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Schellin

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[54] **METHODS AND DEVICE FOR GENERATING LIFT**

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[51] **Int. Cl.** **B64c 29/02**

[58] **Field of Search** .... 244/12 R, 12 C, 17.11, 244/23 R, 23 C, 73 B, 73 C; 416/120, 124, 171; 415/147

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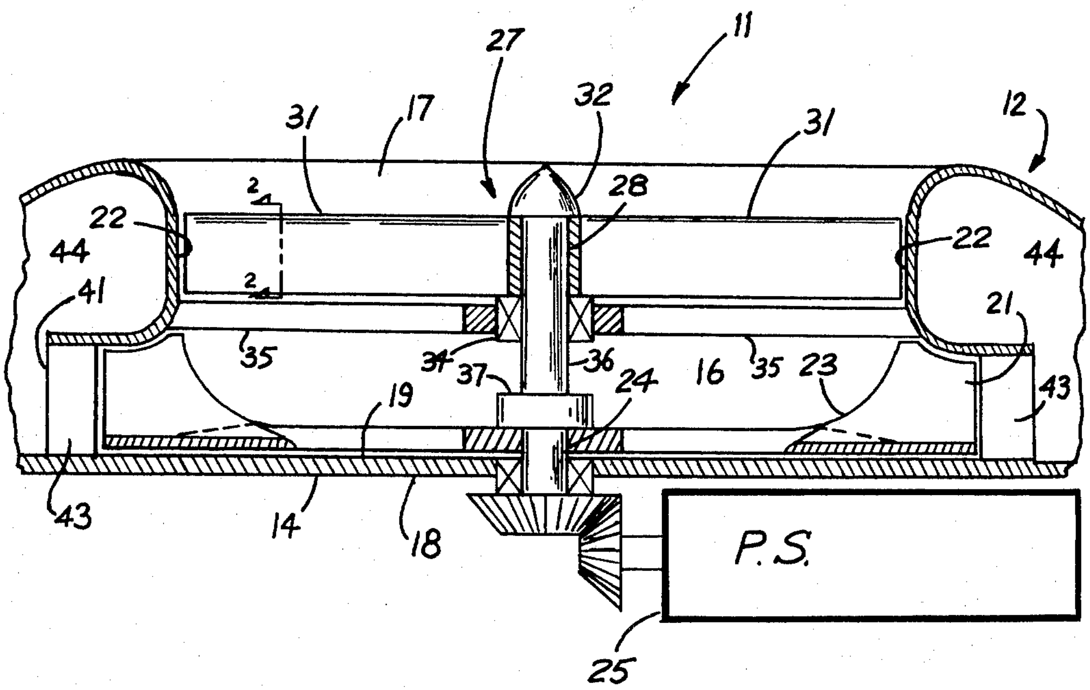
[57] **ABSTRACT**

Lift is generated on a lift plane by exposing the underside of the plane to atmospheric air and its pressure. The top surface of the lift plane is partially enclosed by walls forming a chamber with the lift plane. First and second openings in the walls of the chamber permit a flow of air therethrough. Provision is made to establish a flow of air through the chamber. As air enters the chamber, energy is transferred from the air to a turbine to reduce the pressure of the air entering the chamber, thereby reducing the air pressure exerted against the top surface of the lift plane. The difference between pressures against the underside and the top surface of the lift plane amounts to a net lift force on the plane. The energy transferred to the turbine is applied to an impeller to aid in removing air from the chamber, and to aid in maintaining the air flow through the chamber.

