July 9, 1929. T. B. SLATE 1,720,382

FIREPROOF DIRIGIBLE AIRSHIP

Filed April 28, 1926 2 Sheets-Sheet 1

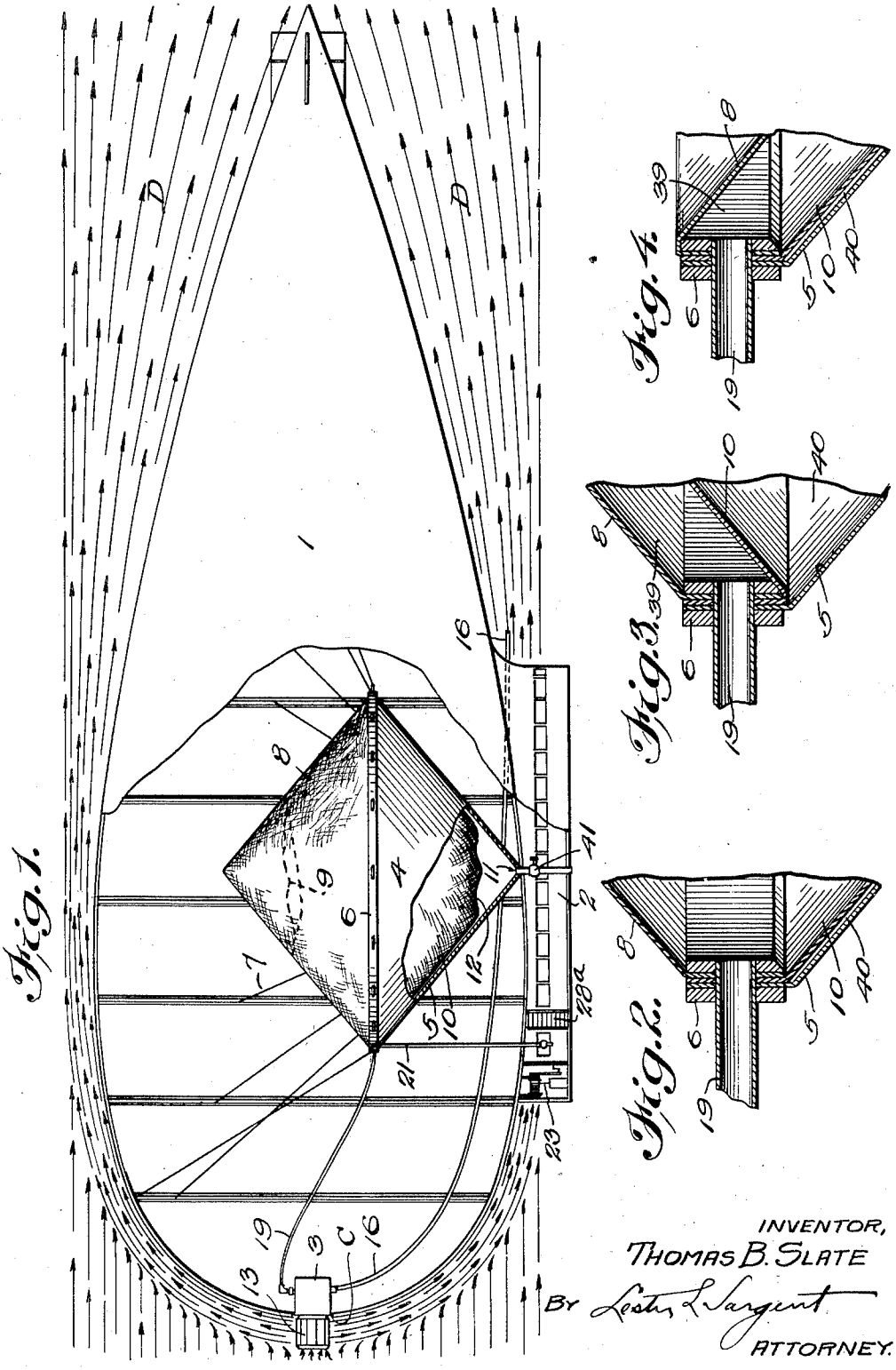


Fig. 1.

