hydrogen as a lifting gas, hydrogen may be used as fuel at any time during the airship phase of the ascent. Secondary to being the lifting gas, hydrogen gas can fuel the thrusters in the transition from airship to spacecraft, and then fuel the spacecraft phase. As hydrogen is consumed by thrusters in the transition from airship to spacecraft, several effects occur which act to assist in the extension of the ascent of the airship: firstly, when hydrogen is pumped out to fuel the thrusters, with the volume of the involved gas retaining structure maintained, the density of the hydrogen in the gas retaining structure is reduced, resulting in the buoyant prolongation of the ascent; secondly, the total mass of the airship is reduced by the consumption of hydrogen consumed by the thrusters from the gas retaining structure, resulting in a lesser and decreasing gravitational force on the airship, and thus a greater and increasing acceleration of the airship for a given strength of thrust; and, thirdly, when an atmospheric oxidizer is not available in sufficient quantity, consumption of stored oxidizer by the thrusters also reduces the overall mass of the airship and thus the effect of the weight of countering buoyancy. Together these effects contribute to the extension of the ascent of the airship.

25 The thruster which intakes gaseous fuel may be described as a "turbo-rocket thruster", and shall hereinafter be referred to as such. A turbo-rocket thruster is a reaction thrusting power plant which uses a gaseous fuel and is capable of accelerating a spacecraft to sub-orbital and orbital speeds and altitudes. The turbo-rocket thruster may be used on aircraft and spacecraft having a large reservoir of gaseous fuel combustible by oxidation, and in particular as an integral component of the present invention. The turbo-rocket thruster can compress the gaseous fuel for efficient combustion with an injected oxidizer to produce reaction thrust. In the case of an airship which uses lifting gas that includes gaseous hydrogen, such a lifting gas may serve as the gaseous fuel for the turbo-rocket thruster. The turbo-rocket thruster is particularly suited to operate with hydrogen lifting gas, which may have been rarefied by an increase in volume of the structure in which hydrogen lifting gas is contained, by compressing the hydrogen lifting gas with a turbine compressor.

35 Although the turbo-rocket thruster has been disclosed as operating by oxidizing a gaseous fuel, it may also operate with other combinations of propellant chemicals which react exothermally or are otherwise productive in the release of energy in some form. Reference herein to a propellant chemical also means a compatible mixture of propellant chemicals. In the latter case of operation of the turbo-thruster, a first propellant chemical is gaseous and intaken for compression as such, and the second propellant chemical is either liquid or gaseous and injected into the compressed first propellant chemical.

40 The embodiment of the turbo-rocket thruster illustrated in FIG. 20 includes a duct casing 1 which defines a gas duct 2, which in turn defines a gas intake 3, a combustion chamber 4, and an exhaust nozzle 5, and surrounds an axial compressor stage 6, a combustion chamber stage, and an axial turbine stage 7. The axial compressor stage 6 has at least one compressor rotor 8 having a plurality of compressor blades 9 extending radially therefrom. The compressor rotor 8 of the axial compressor 8 and 9 is located downstream of first stator guide vane 10 which supports a first hub 11 coaxially with the longitudinal axis of the gas duct 2 to rotatably support the compressor rotor 8. The axial compressor 8 and 9 is driven via a shaft 19 by the axial turbine stage 7, which includes at least one turbine rotor 12 with a plurality of turbine blades 13 extending radially therefrom. The axial turbine 12 and 13 is driven by the burning gaseous fuel passing across the turbine blades 13. The turbine rotor 12 of the axial turbine 12 and 13 is located downstream of a second stator guide vane 14, which supports the oxidizer injectors 15 and in which the oxidizer injectors 15 are located. The second stator guide vane 14 supports a second hub 16 coaxially with the longitudinal axis of the gas

1 duct 2 to also rotatably support the compressor rotor 8 with the first hub 11. The turbine rotor 12 of the axial turbine 12 and 13
is located upstream of a third stator guide vane 17, which supports a third hub 18 coaxially with the longitudinal axis of the gas
duct 2 to also rotatably support, together with the second hub 16, the turbine rotor 12.

The operation of the turbo-rocket thruster commences with the intaking 2 of gaseous fuel 20 drawn from one or more
5 reservoirs, or from the upper atmosphere, by the axial compressor 8 and 9. With compression by the axial compressor 8 and 9 the
gaseous fuel is sent to a combustion chamber 4 to be mixed with an injected 15 oxidizer for ignition and burning. The energetic
products of the combustion of the gaseous fuel then flow through and power the axial turbine 12 and 13, which is connected to and
powers the axial compressor 8 and 9 via a shaft 19 and/or transmission. The energetic exhaust gases 21 then exit from the exhaust
nozzle 5 to the space outside the gas duct 30 to provide reaction thrust.

10 Gaseous fuel is supplied to the turbine compressor 8 and 9 from a gas reservoir by at least one gaseous fuel pipe 22. The
process of supplying gaseous fuel to the turbo-rocket thruster may be assisted by electromagnetically accelerating the gaseous fuel
to the intake, pumping, including ultrasonic pumping, pre-compression, and contraction of the gaseous fuel reservoir.