7 Claims, 2 Drawing Figures



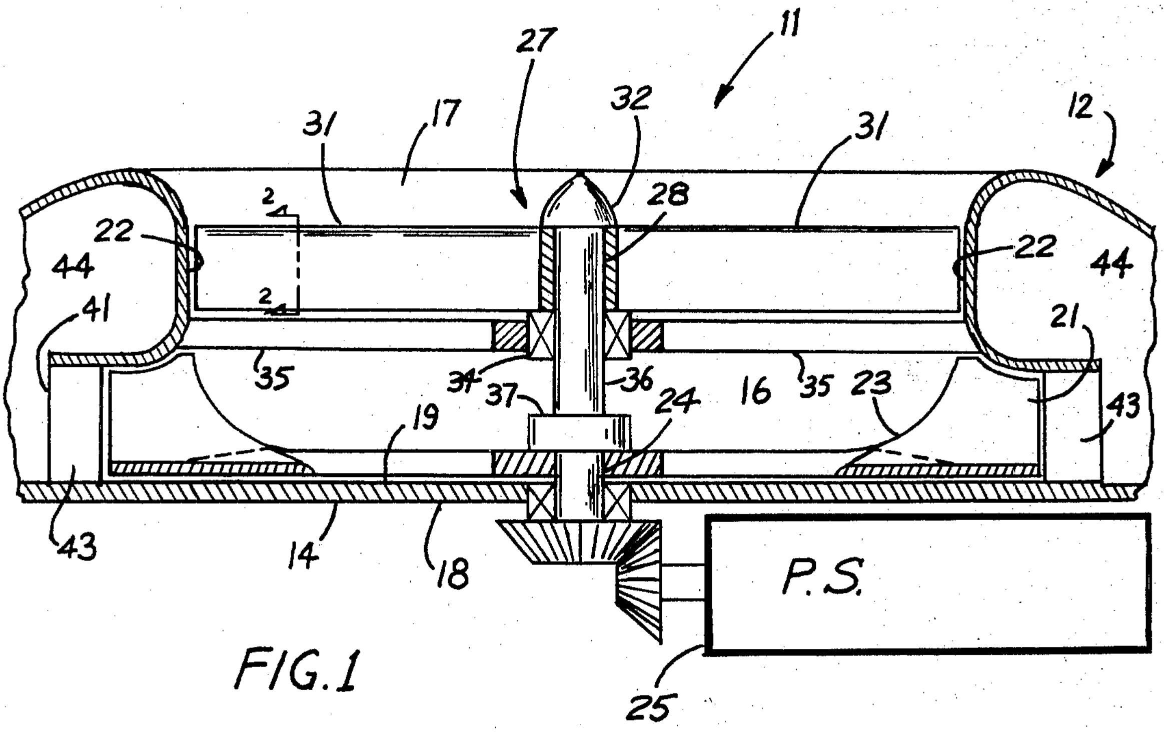

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FIG. 1

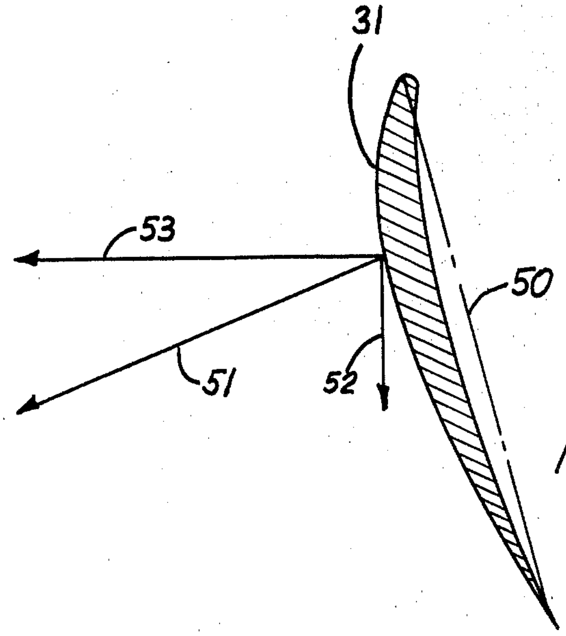
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FIG. 2

METHODS AND DEVICE FOR GENERATING LIFT

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to lift devices for aircraft, and particularly to devices which are capable of providing lift during short-roll and vertical take-offs and landings of aircraft.

2. Discussion of the Prior Art

Helicopters are well known for their vertical take-off and landing capabilities. Their rotating blades generate lift in the same manner in which wings of fixed-wing aircraft provide lift. In either case, air moves relative to airfoils, whether blades or wings, and generates a reduced air pressure against the top surfaces of the airfoils with respect to the pressure exerted against their bottom surfaces. The pressure differential results in net lift forces on the airfoils.

The generation of lift on airfoils is explainable by Bernoulli's Theorem. According to the theorem, the energy of a fluid, such as air, is made up of three separate energy heads: a potential head; a pressure head; and a velocity head. Each of these heads is convertible into any one of the others. In a mass of flowing fluid, the sum of the heads remains constant along the path of the fluid, provided there is no loss or gain of energy along the path due to external forces, such as energy transfers or friction losses.