Fig. 4.

Fig. 3.

Fig. 2.

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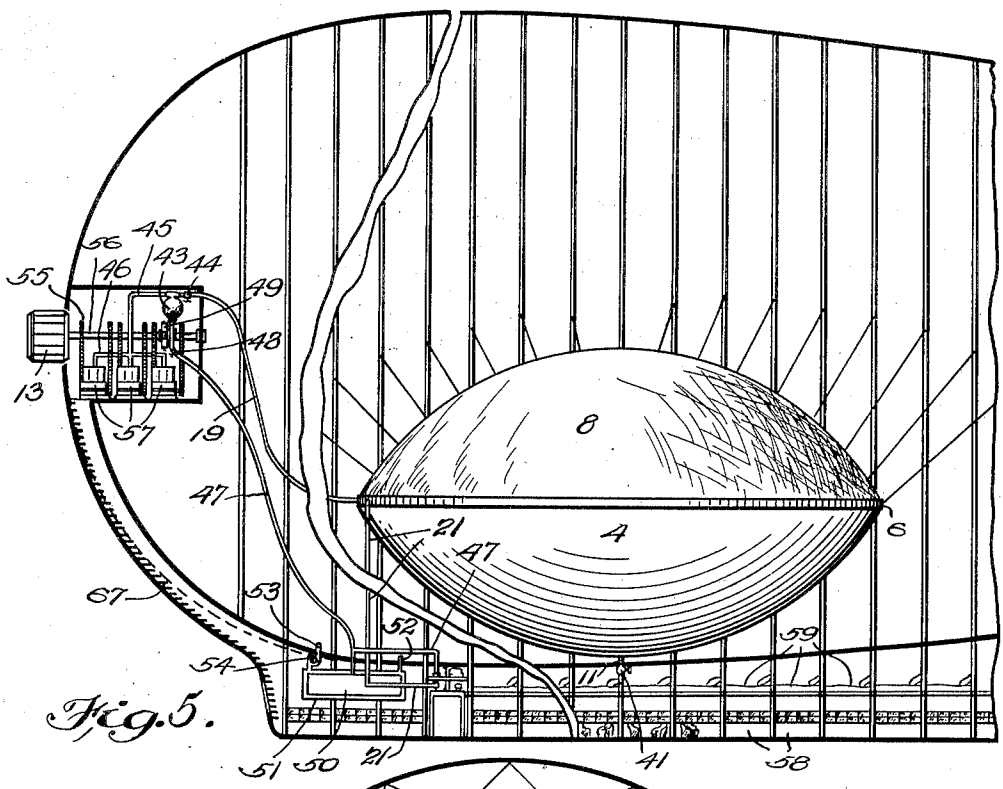


Fig. 5.