The circuit for supplying oxidizer to the supply tube 23 starts at an oxidizer reservoir 24 storing oxidizer having an outlet
connected to pump 25 which may pump the oxidizer from the reservoir 24 into supply tube 23. An oxidizer such as liquid oxygen
15 may be first pumped 25 through a heat exchanger 26 included in the third stator guide vane 17 in the exhaust nozzle 5 so as to
absorb the heat of the exhaust gases passing through the exhaust nozzle 5 and cool the third stator guide vane 17. The temperature
of the liquid oxygen passing through the heat exchanger 26 is raised and the liquid oxygen vaporized so that gaseous oxygen passes
through a supply tube 23 connected to the outlet of the heat exchanger 26. Liquid oxygen may also be made to pass through another
heat exchanger consisting of tubes around and through the casing 1 of the exhaust nozzle 5 and the third hub 18 so as to absorb heat
20 from the exhaust gases 21 and thereby initially raise its temperature and cool the exhaust nozzle 5 and the third hub 18.

Under certain operating conditions, or for certain oxidizers useable without vaporization prior to injection into the
combustion chamber, the heat exchanger 26 may be bypassed by allowing the oxidizer to flow through bypass tube 27 and
subsequently into supply tube 23 by the use of the three-way, three-port valves 28 and 29.

The process of supplying hydrogen, or other lifting gas that may be used as fuel, to such a thruster may be assisted by
25 electromagnetically accelerating the gas to the intake, pumping, including ultrasonic pumping, and pre-compression. Contracting
the gas retaining structures is another means for assisting the extraction of gas from gas retaining structures for supplying fuel to
the thrusters, such as the transition shown between FIGS. 12 and 14. Such supply of fuel gas from a gas retaining structure may
be direct by intake from a gas retaining structure, with or without baffles, or by pipes, ducts, or other gas conduits, or one or more
of same used in combination.

30 Another type of thruster can operate where the hydrogen is rarefied in the gas retaining structures, but with an atmospheric
oxidizer, an example of which is shown in FIG. 21, in which a thruster as shown in FIG. 20 is combined with a thruster that intakes
a gaseous oxidizer to form a dual thruster. The general configuration is similar to dual turbojets, but with a common combustion
chamber. Such a thruster intakes 31 and compresses 32 fuel gas 39 drawn from gas retaining structures with a first compressor
32, and sends it to a combustion chamber 34 where it is mixed with a gaseous oxidizer 40, which may be drawn from the
35 atmosphere 41 and compressed 42 by a second compressor 42, for ignition and burning in the common combustion chamber 34,
44. The energetic products of combustion then flow through and power two turbines 36, 46, each of which are connected to and
power the compressors 32, 42 via their respective shafts 35, 45 and/or transmissions. The energetic exhaust gases 38, 48 then exit
from the exhaust area 37, 47 to the space outside the airship/spacecraft system to provide reaction thrust.

Two configurations of such a dual thruster are possible: one of which is to provide injected oxidizer only to the hydrogen-
40 intake side of the dual system with a means for mechanical division of the combustion chamber to isolate it from the oxidizer-
intake side, which may be used with injected fuel; the other is to provide injected oxidizer to both sides of the dual system shown
in FIG. 21, with both sides intaking fuel gas. The operation of each component thruster of such a dual thruster could also be
isolated from the other by one or more mechanical doors separating the gas flows in each in the region where the combustion
chambers may be joined.

45 Conventional surface rocket launched and powered spacecraft are designed to make the thrust of the rocket engines as

1 large as possible by ejecting mass as rapidly as possible and with the highest possible relative speed. A rapid consumption of fuel and oxidizer also reduces the mass of the rocket that is being accelerated, and thus the acceleration of the rocket is thus enhanced. In the launching of spacecraft from the surface of the earth rapid consumption of fuel is considered to be an advantage, provided that the spacecraft and its contents can survive and endure the extreme acceleration.

5 In the case of the present invention g-forces in the buoyant ascent through the atmosphere to space flight would be significantly moderated by the lack of the necessity for the rapid burn-off of weighty fuel during that phase of operation, inasmuch as activation of the thrusters is not necessary until after the airship has reached neutral buoyancy. The airship may have significant upward momentum at the point of neutral buoyancy, the airship having accelerated upward during buoyant ascent in overcoming gravitational force. The regulation of such acceleration of the airship/spacecraft during buoyant ascent by the regulation of the buoyancy is inherent in the airship aspect of the present invention. The reduction of the level of g-forces is also possible for the descent from space flight and can be accomplished with controlled deceleration by retrofiring of thrusters, rather than by uncontrolled atmospheric braking, so that the speed of the spacecraft is slowed to the extent that airship buoyancy will provide the braking for descent. Neutral buoyancy will occur at a higher altitude as a result of the lower density of the gases in one or more gas retaining structures. The gas retaining structures may contain hydrogen that was collected in space or unconsumed in the ascending flight, and thus available to fuel thrusters for further retrofiring. The gas retaining structures may also have hydrogen and atmospheric gases in separate compartments of one or more of gas retaining structures. The rest of the descent is then accomplished as an airship using the atmosphere as ballast by gradually increasing the density of gas within one or more gas retention structures.