In the case of air flowing over an airfoil, changes in the potential head become negligible because of the relatively small mass of air per volume of air involved. Thus, as the air rushes past the airfoil, the air on top of the airfoil is affected differently by the airfoil than the air below the airfoil. While the energy distribution in the air below the airfoil remains substantially unchanged, the energy of the air above the airfoil changes to some extent from a pressure head to a velocity head. The change decreases the pressure of air exerted against the top surface with respect to that against the bottom surface of the airfoil. Consequently, a lift force is generated on the airfoil.

When it is desired to obtain lift on aircraft for short-roll or vertical take-offs or landings the requirement of relative motion past an airfoil is disadvantageous. On a fixed-wing aircraft, of course, there is no relative motion of air over the wings when the aircraft is not moving; and, consequently, there is no lift generated. Helicopters, on the other hand, generate the necessary relative motion between the air and the airfoils by rotating the blades of their rotors about a vertical axis. The exposed blades of the rotors are vulnerable. They are also dangerous to objects in the vicinity of their path. Also, while helicopters are hovering, a back-flow turbulence is generated about the periphery of the path of the blades. This back-flow turbulence significantly reduces the lift capabilities of helicopters during hover flight operations. It is desired to alleviate or to overcome the discussed disadvantages of vertical lift generation.

SUMMARY OF THE INVENTION

According to the present invention, lift is generated on a lift plane by reducing the total energy or the total head of air on one side of the lift plane with respect to the head of the air on the other side of the lift plane.

A device in accordance with the invention includes a lift plane and a chamber enclosing a top surface of the lift plane. An opening is located in the walls of the chamber to permit air to enter the chamber. A provision is included for evacuating air from the chamber, causing a replenishing flow of air through the opening into the chamber. A provision for removing energy from the air is located in the path of air entering the chamber through the opening. As air enters the chamber through the opening, its energy level is reduced to render the air in the chamber at a lower energy level than the air outside the chamber. A difference between the energy levels of the air in contact with the top surface and an opposite bottom surface of the lift plane results in a pressure differential between the two surfaces to generate a lift force on the lift plane.

In another aspect of the invention the energy removed from the air entering the chamber is applied to aid the provision for evacuating the chamber.

BRIEF DESCRIPTION OF THE DRAWING

Advantages of the invention will become more apparent from the following detailed description and the accompanying drawing, wherein:

FIG. 1 is a cross-sectional view of a lift device representing an embodiment of the invention.

FIG. 2 is a view of a section 2—2 taken through one of the blades shown in FIG. 1, the view showing in addition a schematic diagram of forces acting on the blade.

DETAILED DESCRIPTION

In FIG. 1 a lift device is shown which is designated generally by the numeral **11.** The device **11** functions in an environment of a gas under pressure, such as atmospheric air, to generate a lift. The device **11** is normally incorporated into an aircraft structure, a portion of which is shown and designated generally by the numeral **12.**

A circular lift plane **14** of the device **11** is located at the base of a cylindrical chamber **16.** Opposite the lift plane **14,** a circular opening **17** connects the inside of the chamber with the environment of the device **11.**

A bottom surface **18** of the lift plane **14** is exposed to the environmental pressure on the outside of the chamber **16.** A top surface **19** of the plane **14** faces the chamber **16** and is, consequently, subjected to the pressure inside the chamber. Under static conditions the pressure inside the chamber **16** equals the environmental pressure, and the resulting forces against the bottom and top surfaces **18** and **19** are equal.

Another opening **21,** preferably in a side wall **22** of the chamber **16** permits air to be drawn from the chamber. The opening **21** is preferably an annular opening in the wall **22,** as shown, but it could also be located in the lift plane **14.**

A centrifugal fan or impeller **23** is associated with the annular opening **21.** The impeller **23** is mounted to a shaft **24** to rotate about an axis perpendicular to the lift plane **14** and to the opening **17.** The shaft **24** is rotatably supported in and extends through the lift plane **14.**

To evacuate air from the chamber **16** through the opening **21,** the impeller **23** is driven by a conventional power source **25,** such as an engine which may be coupled directly to the shaft **24.** The evacuation of air from the chamber **16** establishes a replenishing air flow through the opening 17 into the chamber. Within the scope of the impeller 23 and the power source 25 to function as a means for evacuating air from the chamber 16 through the opening 21, a number of variations in the impeller and the power source 25 are possible without departing from the scope of the invention. For example, the air may be evacuated from the chamber 16 by a conventional gas turbine (not shown), which has its air intake coupled to the opening 21 of the chamber 16. In this example, an additional power connection need not be made from the gas turbine to the impeller 23, since the replenishing flow of air into the chamber 16 is already established by the air flow into the gas turbine.

