

- 1 -

LIGHTER-THAN-AIR AIRCRAFT WITH AIR CUSHION LANDING GEAR MEANS

5

This invention relates to an aircraft of the kind having a hull filled with lighter than air gas (hereinafter referred to as a "lighter-than-air aircraft") and a pair of retractable landing gear means arranged so as to be spaced apart on either side of longitudinally extending central vertical plane of the aircraft. In particular, but not exclusively, the
10 invention relates to airships such as non-rigid airships.

Known lighter-than-air aircraft in the form of airships have wheels on the underside of the hull to facilitate the landing and taking off of the airship. Such wheels
15 are in lowered positions when in use for landing and taking off but may be retracted when the airship is in flight to reduce drag. It has also been proposed to provide a lighter-than-air aircraft, in the form of a hybrid air vehicle which combines the characteristics of an airplane, a lighter-than-air airship and a hovercraft, with laterally spaced apart longitudinally extending air cushion landing gear units. These landing gear
20 units support the hull on cushions of air, normally bounded by so-called "skirts", but are not designed to retract in use.

WO 01/72588 discloses a lighter-than-air aircraft according to the preamble of
25 claims 1.

The present invention seeks to provide a lighter-than-air aircraft fitted with retractable air cushion landing gear means.

30

According to the present invention there is provided a lighter-than-air aircraft having a gas-filled hull and a pair of spaced apart landing gear means on the underside

- 2 -

of the hull arranged on opposite sides of a longitudinally extending central vertical plane of the hull, each landing gear means comprising an air cushion unit including bag skirt means and means for supplying air to and removing air from the bag skirt means, characterised by each landing gear means further including actuating means operable to
5 move the bag skirt means between an operative configuration for containing one or more air cushions and an inoperative configuration, wherein the bag skirt means of each air cushion unit comprises first and second bag skirts extending along opposite sides of the air cushion unit and provided with engageable and disengageable connecting means, and the actuating means is operable to connect the connecting means together in the
10 inoperative configuration of the bag skirt means and to disconnect the connecting means when the bag skirt means are moved into their operative configuration. Each bag skirt comprises a first inflatable and deflatable bladder means secured to the underside of the hull, the first bladder means having a second inflatable means extending below the first bladder means when all of the bladder means are inflated. Preferably the bag skirt
15 means of the two air cushion units, when in their operative configurations, are inflated and extend downwardly from the underside of the hull to define downwardly open air cavities in which the air cushions are created and when in their inoperative configurations are positioned closer to the underside of the hull.

20 By positioning the bag skirt means closer to the underside of the hull when in their inoperative configurations the air cushion units are drawn or collapsed towards the underside of the hull and provide the lighter-than-air aircraft with a more streamlined shape.

25 In its simplest form the connecting means comprise connections of a zip fastener or the like, the actuating means moving a slider portion to engage or disengage rows of teeth on the first and second bag skirts. Each bag skirt means, in addition to the
30 longitudinally extending and spaced apart bag skirts, may include longitudinally spaced apart transverse skirts extending between the bag skirts and providing with the bag skirts at least one air cavity.

- 3 -

The means for supplying and removing air to the bag means is intended to fully inflate the bladder means in the operative configurations of the bag skirt means with air being fed at the same time into the air cavities to provide the air cushions. As is conventional in hovercraft design, the air fed into the inflated bladder means may be allowed to escape, e.g. through holes on the inside edge of the bladder means, into the air cavities. When the bag skirt means are moved to their inoperative configurations, the bladder means are at least partially deflated and the actuating means are operated to draw together, and connect together, the at least partially deflated bladder means. When joined together the space enclosed by the connected together, at least partially deflated, bladder means may be partly filled or inflated with air to stabilize the cushion unit. In this "collapsed" condition the outside envelope provided by the bladder means is positioned closer to the hull than the bladder means when in their operative positions.

Conveniently each bag skirt may have a curtain type skirt suspended therefrom.

Embodiments of the invention will now be described, by way of example only, with specific reference to the accompanying drawings, in which:

Figures 1 to 4 are schematic views from the front, the rear, one side and below of a lighter-than-air aircraft according to the present invention;

Figures 5-7 are schematic views illustrating three positions of an air cushion unit of the aircraft shown in Figures 1 to 4 moving from an operative position to an inoperative position;

Figure 8 is a schematic view illustrating an alternative design of air cushion units; and

Figure 9 illustrates schematically how air is supplied into, or withdrawn from, the inside of one of the bladder means of an air cushion unit.

- 4 -

Figures 1 to 4 show a lighter-than-air aircraft according to the invention generally designated by the reference numeral 1. The aircraft is in the form of a pressure-stabilised, preferably non-rigid having a hull 2 with a flattened, generally elliptical cross-section throughout most of its length. The hull 2 is formed of two longitudinally extending side lobes 3 and 4 and is made from reinforced sheet material, e.g. a high strength laminated fabric. The lighter-than-air gas within the hull is conveniently helium.