20 The method by which an airship/spacecraft may attain orbit after being launched from a the surface of a planet such as the earth commences with the launch of the airship/spacecraft with detachment from its mooring, jettisoning solid or liquid ballasts, thus permitting ascent of the airship/spacecraft as a lighter-than-air airship. During the ascent the buoyant force is regulated by the gradual introduction of lifting gases into the gas retaining structures of the airship/spacecraft and the concurrent exhaustion of ballast gases to the atmosphere. The initial ballast gases would best be gases that could not react with the lifting gases under normal conditions, such as nitrogen if the lifting gas was hydrogen. Nitrogen could also serve as a lifting gas, especially if was heated and/or maintained at a lower density in the gas retaining structures than that of the density of the atmosphere outside of the airship/spacecraft. The introduction of the lifting gas into the gas retaining structure should proceed as rapidly as necessary to maintain the upward acceleration required to reasonably maximize the momentum of the airship/spacecraft at neutral buoyancy, to maximize the altitude at which neutral buoyancy occurs, and to minimize the acceleration experienced by the airship/spacecraft, its load, and its occupants. As the lifting gases are introduced into the gas retaining structures the tanks in which they were stored as liquid or otherwise should be jettisoned to reduce the mass of the airship/spacecraft. At the point of maximum vertical velocity due to buoyancy acceleration, the thrusters of the airship/spacecraft should be activated. In the preferred embodiment of this method the activation of the thrusters should occur when the mass of the airship/spacecraft was at a minimum in its buoyant ascent, that is when all of the ballast gases had been exhausted and the tanks that had been emptied of liquid lifting gas had been jettisoned. At such a point the airship/spacecraft may reach a vertical velocity as great as 300 meters/second without having consumed any fuel for thrusting. With such advantage of the momentum provided by the acceleration due to buoyancy, the continued ascent of the airship into space as a spacecraft is then a result of its operation under thruster power. In the preferred embodiment of the method, such thruster power is fueled by the lifting gas which is diatomic hydrogen, and is produced by fuel breathing turbo-rocket thrusters.

40 At the time of launch the airship/spacecraft has a horizontal velocity which is the same as the tangential velocity of the surface of the rotating plane at the latitude of launch. Such motion is largely the same as the atmosphere as it rotates with the planet. Such horizontal velocity should not be augmented or countered by acceleration from thrusting at an altitude below fifty miles to minimize atmospheric drag and less productive expenditure of fuel. Above about 50 miles the climb angle of the airship/spacecraft should be adjusted by redirecting the thrusters on the spacecraft body to increase the horizontal component of acceleration to bring the airship/spacecraft to the appropriate tangential velocity for injection into the orbit desired. Such an increase in tangential velocity also results in an increase in the centrifugal lifting force. The continued lifting with thrusters to the

1 orbital altitude desired, augmented by buoyancy and centrifugal acceleration, is gradually decreased with the increase in the tangential velocity to the point where, at orbital injection, there should be a very small component of velocity that is vertical relative to the horizontal velocity of the airship/spacecraft. The completion of the method is the adjustment of the tangential velocity for orbital injection at the chosen altitude.

5 A method for sub-orbital travel from one location on the surface of a planet such as earth to another location on the surface of the planet may be derived as a variation of the method of attaining orbit. The tangential deceleration and descent required may commence with retrofiring of the thrusters and the effect of increasing buoyancy at a point where approximately half of the ground distance to the destination point on earth has been traveled by the airship/spacecraft.

10 A method for travel from an orbit about a planet such as the earth to the surface of the planet may be initiated with the retrofiring of thrusters to reduce tangential velocity and reduce descent velocity to the same levels as occurred during ascent at an altitude of approximately 50 miles. At this point, which is directly above the destination on the surface of the planet, the only tangential velocity that the airship/spacecraft should have is approximately the tangential velocity of the surface of the planet at the surface destination. Also at this point, a number of the gas retaining structures should be near vacuum, and should start to take on ballast gases as the external pressure increases with the descent through the atmosphere. However, the density of the gases in
15 the gas retaining structures should be regulated to regulate the buoyancy thereof so as to reduce the velocity of descent to avoid atmospheric friction heating and adverse deceleration effects on the load and occupants of the airship/spacecraft. Below the altitude of neutral buoyancy, the descent may be regulated by controlling the buoyancy of the airship/spacecraft and retrofiring of thrusters. Landing of the airship/spacecraft is then as an airship augmented by thruster lift and control.

20 The airship/spacecraft and methods for transition to space travel disclosed herein are adaptable to other planet-atmosphere systems, and are not intended to be limited solely for use in the earth system.

While the invention has been disclosed in connection with a preferred embodiment, it will be understood that there is no intention to limit the invention to the particular embodiment shown, but it is intended to cover the various alternative and equivalent constructions included within the spirit and scope of the appended claims.

25 Brief Description of the Drawings

FIG. 1 is a diagrammatic side view of the airship/spacecraft.

FIG. 2 is a diagrammatic perspective view of the spacecraft body of the airship/spacecraft shown in FIG. 1.

FIG. 3a is a diagrammatic side view of a diaphragm membrane for compartmentalization of gas retaining structures expanded (above), and (in cross-section) folded (below).

30 FIG. 3b is a perspective view of the diaphragm membrane shown in FIG. 3a.

FIGS. 4a through 4i are schematic side views of a gas retaining structure separated into two gas-tight compartments with a flexible membrane in the sequence of the process of introducing gas into the lower compartment and exhausting gas from the upper compartment.

FIG. 5 is a diagrammatic side cutaway view of a gas retaining structure containing other separate gas retaining structures.

35 FIG. 6 is a diagrammatic perspective cutaway view of the gas retaining structure shown in FIG. 5.

FIG. 7 is a diagrammatic side cutaway view of nested gas retaining structures.

FIG. 8 is a diagrammatic perspective cutaway view of the nested gas retaining structures shown in FIG. 7.