Lift is generated by removing or transferring energy from the air as it enters the chamber 16. A removal of energy from the entering air lowers the sum of the pressure and velocity heads. Consequently, the highest pressure of the air inside the chamber 16 is necessarily lower than the atmospheric pressure against the lower surface 18. Such a pressure differential results in a lift force in the direction of the lower pressure.

To transfer energy from the air as it enters through the opening 17, a turbine, designated generally by the numeral 27, is mounted in the opening 17. The turbine 27 is mounted on a shaft 28 extending substantially perpendicularly to the lift plane 14 and to the opening 17. A plurality of blades 31, two of which are shown in FIG. 1, is radially arranged and equally spaced about the shaft 28 to form a turbine wheel 32. FIG. 1 shows the turbine 27 as consisting of a single turbine wheel 32. Within the scope of this invention, the turbine 27 may include more than one turbine wheel 32 or stage; however, a single wheel is shown for clarity.

The shaft 28 is rotatably supported by a bearing 34 mounted in a supporting structure of radially oriented, aerodynamically shaped struts 35. The struts 35 may serve a double function in that they support the shaft and can also act as vanes to redirect the air flow leaving the turbine wheel 32.

An extension 36 of the shaft 28 couples the turbine 27 through a one-way clutch 37 to the shaft 24 of the impeller 23. The clutch 37 disengages the shaft 24 whenever the impeller 23 rotates faster than the turbine 27. However, the clutch 37 couples the shaft 28 to the shaft 24 whenever a torque from the turbine 27 permits the turbine to aid in driving the impeller 23.

A diffuser 41 annularly cages the impeller 23. The diffuser 41 reduces the velocity, and simultaneously increases the pressure, of air leaving the impeller 23, thus performing a function which is well understood in the art. A plurality of vanes 43 guide the air away from the impeller 23 and into exit ducts 44 which are part of the aircraft structure 12.

In operation, the impeller 23, driven by the power source 25, evacuates air from the chamber 16. Air leaves the chamber 16 through the opening 21 and enters the diffuser 41.

The evacuation of air from the chamber 16 induces an air flow through the opening 17 into the chamber 16. The air flow tends to replenish the air evacuated from the chamber. As the air enters the chamber 16 it moves past the blades 31 of the turbine 27.

The blades 31 are airfoils on which the air exerts forces as it moves past the blades and reacts to their pitch. In FIG. 2 an end view of one of these blades 31 shows typical forces acting on each of the blades 31 of the turbine 27.

A force in response to the air flow past the blades 31, acts substantially perpendicular to the chord 50 of the blade 31. The chord 50 is synonymous with the length of the end view of the blade 31 in FIG. 2. A vector 51 indicates schematically the direction and a magnitude of the resultant force acting on the blades 31. The length of the vector 51 is chosen at random. A particular magnitude of the force acting on the blades 31 depends, of course, on a number of factors, an important one being the velocity of the air flowing relative to the blades 31.

Resolving the vector 51 into an axial component 52 in the direction perpendicular to the lift plane 14 and into a rotational component 53 in the plane of rotation of the turbine 27 yields a drag component and a useful component, respectively.

The drag component 52 acts in a direction opposite to the direction of the desired lift to be generated by the device 11. Consequently any lift generated is reduced by a drag force equal to the sum of the drag components 52 of all blades 31. The rotational component 53, on the other hand, acts perpendicularly to the desired direction of the lift on the lift plane 14 and has no detrimental effect on the lift generated on the lift plane 14. The components 53 of all blades 31 combine to produce a torque on the turbine 27. As a result of the torque the turbine accelerates until the torque is balanced out by an equal and opposite load. The torque on the turbine 27 becomes balanced when the clutch 37 couples the shaft 28 to the shaft 24 to permit the turbine 27 to aid the power source 25 in driving the impeller 23.

Applying the torque from the turbine 27 to aid the power source 25 in driving the impeller 23 increases the effectiveness of the impeller in evacuating air from the chamber 16. As more air becomes evacuated from the chamber 16 and the pressure in the chamber decreases with respect to the pressure of the environment, an increased amount of air enters the chamber 16 through the opening 17. The increased air flow into the chamber 16 increases, even more, the power output of the turbine 27, which, in turn, increases its power input to the impeller 23. In a steady state, the power input to the impeller 23 equals the power output from the power source 25 plus the power output from the turbine 27.