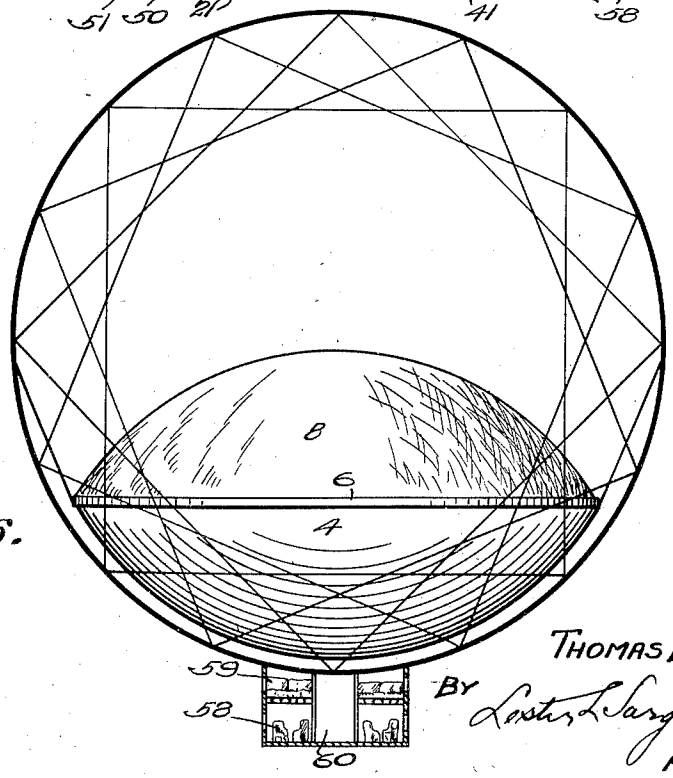


Fig. 6.

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UNITED STATES PATENT OFFICE.

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FIREPROOF DIRIGIBLE AIRSHIP.

Original application filed July 23, 1925, Serial No. 45,649. Divided and this application filed April 28, 1926. Serial No. 105,279.

This application is a division of my application Serial 45,649, filed July 23, 1925, for an airship.

The object of my invention is to provide a novel means for controlling gas expansion and contraction due to changes in atmospheric pressure in various altitudes and to changes of temperature of gases within the airship.

It is a further purpose of my invention to provide a compensation bag that is stationary with the center of buoyancy of the ship and which will not float toward the lower end of the ship and change or affect the balance of the ship by allowing one end to get slightly lower than the other, thereby making the ship entirely rigid so far as air displacement is concerned, and causing it to float on an even keel of its own accord for the reason that when one end is lower than the other it is displacing a denser atmosphere than the higher end of the ship, thereby effecting greater lift and causing the ship to float back to an even keel.

It is a further object of my invention to provide a ship with liquefied hydro-carbon fuel at a temperature and under a pressure that will make large quantities of fuel vapor available at any time that any emergency may require its use, whereby to utilize the vapor expansion as a motive power for starting the ship's engines and for other purposes required by the operators of the ship.

It is also an object of my invention to provide a ship having its fuel supply carried partly in vapor form, the proportion of vapor to liquid being under the control of the operator to reduce the weight of the total fuel supply and to control the balance of gross lift of the ship over the gross weight of ship and cargo.

It is also my object to provide novel means of utilizing the space occupied by the compensation bag for fuel vapor to supply the power to drive the ship.

I attain the objects of my invention by the apparatus illustrated in the accompanying drawings, in which:—

Figure 1 is a diagrammatic view of my invention, partly in side elevation and partly in section, with the direction of air currents indicated by arrows;

Fig. 2 is an enlarged detail view in section of the compensation bag with its central compartment inflated.

Fig. 3 is a similar view with the central compartment of the compensation bag deflated;

Fig. 4 is a similar view with the compensation bag as a whole deflated;

Fig. 5 is a longitudinal section through a larger ship than that shown in Fig. 1, showing a plurality of engines attached to the same propeller, partly in elevation and showing a compensation bag of modified shape;

Fig. 6 is a transverse section through an airship of the type shown in Fig. 5.

Like numerals designate like parts in the respective views.

Referring to the accompanying drawings, I provide an airship shell or covering 1 of a suitable light metal approximately of the shape shown in Fig. 1 and having a passenger and freight compartment 2 extending longitudinally of the shell; and a power plant compartment 3 positioned at the forward end of the ship.

I provide a compensation bag 4 mounted at the center of buoyancy of the airship, immediately over the passenger and freight compartment. This device consists of a funnel-shaped outside cover 5 extending from the bottom of the ship to a stationary ring 6 which is suitably braced by the suspension wires 7 attached to the ribs or wall of the airship so that the outside cover always keeps the same position in the ship as shown. Within the rigid shell 5 is a flexible gas bag, the flexible portion or diaphragm 10 of which is contained within the shell 5 and the upper flexible portion or diaphragm 8 of which, when inflated, extends above the ring 6 to form an inverted funnel-shaped bag. As shown in Figs. 2, 3 and 4, a space 40 is provided between the lower portion 10 of the flexible gas bag and the rigid shell 5.