FIG. 9 is diagrammatic perspective view from below of an airship/spacecraft with a structurally integrated spacecraft body.

40 FIG. 10 is a diagrammatic perspective cutaway view from below of the airship/spacecraft shown in FIG. 9.

FIG. 11 is a fragmentary view of the region of cutaway shown in FIG. 10.

FIG. 12 is a diagrammatic side view of the airship/spacecraft with a gas retaining structure constructed of toroidal structural elements and with a spacecraft body designed for integration into a space structure.

FIG. 13 is a diagrammatic perspective view from below of the airship/spacecraft shown in FIG. 12.

45 FIG. 14 is a diagrammatic side view of the airship/spacecraft shown in FIG. 12 with a contracted gas retaining structure.

- 1 FIG. 15 is a diagrammatic side view of the airship/spacecraft shown in FIG. 12 with an expanded gas retaining structure.
FIG. 16 is a diagrammatic perspective view from above of a space structure comprised of an array of three of the airship/spacecraft shown in FIG. 12.
FIG. 17 is a diagrammatic perspective view of a space structure comprised of a linear array of six of the space structures shown
5 in FIG. 16.
FIG. 18 is a diagrammatic perspective view from above of a space structure comprised of an array of six of the airship/spacecraft similar to that shown in FIG. 12.
FIG. 19 is a diagrammatic perspective view of a space structure comprised of a linear array of ten of the space structures shown in FIG. 18.
10 FIG. 20 is a longitudinal sectional view of a thruster which operates by turbo-compression of hydrogen and combustion with injected oxidizer.
FIG. 21 is a diagrammatic perspective view of a dual thruster which operates by separate turbo-compression of hydrogen and atmospheric oxidizer and mixing for combustion.

15 Best Mode for Carrying Out Invention

Although the airship/spacecraft which uses lifting gas as fuel for thrusters to attain orbit may be utilized with various types of thrusters and gas retaining structures, the best mode of the invention includes components which are also inventive, such as the turbo-rocket thruster, gas retaining structures compartmentalized by a flexible membrane, ballast exhaust thrusters, and pressure vessel gas retaining structures, as part of the present invention.

20

Industrial Applicability

- Objects of the invention are to provide: an airship which has sufficient buoyancy to rise vertically to an altitude of neutral buoyancy in the region of the stratosphere/ionosphere; an airship/spacecraft which uses its lifting gas as fuel for thrusters to power it to space flight; and, an airship/spacecraft that can descend to a planet's surface from space flight. It is also an object of the
25 invention to reduce g-forces and atmospheric friction heating during ascent and descent. It is also an object of the present invention to provide a reaction thrusting power plant which uses a gaseous fuel and is capable of accelerating a spacecraft to sub-orbital and orbital speeds and altitudes.

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1 CLAIMS



What I claim as my invention is:

Claim 1. An airship/spacecraft comprising:

- 5 one or more gas retaining structures;
 a spacecraft body connected to one or more gas retaining structures;
 one or more lifting gases;
 one or more thrusters fueled with a lifting gas; and
 a means of supplying a lifting gas from one or more gas retaining structures to one or more thrusters.
- 10 Claim 2. The airship/spacecraft of claim 1 wherein one of the lifting gases is hydrogen.
- Claim 3. The airship/spacecraft of claim 1 wherein one of the lifting gases is heated nitrogen.
- Claim 4. The airship/spacecraft of claim 1 wherein the gas retaining structures are torsion structures.
- Claim 5. The airship/spacecraft of claim 1 further comprising a means for controlling the volume of one or more of the gas retaining structures.
- 15 Claim 6. The airship/spacecraft of claim 1 further comprising a means for controlling the density of the gas in one or more of the gas retaining structures.
- Claim 7. The airship/spacecraft of claim 1 wherein the lifting gas is intaken and compressed by the thrusters that are fueled with lifting gas.
- Claim 8. The airship/spacecraft of claim 1 further comprising one or more dual thrusters that separately intake and compress lifting
- 20 gas and atmospheric oxidizer for combustion.
- Claim 9. The airship/spacecraft of claim 1 wherein the spacecraft body is detachable from the buoyancy lifting component of the airship/spacecraft for independent aerodynamic flight.
- Claim 10. The airship/spacecraft of claim 1 wherein the spacecraft body has control surfaces for aerodynamically controlling the spacecraft body in atmospheric flight.
- 25 Claim 11. The airship/spacecraft of claim 1 further comprising a means for direction of the thrust of one or more of the thrusters.
- Claim 12. The airship/spacecraft of claim 1 further comprising a framework for a hull the shape of which is changeable under control.
- Claim 13. The airship/spacecraft of claim 12 further comprising a framework hull which is also a gas retaining structure.
- Claim 14. A pressure vessel designed to sustain a pressure differential between its interior and its surroundings, comprising: a hull
- 30 formed from a multiplicity of nested shells including an innermost shell and several outer shells separated by intervening fluid filled clearances.
- Claim 15. The pressure vessel of claim 14 further comprising a means for transporting fluid into and out of each of the nested shells.
- Claim 16. The pressure vessel of claim 14 further comprising a means for maintaining the individual pressure in each fluid filled
- 35 clearance at a fractional value of the overall pressure differential between the interior of the innermost shell and the outside, the sum of the individual pressures in said clearances equaling said overall pressure differential.
- Claim 17. A pressure vessel comprising a hull formed from a multiplicity of nested gas retaining structures including an innermost gas retaining structure and several outer gas retaining structures separated by intervening fluid filled clearances.
- Claim 18. A pressure vessel comprising a hull formed from a plurality of nested gas retaining structures including an innermost
- 40 gas retaining structure and a plurality of outer gas retaining structures separated by intervening gas filled clearances.
- Claim 19. The pressure vessel of claim 17 or claim 18 further comprising a means for transporting fluid into and out of each of the nested gas retaining structures.
- Claim 20. The pressure vessel of claim 17 or claim 18 further comprising a means for maintaining the individual pressure in each gas filled clearance at a fractional value of the overall pressure differential between the interior of the innermost gas retaining
- 45 structure and the outside, the sum of the individual pressures in said clearances equaling said overall pressure differential.