When the device 11 is operating, the lift generated thereby depends directly on the quantity of energy or head which is removed from the air entering the chamber 16 and is transferred to the turbine 27. Lift is generated on the device 11 by reducing the total energy or total head of the air in contact with the top surface 19 of the lift plane 14 with respect to the energy of the air in contact with the bottom surface 18.

In that the total energy of the air is reduced before it gets into contact with the top surface 19 of the lift plane 14, the present invention is distinguished over the conventional method of generating lift by converting a portion of the energy of air from a pressure head to a velocity head. The now disclosed method of generating lift overcomes certain disadvantages of the prior art method.

For instance, the turbine blades 31 are partially guarded by the surrounding aircraft structure 12. Contact, during take-offs or landings, between the guarding structure 12 and objects on the ground, such as tree branches or buildings, would not necessarily result in a destruction of the lift device 11.

Additionally, the lift generated by the device 11 is not subject to a reduction in efficiency because of a back-flow of air during hover flight of the device-associated aircraft. During such a hover flight, air being evacuated from the chamber 16, which finds its way back to the entrance of the chamber at the opening 17, undergoes, once again, a reduction in its energy level as it passes the blades 31 of the turbine 27. Consequently, the generation of lift by the device 11 appears not to be disadvantageously affected by a back-flow of air.

The present invention has been described in relation to the device 11 as a specific embodiment of this invention. It should be understood that the described device 11 can be modified in a number of ways without departing from the spirit and the scope of this invention.

I claim:

1. A method of generating lift on a plane having an upper surface and a lower surface, the plane being located in a gaseous medium under pressure, which comprises:
 exposing the lower surface to the pressure of the gaseous medium;
 establishing a continuous flow of the medium through an opening opposite the upper surface of the plane and into and through a defined space contiguous to the upper surface; and
 removing energy from the medium entering the defined space, to lower the energy level and thereby lower the pressure of the medium within the defined space below the pressure of the medium in contact with the lower surface, whereby a net pressure is generated on the plane which lifts the plane in the direction of the defined space.

2. A method according to claim 1, wherein the opening is a first opening, wherein the defined space is a chamber having the first opening and a second opening for permitting a flow of the medium to be established into and out of the chamber, respectively, wherein establishing a continuous flow of the medium comprises evacuating the medium from the chamber through the second opening, to cause a replenishing flow of the medium through the first opening into the chamber, wherein a turbine is mounted in the flow path of the medium into the chamber, and wherein removing energy from the medium comprises transferring energy from the medium to the turbine.

3. A method according to claim 2, further comprising, applying the energy, transferred from the medium to the turbine, to an impeller to cause the energy to aid in evacuating the medium from the chamber.

4. A lift device, which comprises:
 a lift plane having a bottom surface and a top surface, the bottom surface being exposed to the pressure of atmospheric air;
 walls enclosing the top surface to form a chamber with the top surface, the chamber having a first opening opposite the top surface and a second opening, the first opening providing access for atmospheric air to enter the chamber;
 means, communicating with the second opening, for evacuating air from the chamber through the second opening to establish a replenishing air flow through the first opening into the chamber; and
 means, located in the path of the air flow into the chamber, for removing energy from the air entering the chamber, to lower the pressure of the air within the chamber with respect to the pressure of the atmospheric air, to cause a pressure differential between the top and the bottom surfaces of the plane, whereby a lift is generated on the plane in the direction of the first opening and the lower pressure.

5. A lift device according to claim 4, further comprising means, communicating with the energy removing means, for applying the energy removed from the air entering the chamber to aid in the evacuation of air from the chamber.

6. A lift device according to claim 5, wherein the evacuating means comprises:
 an impeller communicating with the second opening in the chamber;
 a power source coupled to the impeller to drive the impeller and to enable the impeller to evacuate air from the chamber.

7. A lift device according to claim 6, wherein:
 the energy removing means comprises a turbine, the turbine being mounted concentrically with the first opening to accept energy from the air entering the chamber through the first opening, and to convert the accepted energy into rotational energy; and
 the energy applying means comprises means for coupling the rotational energy of the turbine to the impeller to aid the power source in driving the impeller.

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