The sheet material from which the hull is formed is cut into precise, flat shapes which are bonded together to provide the precise curved shape of the hull. When the lobes are filled with helium the pressure stabilized hull is formed having a camber along its length. The two side lobes 3 and 4 are in effect joined, or positioned close together, at the underside of the hull and define a central longitudinal concave surface or recess 9 along the length of the hull. The inflated hull is of a flattened form and has a generally aerodynamic shape which is able to provide aerodynamic lift to the aircraft. Typically, with the design illustrated, approximately one-quarter to one half of the aircraft lift is provided aerodynamically through its lifting body shape and approximately one half to three-quarters of the aircraft lift is provided by the buoyancy of the hull gas, e.g. helium. In longitudinal section, the hull has a generally greater convexity on the top side than on the underside.

The underside of the air vehicle 1 includes a longitudinally extending gondola or payload module 10 positioned in the recess 9 and air cushion landing gear units 11 and 12 on the hull lobes 3 and 4, respectively. The positioning of these units is facilitated by the generally flatter underside of the hull along the length of the hull, at least in a central portion of the hull where these units are located. Each landing gear unit typically comprises a flexible outer skirt defined by spaced apart inflatable bag skirts secured to the underside of the hull 2 and comprising first bladder means 5, 5' along opposite sides of each unit. The space between the first bladder means 5 and 5' is partitioned by three longitudinally spaced apart and flexible transverse skirts 6 to define two air cavities 7

- 5 -

and 7'. Each of the bladder means 5, 5' has long its length second inflatable bladder means 20, 20' extending below the first inflatable bladder means when all of the bladder means are inflated, the second bladder means having along their length interengageable connecting means in the form of engageable teeth of a zip-type fastener. The
5 connecting means are joined at one end by a sliding member (not shown) of a zip-type fastener which is movable by actuating means (not shown) along the length of the landing gear unit to draw the connecting means together and to interlock and connect them together. On movement of the sliding member back to its original position, the connecting means 20, 20' are disconnected from each other. Thus the bladder means 5
10 and 5' can be "zipped" together or "unzipped" as required.

In use the bladder means 5, 5', when in operative configurations, are not connected or "zipped" together and are inflated. Air is supplied to the air cavities 7, 7' to
15 provide air cushions for supporting the air vehicle during landing, taking-off and taxiing procedures. The air supplied to the inflated bladder means 5, 5' may be allowed to escape from inside edges of the latter directly into the air cavities 7, 7' to provide the air cushions. Alternatively or in addition air may be supplied independently into the air cavities. The operative configuration of one of the landing gear units is shown
20 schematically in Figure 5.

When in flight the bladder means 5, 5' may be at least partially deflated and then connected or "zipped" together (see Figure 6) so as to be shown closer to the underside
25 of the hull 2. The space 21 defined inside the joined together bladder means 5, 5' may be partially inflated (see Figure 7) to stabilize the air cushion landing gear unit in its inoperative condition. In their inoperative configurations the landing gear units are "flattened" towards the underside of the hull 2 and provide a more streamlined profile than when in their operative configurations. In other words the air cushion landing gear
30 units when the aircraft is in flight provide a more efficient aerodynamic surface offering less drag.

- 6 -

Figure 9 illustrates schematically how one of the bladder means 5 may be inflated and deflated. As shown two cavities 40 and 41 are housed within, so as to be sealed from, the hull 2 and communicate with the inside of the bladder means 5. By selective operation of fans 42 and 43 driven, for example, by reversible 100 hp motors housed within the cavities 40 and 41, respectively, air can be pumped into and out of the bladder means 5. In particular in the operative configuration, the fan 42 is operable to supply air from outside into the bladder means 5 to inflate the latter. At the same time air may be allowed to pass through the cavity 41, possibly regulated by the fan or valving means (not shown), into the air cavity 7 to provide an air cushion within the air cavity. In the inoperative configuration, either or both of fans 42 and 43 could be operated to remove air from, thereby at least partially deflating, the bladder means 5. When the two bladder means 5, 5' are connected or "zipped" together, the space between the connected together bladder means and the underside of the hull can be partially pressurized by selective use of the fans 42 and 43 to prevent the bladder means from flapping.

When the bladder means are pressurized, air may be rapidly exhausted from each air cavity so that a suction or hold-down force is applied to hold the aircraft down in position on the ground. This suction may be created by operating the fans 42 and 43 so that air is pumped from the air cavities into each of the bladder means 5 and 5'. The relatively widely spaced apart air cushion landing gear units 11, 12, combined with the low height of the hull 2 compared with its length, give the aircraft a high degree of stability when landed enabling elaborate tie-down systems to be dispensed with (although less elaborate tie-down systems may be required in addition to the suck-down air cushion landing gear units).