- 1 Claim 21. The pressure vessel of claim 17 or claim 18 in which the gas retaining structures are compound gas retaining structures.
- Claim 22. A buoyancy lifting capacity control system comprising:
a flexible gas impermeable membrane attached within an airship gas retaining structure ;
said membrane being roughly of the same shape of one of the halves of the gas retaining structure,
5 so that said membrane can be expanded to the shape of either half of the gas retaining structure;
which partitions the gas retaining structure so that separate gas tight compartments may be formed by the walls of the gas retaining
structure and said membrane;
so that each gas tight compartment may each have approximately the same volume as the volume of the gas retaining structure
when the membrane is fully expanded.
- 10 Claim 23. The buoyancy lifting capacity control system of Claim 22, wherein a sheet material thin enough to conform roughly to
the shape of one half of the gas retaining structure while maintaining its structural integrity and separation of the gases on either
side of the membrane.
- Claim 24. The buoyancy lifting capacity control system of Claim 22, wherein the flexible membrane is a folded diaphragm.
- Claim 25. The buoyancy lifting capacity control system of Claim 24, wherein the folded diaphragm flexible membrane is of a
15 sufficiently flexible material so that the membrane can expand to approximate the shape of a half of the gas retaining structure.
- Claim 26. The buoyancy lifting capacity control system of Claim 24, wherein the fold creases in the folded diaphragm flexible
membrane are reinforced with a spring wire,
- Claim 27. The buoyancy lifting capacity control system of Claim 24, wherein the folds in the folded diaphragm flexible membrane
are permanently formed with the membrane.
- 20 Claim 28. The buoyancy lifting capacity control system of Claim 20, wherein the flexible membrane functions as a pump to
exhaust a second gas from the gas retaining structure motivated by the introduction of a first gas into the gas retaining structure
on one side of the membrane, the first side, with a greater pressure than a second gas on the opposite side of the membrane, the
second side, so that the second gas on the second side of the membrane is exhausted from a port in the gas retaining structure on
the second side of the membrane.
- 25 Claim 29. The buoyancy lifting capacity control system of 28, wherein the second gas is ballast gas.
- Claim 30. The buoyancy lifting capacity control system of Claim 29, wherein the ballast gases exhausted from a port in a gas
retaining structure is piped to thruster nozzles.
- Claim 31. The buoyancy lifting capacity control system of Claim 28, wherein the first gas is lifting gas.
- Claim 32. The buoyancy lifting capacity control system of Claim 31, wherein the lifting gases are stored as liquid gases in tanks
30 for expansion into a gaseous state for introduction into a gas retaining structure.
- Claim 33. A ballast exhaust gas thruster comprising:
one or more buoyancy lifting capacity control systems;
conduits for ballast exhaust gases from gas retaining structures with buoyancy lifting capacity control systems; and
one or more directional thruster nozzles for ballast exhaust gases to direct the thrust of the exhaust;
35 so that lift and steering of the airship/spacecraft are assisted.
- Claim 34. A buoyancy lifting component of the airship/spacecraft comprising:
one or more gas retaining structures;
one or more lifting gases;
one or more ballast gases; and
40 one or more buoyancy lifting capacity control systems.
- Claim 35. The buoyancy lifting component of the airship/spacecraft of claim 34 wherein the gas retaining structures are torsion
structures.
- Claim 36. The buoyancy lifting component of the airship/spacecraft of claim 34 wherein the gas retaining structures are toroidal
torsion structures.
- 45 Claim 37. The buoyancy lifting component of the airship/spacecraft of claim 34 further comprising or more ballast exhaust gas



1 thrusters.

Claim 38. The buoyancy lifting component of the airship/spacecraft of claim 34 further comprising a means for controlling the volume of one or more of the gas retaining structures.

5 Claim 39. The buoyancy lifting component of the airship/spacecraft of claim 34 further comprising a means for controlling the density of the gas in one or more of the gas retaining structures.

Claim 40. The buoyancy lifting component of the airship/spacecraft of claim 34 wherein the one or more gas retaining structures are compound gas retaining structures.

Claim 41. The buoyancy lifting component of the airship/spacecraft of claim 34 wherein one or more gas retaining structures are nested to form a pressure vessel.

10 Claim 42. A method of controlling ascent of an airship with a buoyancy lifting capacity control system comprising:

(a) filling the membrane partitioned airship gas retaining structures with ballast gases on one side of the membrane so that the compartment on the opposite side of the membrane is empty;

(b) introducing lifting gas into such empty compartment;

15 (c) exhausting the ballast gases as they are displaced by the expansion of the compartment into which the lifting gas is being introduced;

so that a chosen value for vertical acceleration of the airship is maintained as desired.