I provide a gas compartment 39, which may be filled with a power gas such as natural gas, coal gas, or water gas, preferably natural gas or any other gas rich in heat units and lighter than air. The purpose of this gas compartment is to utilize the space occupied by the compensation bag to carry the fuel supply for the ship. The lower and outer funnel-shaped cover 5 of the compensation bag is provided with an outlet 11 communicating with the atmosphere to allow air to breathe in and out in connection with chamber 40 between the diaphragm 10 of the flexible compensation bag and the rigid outer

cover 5 to cause the diaphragm 10 to contract or expand as at 12. Outlet 11 is preferably provided with a valve 41. Upper diaphragm 8 of the compensation bag will occupy practically its full position as indicated in Fig. 1 when the ship is at anchor near the ground. At the end of a long trip the fuel gas between the lower diaphragm 10 of the compensation bag and the upper diaphragm 8 will have been mostly used up, and the lower diaphragm 10 of the compensation bag will have risen to and occupy the position indicated approximately by the dotted lines 9, as shown in Fig. 1, and its relation to ring 6 will be as shown in Fig. 3. When the ship takes a new supply of fuel gas the diaphragm 10 of the compensation bag will drop approximately to the position shown in Fig. 1 and in Fig. 2 with its lower portion at 12 and the ship will be ready for another trip.

I provide suitable engines 57 in the power plant compartment 3. I provide an intake pipe 19 in connection with the interior of the flexible compensation bag as shown in Figs. 2, 3 and 4. Referring to Fig. 1, I provide a valve-controlled re-filling pipe 21 in connection with the same compartment as pipe 19.

Referring to Fig. 8, I preferably provide a pulsating bag 43 in communication with the fuel supply pipe 19 and with the pipe 45 leading to the manifold 46 of engines 57. A valve 44 is provided in pipe 19, as shown. Engines 57 are operatively connected with fan shaft 56 by the chains 55. The fan shaft also carries the starting motor 49 which is operated by the fuel pressure passing through pipe 47 from the liquefied gas pressure tank 50. Tank 50 is surrounded by a suitable insulating jacket 51. Jacket 51 is provided with vents 52 and 53 and a circulating fan or blower 54 is provided in the path of one of these vents.

As shown in Fig. 8, I provide a passageway 67 having suitable steps or ladder to afford convenient access to the engine room.

Referring to Fig. 6, the car 2 is provided with passenger compartments 58 and sleeping berths 59 and a central aisle 60.

The ship is supplied with fuel vapor such as natural gas, water gas, or any high grade manufactured gas, by filling the fuel gas compartment 39 with the vapor through pipe 21; or by liquefying the gas and filling tanks 50, illustrated in Fig. 8. The liquid is reduced in temperature until its vapor tension is at from 100 pounds to 200 pounds per square inch, or any other convenient pressure to be used through an expansion engine or starting motor 49. This motor on a large ship may be mounted directly on the fan shaft, to which is geared a number of internal combustion engines of ordinary aircraft design or any other light and powerful type of heat engine adapted to aircraft service. The excess gas from the starting engine is piped to the main gas line from the compensation bag to the engine so that the excess gas from the starting engine may flow directly to the manifold to supply the engines. Any surplus quantity of gas can flow back to the compensation bag as a storage supply. This may be regulated at the will of the operator by allowing full pressure to flow through the engine delivering power directly to the fan shaft and filling up the compensation bag, thereby driving air out of the compensation bag through outlet 11 and past valve 41 to the atmosphere. The fuel vapor being lighter than air has a tendency to cause the ship to rise. By throttling the supply of gas to the engine down to a point below that necessary to supply the main engines with fuel will cause them to draw on the supply of gas in the compensation bag, sucking in air to take its place, thereby making the ship heavier and causing it to descend. If a great volume of gas is required momentarily it may be had by opening the throttle valve 48 wide and allowing the pressure in tank 50 to decrease. If a large volume is required over a considerable period of time the rate of evaporation in tank 50 may be increased by circulating hydrogen from the main bag or chamber of the ship through conduit 53 by means of fan 54 and out through conduit 52.