In each of the Figures 1 to 4 landing gear unit 11 is shown with its bladder means pressurized and landing gear unit 12 is shown with its bladder means depressurized. In practice, of course, the bladder means of the two landing gear units 11, 12 would be either both pressurized or both depressurized.

- 7 -

Figure 8 illustrates how the landing gear units 11 and 12 may be arranged to provide good line of sight for an operator within the payload module 10 in the form of a gondola. Each landing gear unit 11, 12 may be formed of low pressure bag skirts 50 nearest to the gondola and high pressure bag skirts 51 furthest from the gondola. This enables the bag skirt 50 to have a lower profile than that of the bag skirt 51 so as not to obstruct the line of vision from the gondola.

A particular advantage of the use of air cushion landing gear units 11, 12 is that the air vehicle can land and take-off from any reasonably flat surface, including unimproved raw land, swamps, marshland and water, e.g. sea. A special runway is not required as with aircraft having wheeled undercarriages. Furthermore cross-wind landing gear drag is reduced or eliminated. In flight drag is considerably reduced by retraction of the landing gear units. The landing gear units 11 and 12 are positioned widely apart to provide the air vehicle with stability during landing and take-off.

The rear end of the air vehicle is formed by the spaced apart ends of the two side lobes 3 and 4. Motors 13 and 14 are mounted at the stern of the lobes 3 and 4, respectively, and these motors may be designed to control vertical and horizontal movements. Additional motors 15 and 16 are mounted on each side of the hull and are preferably mounted to swivel to provide vertical and horizontal vectoring. The use of vectored thrust engines positioned to allow vertical thrust vectors to act through the centres of gravity and pressure of the hull, enables vertical landing and takeoff of the air vehicle.

Towards the rear end of the hull, four angled stabilizing fins 17-20 are arranged.

In use when the aircraft lands and the air within the air cavities is released and suction applied to hold the air aircraft down, the aircraft will settle down gently bringing

- 8 -

the payload module 10 close to the ground. The module suitably has a let down ramp (not shown) to allow wheeled vehicles to drive into and off from the payload module in the manner of a roll on / roll off container ship or the like. The low hull height relative to length, coupled with suction provided by the air cushion landing gear units, give the air
5 vehicle a high degree of stability on ground and ease of ground handling.

The aircraft is designed to be able to transport large loads safely over long distances. By way of example, the aircraft described and illustrated typically has a length
10 of 307 m, a height of 77 m and a width of 136 m. Such an aircraft has a hull envelope volume of 2,000,000 m³, a range of 4,000 nautical miles and a flying altitude of up to 9,000 feet. The aircraft typically has a cruise speed of 100 KTAS and a maximum speed of 110 KTAS. The payload is 1,000,000 kg with a deck space 80 m long, 12 m wide and
15 8 m high. Smaller versions can be constructed, for example down to payloads of less than one tonne.

CLAIMS

1. A lighter-than-air aircraft (1) having a gas-filled hull (2, 3, 4) and a pair of spaced apart landing gear means (11, 12) on the underside of the hull arranged on opposite sides of a longitudinally extending central vertical plane of the hull, each landing gear means comprising an air cushion unit including bag skirt means (5, 5', 20, 20') and means for supplying air to and removing air from the bag skirt means characterised by each landing gear means further including, actuating means operable to move the bag skirt means between an operative configuration for containing one or more air cushions and an inoperative configuration, wherein the bag skirt means of each air cushion unit comprises first and second bag skirts extending along opposite sides of the air cushion unit and provided with engageable and disengageable connecting means, and the actuating means is operable to connect the connecting means together in the inoperative to connect the connecting means together in the inoperative configurations of the bag skirt means and to disconnect the connecting means when the bag skirt means are moved into their operative configuration and each bag skirt comprises a first inflatable and deflatable bladder means (5, 5') secured to the underside of the hull, the first bladder means having a second inflatable bladder means (20, 20') extending below the first bladder means when all of the bladder means are inflated.
2. An aircraft according to claim 1, characterised in that the bag skirt means of the two air cushion units, when in their operative configurations, are inflated and extend downwardly from the underside of the hull to define downwardly open air cavities in which the air cushions are created and, when in their inoperative configurations, are positioned closer to the underside of the hull.
3. An aircraft according to claim 1 or 2, characterised in that the connecting means comprise connections of a zip-type fastener or the like, the actuating means

- 10 -

moving a slider portion to engage or disengage rows of teeth on the first and second bag skirts.

4. An aircraft according to claim 1, 2 or 3, characterised in that said means for supplying and removing air to the bag means is intended to fully inflate the bladder means in the operative configurations of the bag skirt means with air being fed at the same time into the air cavities to provide the air cushions.
5. An aircraft according to claim 4, characterised in that means are provided for the escape of air supplied to the bladder means into the air cavities.