Claim 43. The method of claim 42 wherein the step of introducing lifting gas is performed so that the introduction of lifting gas is gradual.

20 Claim 44. The method of claim 42 wherein the step of exhausting the ballast gases is performed so that the exhaustion of the ballast gases is gradual.

Claim 45. The method of claim 42 wherein the steps of introducing lifting gas and exhausting the ballast gases are performed simultaneously.

Claim 46. The method of claim 42 wherein the step of exhausting the ballast gases is performed so that the exhaustion of the ballast gases is directed to provide directional thrust for the airship.

25 Claim 47. The method of claim 42 wherein the step of exhausting the ballast gases is performed so that the exhaustion of the ballast gases is assisted by an exhausting means.

Claim 48. The method of claim 42 wherein the step of exhausting the ballast gases is performed so that the ballast gases are exhausted from a port in the gas retaining structure on the ballast gas side of the membrane.

30 Claim 49. The method of claim 42 wherein the steps of introducing lifting gas and exhausting the ballast gases are performed without the mixing of the lifting gas with the ballast gases.

Claim 50. The method of claim 42 wherein the step of introducing lifting gas is preceded by the expansion to a gaseous state of lifting gas stored as a liquid in tanks.

Claim 51. An airship/spacecraft array comprising a plurality of connected airship/spacecraft.

35 Claim 52. A method for providing centrifugal artificial gravity comprising: rotating an airship/spacecraft array at sufficient rotational velocity.

Claim 53. A gaseous-fuel breathing, stored oxidizer turbo-rocket thruster comprising:

(a) a gas duct defining a gaseous-fuel intake;

(b) a source of gaseous fuel;

(c) a source of stored oxidizer;

40 (d) a compressor means for compressing gaseous fuel, the compressor means being disposed axially within the gas duct;

(e) injector means to inject oxidizer into the compressed gaseous fuel so that the oxidizer mixes with the compressed gaseous fuel;

(f) a turbine means operatively associated with the compressor means to drive the compressor means, the turbine means being disposed axially within the gas duct, wherein the turbine means is driven by the gaseous fuel burning with the oxidizer; and

(g) a nozzle means operatively associated with the gas duct to exhaust gases from the gas duct.

45 Claim 54. The turbo-rocket thruster of claim 53, further comprising a heat exchange means interposed between the stored oxidizer



- 1 source and the oxidizer injectors to raise the temperature of the oxidizer before entering the combustion chamber and to cool at least one component of the nozzle means.
- Claim 55. The turbo-rocket thruster of claim 53, wherein the source of gaseous fuel is a reservoir of such gaseous fuel.
- Claim 56. The turbo-rocket thruster of claim 53, wherein the gaseous fuel is hydrogen.
- 5 Claim 57. The turbo-rocket thruster of claim 53, wherein the compressor means comprises an axial compressor for compressing gaseous fuel, the axial compressor comprising at least one compressor rotor, each compressor rotor having a plurality of compressor blades extending radially therefrom and disposed within the gas duct.
- Claim 58. The turbo-rocket thruster of claim 53, wherein the turbine means comprises an axial turbine for driving the compressor means, the axial turbine comprising at least one turbine rotor, each turbine rotor having a plurality of turbine blades extending
- 10 radially therefrom and disposed within the gas duct.
- Claim 59. The turbo-rocket thruster of claim 53, further comprising a pump means to pump the oxidizer from the source of stored oxidizer through the oxidizer circuit to the injector means.
- Claim 60. A turbo-rocket thruster comprising:
- (a) a gas duct defining a gaseous-fuel intake;
- 15 (b) a source of gaseous fuel;
- (c) a source of stored oxidizer;
- (d) a turbine compressor for compressing gaseous fuel, the turbine compressor being disposed axially within the gas duct;
- (e) one or more injectors to inject oxidizer into the compressed gaseous fuel so that the oxidizer mixes with the compressed gaseous fuel;
- 20 (f) a gas turbine operatively associated with the turbine compressor to drive the turbine compressor, the gas turbine being disposed axially within the gas duct, wherein the gas turbine is driven by the gaseous fuel burning with the oxidizer; and
- (g) a nozzle operatively associated with the gas duct to exhaust gases from the gas duct.
- Claim 61. The turbo-rocket thruster of claim 60, further comprising a heat exchanger interposed between the stored oxidizer source and the oxidizer injectors to raise the temperature of the oxidizer before entering the combustion chamber and to cool at least one
- 25 component of the nozzle.
- Claim 62. The turbo-rocket thruster of claim 60, wherein the source of gaseous fuel is a reservoir of such gaseous fuel.
- Claim 63. The turbo-rocket thruster of claim 60, wherein the gaseous fuel is hydrogen.
- Claim 64. The turbo-rocket thruster of claim 60, wherein the turbine compressor comprises an axial compressor for compressing gaseous fuel, the axial compressor comprising at least one compressor rotor, each compressor rotor having a plurality of compressor
- 30 blades extending radially therefrom and disposed within the gas duct.
- Claim 65. The turbo-rocket thruster of claim 60, wherein the gas turbine comprises an axial turbine for driving the turbine compressor, the axial turbine comprising at least one turbine rotor, each turbine rotor having a plurality of turbine blades extending radially therefrom and disposed within the gas duct.
- Claim 66. The turbo-rocket thruster of claim 60, further comprising a pump to pump the oxidizer from the source of stored oxidizer
- 35 through the oxidizer circuit to the injectors.
- Claim 67. A turbo-rocket thruster comprising:
- (a) a gas duct defining a gaseous-fuel intake;
- (b) a source of gaseous first propellant chemical;
- (c) a source of second propellant chemical;
- 40 (d) a turbine compressor for compressing the gaseous first propellant chemical, the turbine compressor being disposed axially within the gas duct;
- (e) one or more injectors to inject the second propellant chemical into the compressed gaseous first propellant chemical so that the second propellant chemical mixes with the compressed gaseous first propellant chemical;
- (f) a gas turbine operatively associated with the turbine compressor to drive the turbine compressor, the gas turbine being disposed
- 45 axially within the gas duct, wherein the gas turbine is driven by the gaseous first propellant chemical reacting exothermically with