The circulation of the main volume of hydrogen through the insulation of tank 50 into temperatures below the freezing point will freeze out moisture and other impurities collecting in the main volume of hydrogen. By equipping the ship with a plurality of tanks 50, a tank may be allowed to run empty occasionally and thaw the collection of ice and other impurities from the jacket. By this means a very pure supply of hydrogen is maintained in shell 1. The pipe 19 is equipped with a valve 44 and the opening 11 is equipped with a valve 41. In case of leakage or a puncture in the diaphragm 10 of the compensation bag, the valve 41 may be closed and the compensation bag controlled by valve 44 to maintain approximately atmospheric pressure within the ship. Or valve 44 may be closed and valve 41 left open, allowing both compartments in the compensation bag to fill with air, compensation in weight being thus obtained automatically without the use of the compensation bag as a storage chamber for fuel vapor. Either of these methods of operation may be used in emergency if leakage or other difficulty in operation of the compensation bag occurs.

At landing stations a fresh supply of liquid gas is taken aboard the ship as a cold liquid under little if any pressure and the tanks 50 are filled and sealed so that as the temperature rises they will build up a pressure to the point necessary for the operation of the system. The rate of evaporation may be increased by the circulation of the ship's

hydrogen through the insulation of the tanks to keep the necessary amount of pressure. While the ship is standing at the station and the engines running only under partial capacity to hold the ship in a practically stationary position against whatever amount of wind there may be at the time, the liquid fuel is being vaporized and the large amount of air space in the compensation bag is being displaced with fuel vapor which tends to make the ship lighter.

When the airship is ready to leave a landing station a volume of fuel gas will be evaporated from its liquid state and run into the compensation bag, driving out a large volume of air from the bag and resulting in increased buoyancy of the airship and the ship starts on its journey from the point indicated as A in Fig. 5. The increased buoyancy resulting from the extra supply of fuel vapor in the compensation bag will cause the ship to rise to a higher flying level as indicated diagrammatically by B in Fig. 9. When it is desired to have the ship descend the evaporation of the liquid fuel gas is slowed down by the operator to a point where the engines are using the reserve fuel vapor from the compensation bag and a volume of air to take its place is admitted to the bag through vent or pipe 11. This decreases the buoyancy of the ship and results in a natural descent to the next station or depot as indicated at D in Fig. 9.

The conduits 11 and 19 to the compensation bag are equipped with valves 41 and 44 which enable the operator to control the flow of fuel vapor to the engines and the intake of air to the compensation bag as shown in Fig. 8. In emergency, control of the ship may be maintained as follows: If diaphragm 8 should develop a leak, valve 44 may be closed and use of the fuel vapor compartment discontinued temporarily and the ship will get its compensation automatically by air flowing in and out through pipe 11. If the compensation bag lower diaphragm 10 should develop a leak, valve 41 can be closed and compensation effected completely with the fuel vapor through pipe 19. Or valve 44 may be closed and the entire space occupied by air and fuel vapor in the compensation bag be filled with air to effect compensation automatically through pipe 11.

Motors 34 and 31 used in the elevator system are preferably turbine operated from the fuel vapor of the liquid vapor system, thereby lightening the weight of the machinery and improving the control over the buoyancy of the ship. The exhaust from the turbines is piped to the fuel vapor compartment of the compensation bag. The value of the turbine is that a predetermined amount of tension may be placed on guide wires 35 and the ship allowed to change position up and down and the motor caused to back up by increased tension on the wires or to take up with decreased tension on the wires without the attention of the operator, maintaining the proper length of elevator cable at all times.

The entire ship is metal and noninflammable and the main shell or casing 1 may therefore be filled with hydrogen gas and be practically as safe as it would be with helium. Compensation for gas expansion in the ship is cared for by a fixed compensation bag in approximately the center of lift and in the lower half of the ship. This causes the ship to stand on an even keel of its own accord by reason of the fact that the ship is entirely rigid and if one end should occupy a position lower than the other it will be displacing heavier air and thereby have its lifting power at that end increased, while the other end displacing lighter air will have its lifting power decreased.