- 1 the second propellant chemical; and
 (g) a nozzle operatively associated with the gas duct to exhaust gases from the gas duct.
- Claim 68. The turbo-rocket thruster of claim 67, wherein the source of gaseous first propellant chemical is a reservoir of such gaseous first propellant chemical.
- 5 Claim 69. The turbo-rocket thruster of claim 67, further comprising a heat exchanger interposed between the second propellant chemical source and the second propellant chemical injectors to raise the temperature of the second propellant chemical before entering the combustion chamber and to cool at least one component of the nozzle.
- Claim 70. The turbo-rocket thruster of claim 67, wherein the turbine compressor comprises an axial compressor for compressing the gaseous first propellant chemical, the axial compressor comprising at least one compressor rotor, each compressor rotor having
- 10 a plurality of compressor blades extending radially therefrom and disposed within the gas duct.
- Claim 71. The turbo-rocket thruster of claim 67, wherein the gas turbine comprises an axial turbine for driving the turbine compressor, the axial turbine comprising at least one turbine rotor, each turbine rotor having a plurality of turbine blades extending radially therefrom and disposed within the gas duct.
- Claim 72. The turbo-rocket thruster of claim 67, further comprising a pump to pump the second propellant chemical from the
- 15 source of stored second propellant chemical through the second propellant chemical circuit to the injectors.
- Claim 73. A method of extracting fuel gas from a gas retaining structure comprising the step of contracting the framework of the gas retaining structure.
- Claim 74. A multi-turbo-rocket thruster comprising:
 a plurality of turbo-rocket thrusters connected so that the thrusters have a common combustion chamber;
 20 a source of gaseous fuel;
 a source of oxidizer; and
 one or more mechanical doors separating the gas flows of the turbo-rocket thrusters from each other when said mechanical doors are closed.
- Claim 75. The multi-turbo-rocket thruster of claim 74, wherein the oxidizer is atmospheric oxygen intaken by one or more of the
- 25 thrusters and the gaseous fuel is intaken by the remaining thrusters and burned with the atmospheric oxygen in the common combustion chamber.
- Claim 76. The multi-turbo-rocket thruster of claim 74, wherein gaseous fuel is intaken by all of the thrusters and burned with injected stored oxygen.
- Claim 77. The multi-turbo-rocket thruster of claim 74, wherein the combustion chamber doors are closed and gaseous fuel is
- 30 intaken by one or more of the thrusters and burned with injected stored oxygen and atmospheric oxygen is intaken by one or more of the remaining thrusters to burn injected fuel.
- Claim 78. A method for attaining orbit about the earth with an airship/spacecraft following launch from its moorings and jettison of ballast, comprising the steps of:
 (a) regulating the buoyancy of the gas retaining structures of the airship/spacecraft to control the ascent of the airship/spacecraft;
 35 (b) activating one or more thrusters of the airship/spacecraft at approximately the altitude of neutral buoyancy;
 (c) continuing the ascent of the airship/spacecraft with the application of thruster power;
 (d) decreasing the climb angle of the airship/spacecraft; and
 (e) increasing the tangential velocity of the airship/spacecraft to orbital velocity while decreasing the climb angle.
- Claim 79. The method of claim 78 wherein the step of regulating the buoyancy includes introduction of lifting gases into the gas
- 40 retaining structures of the airship/spacecraft and the concurrent exhaustion of ballast gases to the atmosphere.
- Claim 80. The method of claim 78 comprising the additional step of jettisoning tanks in which liquid lifting gas was stored after the contents have been removed.
- Claim 81. The method of claim 78 wherein the step of regulating the buoyancy includes regulating the upward acceleration of the
- 45 Claim 82. The method of claim 78 wherein the step of regulating the buoyancy includes regulating the upward acceleration of the



- 1 airship/spacecraft during buoyant ascent to maximize the momentum of the airship/spacecraft at neutral buoyancy.
- Claim 83. The method of claim 78 wherein the step of regulating the buoyancy includes regulating the upward acceleration of the airship/spacecraft during buoyant ascent to minimize the acceleration experienced by the airship/spacecraft to the point of neutral buoyancy.
- 5 Claim 84. The method of claim 78 wherein the steps of regulating the buoyancy, activating one or more thrusters, and continuing the ascent of the airship/spacecraft with the application of thruster power include maintaining vertical ascent of the airship/spacecraft through the atmosphere until atmospheric drag on the airship/spacecraft becomes insignificant.
- Claim 85. The method of claim 78 wherein the steps of regulating the buoyancy, activating one or more thrusters, and continuing the ascent of the airship/spacecraft with the application of thruster power include maintaining vertical ascent of the
- 10 airship/spacecraft through the atmosphere to an altitude of approximately 50 miles.
- Claim 86. The method of claim 78 wherein the steps of regulating the buoyancy, activating one or more thrusters, and continuing the ascent of the airship/spacecraft with the application of thruster power include maintaining the horizontal velocity imparted to the airship/spacecraft at launch due to the rotation of the earth during the ascent of the airship/spacecraft through the atmosphere until atmospheric drag on the airship/spacecraft becomes insignificant.
- 15 Claim 87. The method of claim 78 wherein the steps of regulating the buoyancy, activating one or more thrusters, and continuing the ascent of the airship/spacecraft with the application of thruster power include maintaining the horizontal velocity imparted to the airship/spacecraft at launch due to the rotation of the earth during the ascent of the airship/spacecraft through the atmosphere to an altitude of approximately 50 miles.
- Claim 88. The method of claim 78 wherein the steps of activating one or more thrusters, continuing the ascent of the
- 20 airship/spacecraft with the application of thruster power and increasing the tangential velocity include fueling thrusters with lifting gas.
- Claim 89. The method of claim 78 wherein the step of increasing the tangential velocity includes adjusting the tangential velocity and climb angle of the airship/spacecraft for orbital injection at the chosen altitude.
- Claim 90. A method for suborbital travel between two surface locations on a planet with an atmosphere with an airship/spacecraft following launch from its moorings and jettison of ballast, comprising the steps of:
- 25 (a) regulating the buoyancy of the gas retaining structures of the airship/spacecraft to control the ascent of the airship/spacecraft;
- (b) activating one or more thrusters of the airship/spacecraft at approximately the altitude of neutral buoyancy;
- (c) continuing the ascent of the airship/spacecraft with the application of thruster power;
- (d) decreasing the climb angle of the airship/spacecraft; and
- 30 (e) increasing the tangential velocity of the airship/spacecraft while decreasing the climb angle and vertical velocity to approximately zero at a point above the planet's surface which is approximately equidistant from the location of launch of the airship/spacecraft on the planet's surface to the location of the destination on the planet's surface.
- (f) retrofiring and directing thrusters so that the airship/spacecraft travels on a trajectory to a point above the location of the destination on the planet's surface at which the airship/spacecraft has neutral buoyancy and a tangential velocity approximately
- 35 that of the location of the destination on the planet's surface due to rotation of the planet.
- (g) regulating the buoyancy of the gas retaining structures of the airship/spacecraft to control the descent of the airship/spacecraft;
- (h) maintaining a tangential velocity approximately that of the location of the destination on the planet's surface due to rotation of the planet during descent, so that the descent is vertical;
- (i) retrofiring of thrusters to augment buoyancy force to land the airship/spacecraft at the location of the destination on the planet's
- 40 surface.
- Claim 91. The method for suborbital travel between two surface locations on a planet with an airship/spacecraft of Claim 90, wherein the planet is the earth.
- Claim 92. A method for travel to the surface of a planet from an orbit about the planet with an airship/spacecraft, comprising the steps of:
- 45 (a) retrofiring and directing thrusters so that the airship/spacecraft travels on a trajectory to a point above the location of the

- 1 destination on the planet's surface at which the airship/spacecraft has neutral buoyancy and a tangential velocity approximately
that of the location of the destination on the planet's surface due to rotation of the planet;
(b) reducing the tangential and descent velocities ;
(c) regulating the buoyancy of the gas retaining structures of the airship/spacecraft to control the vertical descent of the
5 airship/spacecraft;
(d) maintaining a tangential velocity approximately that of the location of the destination on the planet's surface due to rotation
of the planet during descent, so that the descent is vertical;
(e) retrofiring of thrusters to augment buoyancy force to land the airship/spacecraft at the location of the destination on the planet's
surface.
- 10 Claim 93. The method for travel to the surface of a planet from an orbit about the planet with an airship/spacecraft of Claim 92,
wherein the planet is the earth.
- Claim 94. An airship/spacecraft comprising:
one or more gas retaining structures;
one or more gas retaining structures each further comprising a buoyancy lifting capacity control system;
15 one or more gas retaining structures each further comprising a pressure vessel designed to sustain a pressure differential
between its interior and its surroundings;
a spacecraft body connected to one or more gas retaining structures;
one or more lifting gases;
one or more thrusters fueled with a lifting gas;
20 a means of supplying a lifting gas from one or more gas retaining structures to one or more thrusters; and
one or more ballast exhaust gas thrusters.
- Claim 95. An airship/spacecraft comprising:
one or more gas retaining structures;
one or more gas retaining structures each further comprising a buoyancy lifting capacity control system;
25 a spacecraft body connected to one or more gas retaining structures;
one or more lifting gases;
one or more thrusters fueled with a lifting gas;
a means of supplying a lifting gas from one or more gas retaining structures to one or more thrusters; and
one or more ballast exhaust gas thrusters.
- 30 Claim 96. An airship/spacecraft comprising:
one or more gas retaining structures;
one or more gas retaining structures each further comprising a buoyancy lifting capacity control system;
a spacecraft body connected to one or more gas retaining structures;
one or more lifting gases;
35 one or more thrusters fueled with a lifting gas; and
a means of supplying a lifting gas from one or more gas retaining structures to one or more thrusters.

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