I provide suitable cross-bracing wires 14 affixed to the rings 66. This type of airship may be cross-braced in its cross-section by cross-bracing from one side to the other by staggered spokes as in a bicycle wheel with what would correspond to the hub of the wheel being of considerable length, and further braced longitudinally by crossing braces from one ring to another throughout the length of the ship, except the small portion occupied by the compensation bag.

What I claim is:

1. In an airship of the lighter than air type, the combination with an airship hull, of a compensation bag positioned in the lower portion of the ship at the center of buoyancy said compensation bag including a rigid cup-shaped member mounted in a fixed position in the lower portion of the airship, a flexible bag mounted in and attached to the upper edge of the aforesaid rigid cup-shaped member and providing a chamber between the aforesaid members, a conduit for supplying a fuel gas to the flexible bag, and a conduit for the flow of air to and from the chamber between the rigid cup-shaped member and the lower portion of the flexible bag.

2. In an airship of the lighter than air type, the combination of a rigid shell of noninflammable material forming the main hull, a compensation bag positioned in the lower portion of the ship at the center of buoyancy, said compensation bag including a rigid cup-shaped member mounted in a fixed position in the lower portion of the airship, a flexible bag mounted in and attached to the upper edge of the aforesaid rigid cup-shaped member and providing a chamber between the aforesaid members, a conduit for supplying a fuel gas to the flexible bag, and a conduit for the flow of air to and from the chamber between the rigid cup-shaped member and the lower portion of the flexible bag.

3. In an airship of the lighter than air type, the combination with an airship hull, of a compensation bag positioned in the lower

portion of the ship at the center of buoyancy, said compensation bag including a rigid cup-shaped member mounted in a fixed position in the lower portion of the airship, a flexible bag mounted in and attached to the upper edge of the aforesaid rigid cup-shaped member and providing a chamber between the two members, a conduit for supplying fuel gas to the flexible bag, a valve-controlled conduit for the flow of air to and from the chamber between the rigid cup-shaped member and the lower portion of the flexible bag, means for propelling the airship, and valve-controlled means for supplying fuel gas from the compensation bag to operate the propelling means.

4. In an airship of the lighter than air type, the combination of a rigid shell of non-inflammable material forming the main hull, a compensation bag positioned in the lower portion of the ship at the center of buoyancy, said compensation bag including a rigid cup-shaped member mounted in a fixed position in the lower portion of the airship, a flexible bag mounted in and attached to the upper edge of the aforesaid rigid cup-shaped member and providing a chamber between the two members, a conduit for supplying fuel gas to the flexible bag, a valve-controlled conduit for the flow of air to and from the chamber between the rigid cup-shaped member and the lower portion of the flexible bag, means for propelling the airship, and valve-controlled means for supplying fuel gas from the compensation bag to operate the propelling means.

5. An airship of the lighter than air type having a compensation bag permanently fastened at the center of buoyancy of the airship, the lower half of the bag being a rigid shell.

6. In an airship of the lighter than air type, the combination of a compensation bag having its lower half formed of a rigid shell affixed at the center of buoyancy of the airship and having the upper half of the compensation bag of flexible material adapted to float up or down to compensate for variation in pressure inside the ship depending on variation in atmospheric pressure outside the ship, and having a passage at its lower extremity communicating with the outside atmosphere.

7. In combination with the apparatus disclosed in claim 6, a flexible diaphragm placed inside the compensation bag between the upper and lower half thereof to provide an air-tight chamber for the reception of fuel gas.

8. In combination with an airship of the lighter than air type, a compensation bag having its lower half formed of a metallic fire-proof shell permanently fastened at the center of buoyancy of the ship, and a plurality of flexible diaphragms affixed in spaced relation to the metal shell near the edge thereof whereby to provide a plurality of chambers in the compensation bag.

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